NORTHERN BOBWHITE HUNTING: BEHAVIOR
OF HUNTERS AND DOGS

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2001

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
July, 2007
NORTHERN BOBWHITE HUNTING: BEHAVIOR OF
HUNTERS AND DOGS

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ACKNOWLEDGMENTS

I thank the Bollenbach Endowment, Game Bird Research Fund, Frank W. Merrick Foundation Management, Oklahoma Agricultural Experiment Station, and the Oklahoma State University Department of Natural Resource Ecology and Management for financial and logistic support. I would like to thank Drs. Fred Guthery, Terry Bidwell, and Craig Davis for their guidance, assistance, and encouragement. Thanks to Rob Chapman, Missouri Department of Conservation; Wade Free, Oklahoma Department of Wildlife Conservation; and R. Dwayne Elmore, Oklahoma State University, for providing dogs and subjects, and aiding in data collection. I extend my appreciation to the hunters and landowners for their voluntary participation in my research. Without them this project would not have been possible. Thanks are also owed to my fellow graduate student, Stacy Dunkin, for his tutelage in GIS methodology. Finally, I would like to give my special appreciation to my wife, Melissa, for her constant support and encouragement.
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CHAPTER 1

ACCURACY AND BIAS IN GARMIN FORETREX 201® GPS UNITS

Abstract: I tested Garmin Foretrex 201® Global Positioning System (GPS) units (Garmin International, Olathe, Kansas, USA) for accuracy and bias while performing 2 tasks. Task 1 (stationary test) involved keeping units stationary to record position fixes in 7-sec intervals for 30 min. Task 2 (line test) involved carrying the units in a straight line while recording position fixes. In GPS methodology, accuracy refers to a unit’s ability to record its actual position. Bias refers to the observed fixes having a systematic rather than random inaccuracy. Both tests indicated the Foretrex 201 units recorded fixes that were on average accurate to within 10.1 m ± 0.80 SE. The Foretrex 201s recorded position fixes in the 7-sec interval 99.4% of the time. However, a χ² test of the distribution of the fixes relative to a known location indicated bias (P ≤ 0.001) in all units (n = 5). This bias does not preclude the Foretrex 201 units from being used to determine location, but it implied the locations were systematically inaccurate. Despite an increase in accuracy over the last 6 years, GPS technology has sources of inaccuracy that lead to lost or biased data which adversely affect results. By testing a specific model GPS unit, idiosyncrasies and sources of error inherent to that model can be identified and corrective actions can be taken.
INTRODUCTION

Global Positioning System (GPS) is a 24-satellite navigation system developed for the U.S. military (Garmin 2000). The first satellite was launched in 1978 and the system became fully functional in 1994. In the mid 1980s the U.S. military made the system available for public use. However, the system was subject to selective availability. This Department of Defense program limited the number of signals a public GPS receiver could pick up, making public GPS receivers inaccurate. In May 2001, the selective availability program was disbanded and civilian GPS receivers made accuracy advancements. Accuracy was improved by \( \geq 10 \) times once the selective availability program was removed (Garmin 2000).

Following advancements in accuracy, GPS technology became widely used in wildlife research. Accurate and reliable data could be collected in all terrain and weather conditions (Dussault et al. 1999). Despite the increase in accuracy, GPS units suffer from sources of error that result in lost, inaccurate, or biased data. This should be taken into account when designing a study and selecting a GPS model.

The objective of this study was to determine accuracy and bias of the Foretrex 201 GPS unit. This model was selected for 2 reasons. First, it was representative of commercially available GPS units (accurate to within 15 m, 12-channel receiver). Second this model was to be used in future research.

STUDY AREA

The study was conducted in Payne County, Oklahoma, in April 2006. The site was an open field on the Oklahoma State University campus in Stillwater. Stillwater is in north-central Oklahoma and is categorized as predominately tall-grass prairie (Woods et
al. 2005). The average annual precipitation for the area is 831 mm with an average temperature of 15.0 °C (Cassels et al. 1995).

METHODS

Stationary Test

I tested the Foretrex 201 units for accuracy and bias in the stationary and line tests. In GPS methodology accuracy refers to a unit’s ability to report its location and velocity at the time the fix was taken. Bias refers to the reported fixes having a systematic rather than random distribution about the true location. Five randomly selected Foretrex 201 units were set to record position fixes in 7-sec intervals with the Wide Angle Augmentation System function enabled. The testing site had a clear view of the open sky. Units were placed on the ground within 0.31 m of each other and allowed to initiate signal for 30 min prior to the test (manufacturer’s guidelines). After 30 min the track logs were cleared and the test began. The units remained stationary on the ground recording fixes for 30 min. When 30 min elapsed, the fixes were saved and the units turned off. A Garmin GPS II Plus® (GPS II) (Garmin International, Olathe, Kansas, USA) was used to record the Universal Transverse Mercator (UTM) coordinates of the test site. This GPS was reported to be accurate within 3–5 m. Therefore, the UTM location recorded was considered the location where the test occurred (true location). The GPS II Plus was tested in the same way as the Foretrex 201s. The fixes were downloaded into Microsoft Excel 2003® (Microsoft Corporation, Redmond, Washington, USA) using DNR Garmin 5.1.1 (Minnesota Department of Natural Resources, St. Paul Minnesota, USA) software. The Foretrex 201 fixes were then analyzed for consistency in maintaining a 7-sec recording interval, dispersion of locations relative to the assumed
true location, and velocity consistent with a stationary position. Velocity (m/sec) for each unit was determined by calculating the distance between location fixes and dividing the distance by elapsed time between fixes (7 sec).

**Line Test**

The same 5 Foretrex 201s used in the stationary test were used during the line test. They were set to record at 7-sec intervals. Two UTM coordinates were taken with the GPS II. These locations were approximately 190 m apart and served as the start and stop points for the test. The 5 Foretrex 201s were carried simultaneously between the 2 points.

**Data Analysis**

*Stationary Test.* — Tests for bias were conducted by plotting fixes on a Cartesian plane with the true location as the point of reference. The argument function of Excel was used to assign a 1 in the quadrant where it was located and a 0 in the quadrants where it was not. Under a random distribution, I expected an equal number of deviations in each quadrant. I used a $\chi^2$ test with 3 df to determine if the observed fixes were randomly distributed over the 4 quadrants. Accuracy in the stationary test was tested using the absolute deviation from the true location. This was done by finding the distance from each Foretrex 201 fix to the true location using the distance formula (Miller et al. 1994)

$$d = \sqrt{(y_t - y_f)^2 + (x_t - x_f)^2}$$

where

$d =$ the distance from the true location to the Foretrex 201 fix (m),

$y_f =$ the northing UTM coordinate of the Foretrex 201 fix,
\[ y_2 = \text{the northing UTM coordinate of the true location}, \]
\[ x_1 = \text{the easting UTM coordinate of the Foretrex 201 fix}, \text{ and} \]
\[ x_2 = \text{the easting UTM coordinate of the true location}. \]

*Line Test.*— The line determined by the GPS II start and stop coordinates was used to determine bias in the fixes of the Foretrex 201s. The location of the Foretrex 201 fixes in relation to the line was used to assign the fixes +1 if they were east of the north to south path of travel and -1 if they were west. Bias was determined by using a \( \chi^2 \) statistic with 1 df to test for an even distribution of the fixes east and west of the line of travel. Accuracy was tested by determining the equation of the line of travel using the UTM coordinates of the start and stop locations of the test and the point-slope formula

\[
y - y_i = b(x - x_i) \quad \text{(Miller et al. 1994)}\]

where \( b \) = the slope of the line. The slope of the line of travel was determined by using the starting and stopping UTM coordinates and the slope formula

\[
b = \left( y_2 - y_1 \right) / \left( x_2 - x_1 \right) \quad \text{(Miller et al. 1994)}\]

Next, I calculated the slope of the line that was perpendicular to the line of travel at a Foretrex 201 location. The slope of this line was the negative inverse of the slope of the line of travel and was calculated with the equation \( b_p = 1 / -b \) (Miller et al. 1994) where \( b_p \) = the slope of the line perpendicular to the line of travel. Once the slope of the line perpendicular to the line of travel was determined the line’s equation was calculated using the point-slope formula. It was then possible to determine the coordinates of the intersection of the line of travel and the line that was perpendicular to it by setting the equations of both points equal to each other and solving for the variables.

The deviation of the Foretrex 201 fixes from the line of travel was calculated using the coordinates of the intersection of the path of travel and the line perpendicular to
it, the coordinates of the Foretrex 201 fixes, and the distance formula. As in the test for bias, if the coordinates of the Foretrex 201 fix placed it east of the line of travel it was multiplied by +1, and by -1 if it was west of the line of travel. The absolute deviation for the line test was the mean of the absolute value of the deviations of the Foretrex 201 fixes from the line of travel. The actual deviation was the mean of the deviations with the element of directionality (east versus west of the line of travel).

RESULTS

Stationary Test

The 5 Foretrex 201s yielded 1,741 fixes over the 30-min test. The average reported velocity of the units was 0.1 m/sec ± 0.45 SD. The average absolute deviation from the point of reference was 10.1 m ± 0.80 SE (Table 1.1). The Foretrex 201s maintained the 7-sec recording interval >99% of the time, which suggested a high degree of timing reliability (Table 1.1). Each unit was biased \((P \leq 0.001)\) (Fig. 1.1).

Line Test

The mean absolute deviation of the Foretrex 201 fixes \((n = 456)\) was 1.63 m ± 0.06 SE (Table 1.2). During the test the Foretrex 201s maintained a 7-sec collection interval >99% of the time. Bias (Fig. 1.2) was not present in 2 units \((P = 0.116\) and \(0.317, \chi^2 = 1.9 \text{ and } 2.3\) but was present in 3 \((P < 0.001, \chi^2 \geq 16.4)\). The mixed results indicated variation among the units. The mean actual deviation of all 5 Foretrex 201s was negative (Table 1.2). In the units where the \(\chi^2\) test did not indicate bias the negative mean actual deviation was a result of deviations west of the line of travel being of a greater average magnitude than those east of the line. This was also interpreted as an indication of bias.
Table 1.1. Controlled performance tests of Foretrex 201 GPS units while stationary, Payne County, Oklahoma, April 2006.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Absolute deviation</th>
<th>Apparent velocity (m/sec)</th>
<th>Time</th>
<th>$\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$n$</td>
<td>$\bar{x}$</td>
<td>SE</td>
<td>$\bar{x}$</td>
</tr>
<tr>
<td>Foretrex</td>
<td>349</td>
<td>10.1</td>
<td>0.36</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>352</td>
<td>13.1</td>
<td>0.31</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>350</td>
<td>8.4</td>
<td>0.24</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>346</td>
<td>9.7</td>
<td>0.14</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>349</td>
<td>9.2</td>
<td>0.35</td>
<td>0.4</td>
</tr>
<tr>
<td>GPS II</td>
<td>329</td>
<td>6.3</td>
<td>0.18</td>
<td>0.3</td>
</tr>
</tbody>
</table>

*a Distance from true location to Foretrex 201 location.

*b Proportion of locations that maintained a 7-sec recording interval between locations.

*c Tests for random dispersion of Foretrex 201 locations relative to the true locations relative to the true location ($P < 0.001$ for all tests).

*d Maximum deviation from 7-sec recording interval was ± 1-sec.
Figure 1.1. Distribution of 1 Foretrex 201 unit fixes plotted on a Cartesian plane compared to the true location during the stationary test for accuracy and bias, Payne County, Oklahoma, April 2006.

Table 1.2. Tests of deviation and bias for Foretrex 201 units carried along a straight line (190 m) Payne County, Oklahoma, April 2006.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Deviation</th>
<th>Absolute^a</th>
<th></th>
<th>Actual^b</th>
<th></th>
<th>(\chi^2)^c</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n)</td>
<td>(\bar{x})</td>
<td>SE</td>
<td>(\bar{x})</td>
<td>SE</td>
<td></td>
</tr>
<tr>
<td>Foretrex</td>
<td>91</td>
<td>2.0</td>
<td>0.13</td>
<td>-0.1</td>
<td>0.23</td>
<td>35.7</td>
</tr>
<tr>
<td></td>
<td>91</td>
<td>2.2</td>
<td>0.17</td>
<td>-0.9</td>
<td>0.23</td>
<td>1.9</td>
</tr>
<tr>
<td></td>
<td>88</td>
<td>1.8</td>
<td>0.14</td>
<td>-0.8</td>
<td>0.22</td>
<td>16.4</td>
</tr>
<tr>
<td></td>
<td>99</td>
<td>1.3</td>
<td>0.09</td>
<td>-0.1</td>
<td>0.25</td>
<td>2.3</td>
</tr>
<tr>
<td></td>
<td>87</td>
<td>0.9</td>
<td>0.04</td>
<td>-0.4</td>
<td>0.10</td>
<td>23.3</td>
</tr>
<tr>
<td>GPS II</td>
<td>97</td>
<td>0.6</td>
<td>0.06</td>
<td>-0.1</td>
<td>0.01</td>
<td>25.1</td>
</tr>
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^a Perpendicular deviation Foretrex 201 location to the true line of travel.
^b Perpendicular deviation from Foretrex 201 locations to the line of travels as adjusted (+,-) for side of the line on which the location occurred.
^c Test for random dispersion of Foretrex 201 locations relative to the true line of travel.
Figure 1.2. Distribution of a Foretrex 201 fixes and a GPS II fixes plotted along the path of travel. (a) Position fixes from a Foretrex 201 unit taken along the path of travel plotted against the line drawn between the starting and ending locations of the test. (b) Position fixes from the GPS II unit taken along the path of travel and plotted against the line drawn between the starting and ending location of the test.
DISCUSSION

Through this study I identified the idiosyncrasies that were inherent to the Foretrex 201 units. The results of the stationary test indicated there was a range of velocities associated with an actual velocity of 0 m/sec (Table 1.1). To properly use GPS track logs to interpret movement, or lack thereof, it was important to determine the range of velocities associated with a stationary object rather than assuming a velocity of 0 m/sec. The results of the line test showed the fixes held to the path of travel well within the manufacturer’s reported 15-m accuracy. However, they also indicated lateral deviations in a path of travel were due to the inaccuracy of the fixes and not the subject moving off of the path. Part of my descriptive study involving these units was to develop a density estimation technique based on buffering the GPS tracks of the dogs with the effective strip width as determined by line-transect theory (Buckland et al. 1993). For this estimation technique to be feasible, the deviation from a path of travel that was attributed to the inaccuracies of the GPS units as opposed to actual movement in the search pattern of a dog needed to be determined. The results of the line test showed that on average the deviations from the path of travel that could be associated with inaccuracies within the units were ≤2.2 m. This helped to establish a diagnostic pattern for determining a dog’s true path of travel.

MANAGEMENT IMPLICATIONS

Despite an increase in accuracy over the last 6 years, GPS technology has several sources of error that remain inherent to the technology. Sources for error in GPS units are ionosphere and troposphere delays, signal multipath (GPS signal reflects off of an object), receiver clock errors, and satellite geometry, as well as the influences of
topography and forest canopy on signal strength (Garmin 2000, Cain et al. 2005, DeCesare et al. 2005). The results indicated the Foretrex 201 units were as accurate as the manufacturer indicated and maintained the 7-sec recording interval >99% of the time. The tests did, however, reveal bias in this model GPS unit with regard to the location of fixes. The Foretrex 201 units were tested under ideal conditions to develop a baseline. I would expect certain field conditions may adversely impact the reliability and accuracy of all GPS units currently available. My recommendation to researchers designing studies around GPS technology would be to test the particular GPS units in a variety of tasks that mimic the field conditions expected to be encountered during the research.
CHAPTER 2

NORTHERN BOBWHITE HUNTING: BEHAVIOR OF HUNTERS AND DOGS

Abstract: I collected Global Positioning System (GPS) track logs and recorded behavioral observations on 93 northern bobwhite (Colinus virginianus) hunts in Oklahoma, Texas, and Missouri during the 2005–2006 and 2006–2007 hunting seasons to obtain: 1) descriptions of hunter and dog behaviors and 2) empirical data for the hunter-covey interface (HCI) models. Until the introduction of HCI theory and the models it contains, little research was done on the events and processes of a bobwhite hunt. The HCI theory describes and quantifies the quail hunting dynamic through the spatial and temporal relationship between hunters, dogs, and quail. I collected data on dog and hunter behaviors, travel characteristics, flushing patterns of bobwhites, and bobwhites harvested/flush. Most of a dog’s time during a hunt was spent searching for bobwhites (50.5% ± 2.15 SE and 82.0% ± 1.26 SE during 2005–2006 and 2006–2007 respectively). There was a negative relationship between mean dog velocity and flushes/km for both seasons ($r = -0.40$, $P = 0.002$ and $r = -0.20$, $P = 0.04$, respectively). Hunter velocity was consistent with a mean of 0.8 m/sec ± 0.03 SE for both seasons. The 2005–2006 data indicated an average flush consisted of 6.7 birds ± 0.62 SE. During the 2006–2007 season an average flush consisted of 5.9 birds ± 0.84 SE. This research provided movement data on hunters and dogs that show area use patterns and help to predict
and manage hunting pressure on discrete units of land.

INTRODUCTION

Little research was done on the various elements that combine to form the bobwhite hunting process until Radomski and Guthery (2000) introduced hunter-covey interface (HCI) theory. This theory and the models it contains explain how the movement of hunters and dogs combine to form the quail hunting dynamic and how this dynamic changes over space and time (Radomski and Guthery 2000, Guthery 2002, Hardin et al. 2005). Hunter-covey interface models may allow researchers to understand and manage quail harvest. Empirical tests of HCI models by Hardin et al. (2005) showed the models might be useful for managing hunting pressure, optimizing harvest, and sustaining populations.

The static HCI model (Guthery 2002) predicts daily harvest based in part on the velocity of a hunt and area covered during a hunt. The governing equation for this model is

\[ K_t = m_t \left( \frac{v_t h_t w_t}{A} \right) \left( \frac{N_t}{c_t} \right) \]

where

- \( K_t \) = the number of birds harvested on day \( t \),
- \( m_t \) = the mean number of birds shot per covey flushed on day \( t \),
- \( v_t \) = the velocity at which hunters travel on day \( t \) (linear units/hr),
- \( h_t \) = hours spent hunting on day \( t \),
- \( w_t \) = the effective width of hunting zone on day \( t \) (linear units),
- \( A \) = the area (ha) available for hunting,
\( p_{ft} = \) the probability of flush given encounter on day \( t \),

\( N_t = \) the total quail population at the beginning day \( t \), and

\( c_t = \) average covey size on day \( t \).

The ability of HCI models to accurately predict aspects of quail hunting relies not only on the selection of variables that drive the system, but also on a complete understanding of those variables and how they interact with one another (Morrison et al. 2001).

My objective was to gather descriptive data on the behavioral and movement characteristics of hunters and dogs. The research provided original data on hunter and dog behavior and empirical estimates of 3 variables in the HCI models (\( m_t, v_t, \) and \( h_t \)).

**STUDY AREA**

I gathered data from multiple sites in western Oklahoma, north-central Texas, and western Missouri. Missouri’s bobwhite hunting season went from 1 November 2005 through 15 January 2006. The Oklahoma bobwhite season went from 12 November 2005 through 15 February 2006. The Texas bobwhite hunting season went from 29 October 2005 through 26 February 2006. The Missouri study sites were not used during the 2006–2007 season. The Texas and Oklahoma bobwhite seasons remained the same for the 2006–2007 season.

**Missouri**

Missouri data were collected on the White River Trace Conservation Area, Dent County. This area, managed by the Missouri Department of Conservation, is a bobwhite focus area (R. N. Chapman, Missouri Department of Conservation, unpublished data). Primary management of the area involved natural community restoration. The landscape consisted of an extensive grassland-savanna-woodland complex with gently rolling to
Mecozzi

moderately steep topography. The average annual precipitation for the state is 470 mm with an average temperature of 13.4 °C (Chapman et al. 2001). Management practices include an extensive prescribed burning program that aided in the restoration of grasslands, savannas, and woodlands and the maintenance of structural and compositional diversity of vegetation (R. N. Chapman, Missouri Department of Conservation, unpublished data).

Texas

The Texas study area was confined to northern Texas in the Rolling Plains ecological region (Gould 1975). Topography was flat to rolling, with natural vegetation of mixed-grass plains, short-grass high plains, shinnery oak (*Quercus havardii*) grasslands, and honey mesquite (*Prosopis glandulosa*) grasslands. Grass species included tall and mid-grasses such as little bluestem (*Schizachyrium scoparium*) and blue grama (*Bouteloua gracilis*). Riparian areas were dominated by various hardwood species. Eastern redcedar (*Juniperus virginiana*) typically occurs on the steep slopes along rivers. Annual precipitation for the region is between 332 and 734 mm (Seyffert 2001) with an average temperature of 18 °C (McMahan et al. 1984).

Oklahoma

Oklahoma contains vast plains, elevated karst plateaus, hills, and folded, low mountains. I used multiple sites in northwestern Oklahoma for data collection. Northwestern Oklahoma, excluding the Panhandle, was comprised of tall grass prairie, shinnery oak, short grass high plains, sand sage (*Artemisia filifolia*) grassland, mixed grass eroded plains, and bottomlands (Woods et al. 2005). This region has an average annual precipitation of 410 mm with an average temperature of 16.2 °C.
METHODS

During the 2005–2006 and 2006–2007 hunting seasons, I observed hunters and pointing dogs during walking quail hunts. At the onset of each hunt I recorded the breed, age, sex, and name of dog(s). Hunters volunteered and therefore the study required an Institutional Review Board Consent Form (Appendix A) and an Institutional Review Board Permit (Permit # AS0618) (Appendix B).

I defined a quail hunt as a pass though an area by a hunter. A hunt began when a hunter left the vehicle and concluded when he or she returned. No controls for hunter or dog skill level were set prior to a hunt.

**Movement and Velocity**

Upon arrival at a study site, I turned on the Garmin Foretrex 201® (Garmin International, Olathe, Kansas, USA) GPS units and left them in a clear, open area for 30 min prior to the start of a hunt. This established a satellite fix as recommended by the manufacturer. The manufacturer reported that on average the Foretrex 201 units are accurate within 15 m. I also synchronized my watch with the internal clocks of the GPS units for later analysis.

I attached the GPS units to dog collars using the built-in wrist strap on the units. During the 2005–2006 hunting season subjects consisted of ≤2 dogs and ≤2 hunters so long as a hunt contained ≥1 dog and 1 hunter. Eleven hunts during the 2005–2006 season had >2 dogs hunting simultaneously. The 2005–2006 protocol left these dogs unmonitored. During the 2006–2007 season, I fitted all dogs with GPS units. During the 2005–2006 season 7 hunter and 8 dog track logs had to be removed from the data. The
The most common source of GPS error occurred when units lost signal for a prolonged period of time or shut off. To correct this problem, I attached 2 GPS units to each dog’s collar during the 2006–2007 season. A second problem during the 2005–2006 season was 3 GPS units suffered structural failure around the wrist strap used to attach units to dog collars. This resulted in GPS units being lost in the field. To correct this problem, I used flexible nylon cable ties with 18.0-kg tensile strength (General Electric, Oklahoma City, Oklahoma, USA) to attach GPS units to dog collars in 2006–2007. During 2005–2006 hunters placed the units in their pocket. This may have contributed to GPS error. During 2006–2007 hunters attached GPS units to their hunting vests.

**GPS Setup.** — I collected all points in the track log file at 7-sec intervals. Hardin et al. (2005) showed the 7-sec interval was favorable for 2 reasons. First, a 7-sec interval allowed the GPS units to record data continuously for approximately 4 hr, allowing all information from a hunt to be collected on a single unit. Second, the turning angles of the dogs showed little difference between the 7-sec interval and longer intervals. Therefore, the 7-sec interval optimized the collection effort of each hunt (Hardin et al. 2005).

**Data Analysis.** — I converted GPS track logs (hereafter, tracks) from hunters and dogs to Universal Transverse Mercator (UTM) coordinates and downloaded to a spreadsheet using DNR Garmin 5.1.1 software (Minnesota Department of Natural Resources, St. Paul Minnesota, USA). These data allowed me to determine how far hunters and dogs traveled during a hunt and their rate of travel. The distance traveled between GPS locations for dogs and hunters was determined with the distance formula (Miller et al. 1994).


\[ d = \sqrt{(y_2 - y_1)^2 + (x_2 - x_1)^2} \]

where

- \( d \) is the distance traveled between consecutive locations (m),
- \( y_1 \) is the northing UTM coordinate of the Foretrex 201 fix at time 1,
- \( y_2 \) is the northing UTM coordinate of the Foretrex 201 fix at time 2,
- \( x_1 \) is the easting UTM coordinate of the Foretrex 201 fix at time 1, and
- \( x_2 \) is the easting UTM coordinate of the Foretrex 201 fix at time 2.

The total distance was the sum of between-location distances. The dog-to-hunter distance and dog-to-dog distances (when hunting multiple dogs) were determined using the distance formula. I analyzed these data sets using the descriptive statistics function of ProStat 4.1\(^\circledR\) (Poly Software International, Pearl River, New York, USA).

Comparison between GPS tracks from the same hunt required that GPS fixes maintained the 7-sec recording interval. Failure to maintain the recording interval indicated signal degradation. When the 7-sec interval was not maintained but the location was within the plausible hunting path (distances that could physically be covered within the elapsed time between locations) of the dog or hunter tracks, I used the data for analyzing velocity and distance.

I determined velocity at which a dog traveled by taking the distance traveled between GPS fixes and dividing it by the 7-sec interval. I calculated the average velocity of a dog for a hunt. The overall average dog velocity for each season was calculated by averaging the mean velocity from each hunt. Hunter velocity was determined in the same manner. To illustrate variation during and between hunts, I constructed a frequency distribution of velocities on a slow, average, and fast hunters and dogs. I used regression
analysis to determine the strength of the relationship between average hunter and dog velocities during hunts and the number of flushes/km.

**Behavior**

I used \(\leq 4\) subjects per hunt for behavioral samples. Subjects consisted of various combinations of dogs and hunters so long as a hunt contained \(\geq1\) hunter and \(\geq1\) dog being monitored. I chose a 4-subject limit so I could accurately monitor all subjects during a hunt. Behavior data were collected using a portable audiocassette recorder (Sony Corporation of America, New York, New York, USA) and a predefined list of 8 hunter (Table 2.1) and 12 dog (Table 2.2) behaviors that are associated with quail hunting. I followed the hunter(s) and dog(s) recording behaviors. Hunter and dog behaviors of interest and the time the behavior occurred were recorded continuously upon the start of a hunt. The next sample was taken when a behavior changed. Behavioral sampling included measuring the distance from where a dog went on point to where a bird(s) flushed (hereafter point-to-flush distance; PFD), number of shots fired per flush, number of birds shot per flush, birds downed/shot, and time spent hunting. Point-to-flush distances were measured using a hip chain (Forestry Supplies, Inc., Jackson, Mississippi, USA). A hip chain contains a spool of thread and a counter calibrated to measure in 0.31-m intervals. The end of the spool was attached to an object where the dog went on point. I then walked to the location the birds flushed and read the counter, recorded the measurement, broke the tied off the piece of string, and reset the counter.
Table 2.1. Definitions of hunter behaviors associated with northern bobwhite hunting in Missouri, Texas, and Oklahoma during the 2005–2006 and 2006–2007 hunting seasons.

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approaching point</td>
<td>A quick paced walk to where a dog(s) is on point</td>
</tr>
<tr>
<td>Hunting for live singles</td>
<td>Hunting where flushed covey lands</td>
</tr>
<tr>
<td>Other</td>
<td>Any behavior not associated with quail hunting</td>
</tr>
<tr>
<td>Resting</td>
<td>Hunter not actively engaged in hunting</td>
</tr>
<tr>
<td>Searching for dog</td>
<td>Searching for a dog that is out of sight and will not respond to calling</td>
</tr>
<tr>
<td>Searching for downed birds</td>
<td>The act of searching for birds that have been downed</td>
</tr>
<tr>
<td>Tending dog</td>
<td>Removing bur, watering, positive feedback</td>
</tr>
<tr>
<td>Walking</td>
<td>Moving on foot</td>
</tr>
</tbody>
</table>

Appendix C provides data on hunts of pen-reared birds.

_Data Analysis._ — I determined the percentage of a hunt spent performing a behavior (hereafter, time budget). These data sets were analyzed using the descriptive statistics function of the ProStat 4.1®. I compared the time budget for hunters and dogs, number of birds flushed, number of shots/hunter/flush, number of birds shot/flush, and the PFDs.
Table 2.2. Definitions of pointing dog behaviors associated with northern bobwhite hunting in Missouri, Texas, and Oklahoma during the 2005–2006 and 2006–2007 hunting seasons.

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Being tended</td>
<td>Having a bur removed, positive feedback</td>
</tr>
<tr>
<td>False point</td>
<td>Pointing when bobwhites are not present, or pointing animals other than quail</td>
</tr>
<tr>
<td>Honoring point</td>
<td>Going on point cued from another dog’s point</td>
</tr>
<tr>
<td>Hunting for live singles</td>
<td>Hunting where a flushed covey lands</td>
</tr>
<tr>
<td>Investigation</td>
<td>Slowly searching a specific area, often referred to as being “birdy”</td>
</tr>
<tr>
<td>Other</td>
<td>Behaviors not associated with quail hunting</td>
</tr>
<tr>
<td>Out of sight</td>
<td>Dog has left hunter’s sight</td>
</tr>
<tr>
<td>Point</td>
<td>A rigid, stationary posture associated with the presence of bobwhites</td>
</tr>
<tr>
<td>Ranging</td>
<td>Searching for bobwhites</td>
</tr>
<tr>
<td>Resting</td>
<td>Dog not actively engaged in hunting</td>
</tr>
<tr>
<td>Searching for downed birds</td>
<td>The act of retrieving birds that have been downed</td>
</tr>
<tr>
<td>Watering</td>
<td>Dog drinking water</td>
</tr>
</tbody>
</table>

I estimated the effect of bobwhite group size on PFDs. I constructed sampling distributions of mean PFDs for singletons, 2–7 birds, and >7 birds based on the mean and standard error (Mendenhall and Beaver 1994).

RESULTS

I sampled 31 hunters and 68 dogs in this study. The distribution by breed was 42 English pointers, 12 German short-hair pointers, 8 English setters, 5 Brittany spaniels,
and 1 vizsla (Hungarian short-haired pointer). I collected data on 23 hunters for multiple
hunts and 3 hunters were sampled during both the 2005–2006 and the 2006–2007
seasons. Data were collected on 46 dogs for multiple hunts and 6 dogs were sampled
during both the 2005–2006 and 2006–2007 seasons. I collected data for 45 hunts during
tracks and 14,987 GPS locations for 33 hunter tracks. In comparison, the 2006–2007
season produced data for 48 hunts. The 2006–2007 hunts generated 41,625 GPS
locations for 97 dog tracks and 22,048 locations for 52 hunter tracks.

A hunt on the Sutter Ranch in western Oklahoma provided an example of tracking
2 dogs and 1 hunter locations (Fig. 2.1). This hunt took place between 1553 and 1635 on
1 February 2006. One pointer traveled 3.7 km at an average velocity of 1.5 m/sec ± 0.06
SE (n = 337), whereas the second traveled 5.2 km at an average velocity of 1.9 m/sec ±
0.12 SE (n = 325). The guide traveled 1.6 km at an average velocity of 0.7 m/sec ± 0.02
SE (n = 307).

Hunter Movement

Hunters during the 2005–2006 season (n = 33) had an average distance traveled
on a hunt of 3,024.0 m ± 305.68 SE (95% CI = 2,399.9–3,650.2 m, range = 1,007.8–
8,035.5 m). The average distance traveled by a hunter (n = 52) during the 2006–2007
hunting season was 2,501.3 m ± 236.2 SE (95% CI = 2,038.1–2,964.5 m, range = 744.6–
7,474.9 m). Hunters during the 2005–2006 season had an average velocity of 0.8 m/sec ±
0.03 SE (95% CI = 0.74–0.86 m/sec, range = 0.4–1.1 m/sec). Hunters during the 2006–
2007 hunting season also had an average velocity of 0.8 m/sec ± 0.03 SE (95% CI =
0.74–0.86 m/sec, range = 0.6–1.8 m/sec). A frequency distribution of hunter velocities
Mecozzi

showed the variable nature of hunter movement (Fig. 2.2). Both seasons showed essentially no relationship \( r^2 < 0.053 \) between number of flushes/km and average hunter velocity.

Figure 2.1. Example of dog and hunter GPS tracks hunting northern bobwhites on Sutter Ranch, Ellis County, Oklahoma, February 2006. Circles denote the location of covey flushes.
Figure 2.2. Frequency distribution of hunter velocities while hunting northern bobwhites in Texas and Oklahoma during the 2005–2006 and 2006–2007 hunting seasons. a) hunter with average velocity of 0.4 m/sec ($n = 1,043$), b) hunter with an average velocity of 0.8 m/sec ($n = 1,293$), and c) hunter with an average velocity of 1.0 m/sec ($n = 976$).

**Dog Movement**

I collected 57 dog tracks during the 2005–2006 hunting season and 97 during the 2006–2007 season. Velocity and distance (Table 2.3) varied between hunts within a
season but were consistent between seasons (overlapping 95% CIs). A frequency
distribution demonstrated the variability of dog velocities within hunts (Fig. 2.3). I
observed a weak but undoubtedly real tendency for mean bird dog velocity to decline
with flushes/km. (Fig. 2.4).

Figure 2.3. Frequency distribution of dog velocities while hunting northern bobwhites in Texas and Oklahoma during the 2005–2006 and 2006–2007 hunting seasons. a) a dog with an average velocity of 1.7 m/sec ($n = 342$), b) a dog with an average velocity of 2.6 m/sec ($n = 197$), and c) a dog with an average velocity of 3.2 m/sec ($n = 343$).
Table 2.3. Dog travel characteristics while hunting northern bobwhites in Oklahoma and Texas during the 2005–2006 and 2006–2007 hunting seasons.

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td></td>
<td>$n$</td>
<td>$\bar{x}$</td>
<td>SE</td>
<td>Range</td>
<td>$n$</td>
<td>$\bar{x}$</td>
</tr>
<tr>
<td>Distance traveled (m)</td>
<td>57</td>
<td>8,908.6</td>
<td>765.70</td>
<td>1,823.0–28,200.0</td>
<td>97</td>
<td>7,839.5</td>
</tr>
<tr>
<td>Mean velocity$^a$ (m/sec)</td>
<td>57</td>
<td>2.3</td>
<td>0.08</td>
<td>1.2–4.5</td>
<td>97</td>
<td>2.6</td>
</tr>
<tr>
<td>Mean distance to hunter$^a$ (m)</td>
<td>39</td>
<td>53.0</td>
<td>3.85</td>
<td>25.4–149.2</td>
<td>106</td>
<td>62.5</td>
</tr>
<tr>
<td>Mean distance to dog(s)$^a$ (m)</td>
<td>15</td>
<td>75.3</td>
<td>8.89</td>
<td>30.6–166.6</td>
<td>72</td>
<td>66.2</td>
</tr>
</tbody>
</table>

$^a$ Mean of individual means.
Figure 2.4. Mean dog velocity as a function of northern bobwhite covey flushes/km in Texas and Oklahoma during the 2005–2006 (a) and 2006–2007 (b) hunting seasons.

Behavior

The 95% CIs for mean percentage of a hunt spent in each behavioral class indicated differences in hunter behaviors between seasons with the exception of searching for dogs (Table 2.4). Dog behaviors also differed between seasons (Table 2.5). The average duration for a hunt \( (n = 45) \) during the 2005–2006 season was 82.3 min ± 8.16 SE but the duration of hunts over the season varied greatly (range = 14.0–270.0 min). In comparison, during 2006–2007 the average duration for a hunt \( (n = 48) \) was 50.2 min ± 5.1 SE (range = 17.0–148.9 min).
During the 2005–2006 season hunters took an average of 1.0 shots/hunter/flush ± 0.06 SE (range = 0.0–4.0) on 135 pointed and non-pointed flushes. The average number of birds shot/flush was 1.25 ± 0.07 SE (range = 0.0–4.0 birds shot/flush) but varied by number of birds flushed. The average number of birds shot/flush for >7 bird flushes (n = 52) was 1.5 ± 0.15 SE (range = 0–4), 2–7 bird flushes (n = 43) averaged 1.3 ± 0.10 SE (range = 0–3), single bird flushes (n = 40) averaged 0.8 ± 0.06 SE (range 0–1). Shooting success (birds downed/shots fired) averaged 0.58 ± 0.03 SE (range = 0.0–1.0).

During the 2006–2007 season hunters on average took 0.69 shots/hunter/flush ± 0.12 SE (range = 0.0–2.0) on 33 flushes (both pointed and non-pointed flushes). The average number of birds shot/flush was 0.67 ± 0.11 SE (range = 0.0–2.0) but varied by number of birds flushed. The average number of birds shot on flushes containing >7 birds (n = 12) was 0.9 ± 0.22 SE (range 0–2), 2–7 bird flushes (n = 13) averaged 0.5 ± 0.14 SE (range = 0–1), and single bird flushes (n = 8) average 0.5 ± 0.19 SE (range = 0–1). Shooting success averaged 0.41 ± 0.08 SE (range = 0.0–1.0). The number of shots/hunter/flush decreased by 31.0% over the 2 seasons. The number of birds shot per flush also decreased by 46.4%.

The 2005–2006 flushes had an average PFD of 5.6 m ± 0.47 SE (range = 0.6–29.3 m). An average flush contained 6.7 birds ± 0.62 SE (range = 1.0–50.0 birds). Point-to-flush distance for the different group sizes during the 2005–2006 season showed that single birds (n = 36) on average flushed at 3.2 m ± 0.44 SE (range = 0.6–9.8 m, 95% CI = 2.3–4.1 m), 2–7 birds (n = 41) at 4.6 m ± 0.66 SE (range = 0.6–21.3 m, 95% CI = 3.3–5.9 m) and >7 birds (n = 51) at 8.2 m ± 0.90 SE (range = 0.9–29.3 m, 95% CI = 6.4–10.0 m).
The 2006–2007 flushes had an average PFD of 6.6 m ± 1.30 SE (n = 27, range = 0.3–26.5 m). An average flush contained 5.9 birds ± 0.84 SE (range = 1.0–18.0 birds). The PFD for different group sizes showed that single birds (n = 6) on average flushed at 2.9 m ± 1.12 SE (range = 0.3–6.1 m, 95% CI = 0.0–5.8 m), 2–7 birds (n = 14) at 7.7 m ± 2.22 SE (range = 1.8–26.5 m, 95% CI = 2.9–12.5 m), and >7 birds (n = 7) at 7.7 m ± 2.26 SE (range = 3.0–19.2 m, 95% CI = 2.2–13.2 m). The pooled (over years) sampling distribution of PFDs for 3 size groups of bobwhites (Fig. 2.5) indicated the PFDs for mid-size and larger groups were highly variable compared to the PFDs for singletons.

**Figure 2.5.** Estimated sampling distributions of point-to-flush distances for northern bobwhite groups of different sizes in Texas and Oklahoma during the 2005–2006 and 2006–2007 hunting seasons.
Table 2.4. Activity budget of hunters while hunting northern bobwhites in Oklahoma, Texas, and Missouri during the 2005–2006 ($n = 59$) and 2006–2007\(^a\) ($n = 55$) hunting seasons.

<table>
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</thead>
<tbody>
<tr>
<td></td>
<td>$\bar{x}$</td>
<td>SE</td>
<td>Range</td>
<td>$\bar{x}$</td>
</tr>
<tr>
<td>Walking</td>
<td>60.5</td>
<td>2.40</td>
<td>26.0–100.0</td>
<td>75.2</td>
</tr>
<tr>
<td>Approaching point</td>
<td>11.8</td>
<td>1.24</td>
<td>0.0–33.0</td>
<td>4.8</td>
</tr>
<tr>
<td>Other</td>
<td>9.8</td>
<td>1.32</td>
<td>0.0–38.0</td>
<td>15.2</td>
</tr>
<tr>
<td>Searching for downed birds</td>
<td>9.4</td>
<td>1.24</td>
<td>0.0–53.0</td>
<td>1.1</td>
</tr>
<tr>
<td>Hunting for live singles</td>
<td>4.9</td>
<td>0.99</td>
<td>0.0–29.0</td>
<td>0.9</td>
</tr>
<tr>
<td>Resting</td>
<td>3.3</td>
<td>0.59</td>
<td>0.0–16.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Searching for dog</td>
<td>0.4</td>
<td>0.22</td>
<td>0.0–10.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Tending dog</td>
<td>0.4</td>
<td>0.16</td>
<td>0.0–7.0</td>
<td>1.8</td>
</tr>
</tbody>
</table>

\(^a\) Data were collected in Texas and Oklahoma only.
Table 2.5. Activity budget of dogs while hunting northern bobwhites in Oklahoma, Texas, and Missouri during the 2005–2006\(^a\) and 2006–2007\(^b,c\) hunting seasons.

<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td>(\bar{x})</td>
<td>SE</td>
<td>Range</td>
</tr>
<tr>
<td>Ranging</td>
<td>50.5</td>
<td>2.15</td>
<td>17.9–99.0</td>
</tr>
<tr>
<td>Investigation</td>
<td>10.2</td>
<td>1.07</td>
<td>0.0–36.7</td>
</tr>
<tr>
<td>Searching for downed birds</td>
<td>9.9</td>
<td>1.07</td>
<td>0.0–47.5</td>
</tr>
<tr>
<td>Out of sight</td>
<td>6.3</td>
<td>0.94</td>
<td>0.0–27.8</td>
</tr>
<tr>
<td>False pointing</td>
<td>4.4</td>
<td>0.59</td>
<td>0.0–28.2</td>
</tr>
<tr>
<td>Honoring point</td>
<td>4.3</td>
<td>0.68</td>
<td>0.0–35.9</td>
</tr>
<tr>
<td>Other</td>
<td>4.1</td>
<td>0.70</td>
<td>0.0–27.5</td>
</tr>
<tr>
<td>Pointing</td>
<td>3.1</td>
<td>0.47</td>
<td>0.0–22.9</td>
</tr>
<tr>
<td>Hunting for live singles</td>
<td>2.9</td>
<td>0.58</td>
<td>0.0–26.3</td>
</tr>
<tr>
<td>Watering</td>
<td>2.1</td>
<td>0.36</td>
<td>0.0–13.2</td>
</tr>
<tr>
<td>Resting</td>
<td>0.7</td>
<td>0.23</td>
<td>0.0–13.4</td>
</tr>
<tr>
<td>Being tended</td>
<td>0.3</td>
<td>0.12</td>
<td>0.0–6.7</td>
</tr>
</tbody>
</table>

\(^a\) \(n = 70\) for honoring point and \(77\) for all other behaviors.  
\(^b\) \(n = 85\) for honoring point and \(91\) for all other behaviors.  
\(^c\) Data were collected in Oklahoma and Texas only.
DISCUSSION

The method I used to define a hunt increased the number of hunts that could be sampled in a day. However, it resulted in subjects and locations being sampled multiple times on the same day. Samples were not independent, which implies that my estimates of uncertainty (SEs) might have been biased low. Additionally, subjects were volunteers and thus not randomly sampled. Due to the non-random selection of samples the results may be particular to the subjects and areas sampled.

Hunter Movement

The mean velocity of hunters was less variable between seasons than within a season. Richardson (2006) reported similar average hunter velocities of 0.73 m/sec and 0.77 m/sec during a 2-yr study. Average hunter velocity may be driven by multiple factors such as terrain hunted, age and health of hunters, number of dogs used, and the time between flushes in addition to the number of flushes per distance traveled.

Dog Movement

Results of average dog velocity were similar to those reported by Hardin et al. (2005). They reported average velocities of 2.3–3.0 m/sec over a 2-yr study but noted that velocities were variable both between years and dependent on site topography and vegetation cover. The relationship between the average velocity of a dog while hunting and flushes/km was stronger than average hunter velocity and flushes/km indicating dog behavior (i.e. movement) during a hunt was largely controlled by the presence or absence of bobwhites. However, there appeared to be heteroscedasticity in the regression analysis for both years (Fig. 2.4). Variability in mean velocity appeared to be higher at low flush rates then at high flush rates.
Hunter and Dog Behavior

The mean percentages of time for almost all behaviors, both hunter and dog, differed between seasons. The most likely explanation of this pattern is both hunter and dog behaviors were driven by the abundance of birds. The Oklahoma Department of Wildlife Conservation roadside bobwhite index indicated an 83% decline (D. Schoeling, Oklahoma Department of Wildlife Conservation, unpublished data) in bobwhite abundance from the 2005–2006 season to 2006–2007 for the Northwest region. Correspondingly, there was a 31.5% increase in the mean percentage of a dog’s hunt spent ranging from 2005–2006 to 2006–2007 (Table 2.5).

Bennitt (1951), Guthery (2002), and Hardin (2005) reported mean birds shot/covey flush as 1.87 ± 0.02 SE, 1.67 ± 0.07 SE, and 1.77 ± 0.04 SE. My 2005–2006 results for >7 bird flushes were similar (1.5 ± 0.15 SE); the 2006–2007 results for >7 bird flushes, however, were considerably different (0.9 ± 0.22 SE). The most likely explanation for this difference was the decline in bobwhite population abundance. The decline in number of birds/flush, and the number of shots fired/hunter can also be attributed to the decrease in bobwhite population abundance over the 2 seasons.

MANAGEMENT IMPLICATIONS

The HCI theory was designed as a tool to manage the amount and distribution of hunting pressure on discrete areas (Guthery 2002). With regards to the HCI models, I collected empirical data on the velocity of hunters and dogs, the duration of a hunt, and mean number of birds shot/covey flushed. These results can be used in planning and managing hunting under the HCI model. Under the HCI model daily harvest is a product of (among other variables) the rate of travel and time spent hunting. By manipulating
these variables daily harvest can be increased or decreased according to desired management goals.

Hunter shooting success (birds shot/shot fired) and data on average shot/hunter/flush may be used on discrete areas and potentially at the state level to assess whether limits need to be placed on hunting party size or the shot capacity of firearms used.

Hunter and dog time budget data may serve to adjust traditional methods of indexing harvest pressure. Harvest rate (a component of harvest pressure) on discrete areas has been estimated using hunting effort/area (Roseberry and Klimstra 1984). They estimated 60 gun hours/100 ha over a hunting season produces a >50% harvest rate. Time spent hunting (gun hours), however, is not necessarily a reliable index of harvest rate or hunting pressure given the many behaviors that combine to form the quail hunting dynamic. Time spent hunting needs to be truncated to time spent actively searching for bobwhites, the proportion of a hunt spent resting, or searching for a lost dog should not be included in the index.
CHAPTER 3

ESTIMATING NORTHERN BOBWHITE DENSITY WITH BIRD DOGS

Abstract: Although an increase in population density is often a measure of success in wildlife management, the techniques used to estimate density may be time-consuming and expensive. Using Global Positioning System (GPS) and Geographic Information System (GIS) technology and line-transect theory, I developed a method of estimating the density of northern bobwhites (Colinus virginianus) during recreational hunts with bird dogs. Data were collected during the 2005–2006 and 2006–2007 hunting seasons in western Oklahoma and north Texas. I estimated effective strip width (ESW) of a bird dog’s path using line transect theory and point-to-flush distances. For coveys >7 birds ($n = 58$), estimated ESW was 13.2 m (95% CI = 11.1–15.6 m). The area covered by a single dog was its GPS path buffered by ESW. For $\geq 2$ dogs, the area covered was the union of the areas of individual dogs; taking the union eliminated between- or among-dog redundancy in searched areas. Density was the number of birds flushed on a particular hunt divided by search area. During the 2005–2006 hunting season, average bobwhite density was 1.4 birds/ha $\pm$ 0.28 SE ($n = 33$). Density declined to 0.2 birds/ha $\pm$ 0.07 SE during 2006–2007 ($n = 46$). The technique of estimating bobwhite density with bird dogs needs further testing and development, but it might prove useful in research and management.
INTRODUCTION

Continuous census is the yardstick of success or failure in conservation (Leopold 1933: 170). Estimates of density, however, are often problematic to carry-out. The difficulties occur in 3 areas. First, many methods are expensive, time consuming, or labor intensive such as Lincoln indices and line-transect surveys (Wellendorf et al. 2004). Second, density estimates are often time or season specific such as covey call-counts. Lastly, some estimators (summer male whistling indices) are an index of fall population density. Clearly, there is a need for a density estimation method that can be applied throughout the year with minimal expenditure of time, expense, and effort.

The efficiency of trained bird dogs in locating bobwhites has received limited attention. Kellogg et al. (1982) found that dogs located on average 40% of the coveys in an area. However, they noted that recreational hunting often takes place on areas where hunters believe they will be most productive at finding birds. Therefore, recreational hunting might reveal a higher percentage of birds than Kellogg et al. (1982) reported. Hardin et al. (2005), using radio-marked bobwhites, reported that recreational hunters with dogs located 56% of the coveys in an area. Bobwhites missed by dogs would negatively bias density estimates. However, this bias can be corrected through the use of line-transect theory (Southwell 1996).

The invention of GPS technology in the 1970s and the increase in accuracy that occurred throughout the 1990s (Garmin 2000) has made it possible to estimate the area searched by a dog if its effective radius is known. Hardin et al. (2005) observed that some areas were searched multiple times by a dog. These redundant areas occurred within a dog’s search pattern and also between search patterns when multiple dogs were
hunted. Redundancy in dog search patterns would create an over estimation of the area hunted and an underestimation of bobwhite density and therefore must be removed.

My objectives were to develop methods to 1) calculate the non-redundant area searched by dogs and 2) estimate bobwhite density by combining line-transect theory with point-to-flush distances (PFD), dog GPS tracks, GIS analysis, and the number of birds flushed during a hunt.

**STUDY AREA**

The Oklahoma and Texas study areas used in Chapter 2 were also used in this portion of the study.

**METHODS**

Estimation of the area searched by dogs required first that the ESW (Burnham et al. 1980) of a dog’s path be estimated. I based this estimate on PFDs, which were measured using a hip chain (Chapter 2). I used program DISTANCE 5.0 (Research Unit for Wildlife Population Assessment, University of St. Andrews, Fife, Scotland) to estimate ESW from PFDs. Distance data were analyzed according to group size: singletons, singletons and pairs, 2–7 birds, and >7 birds. Smaller groups and singletons usually represented fractured coveys that might not have behaved similarly to full coveys. Distance data were pooled over years to increase sample size. I used the half-normal key function with a cosine series expansion (Buckland et al. 1993) to model the detection function (probability of detection given PFD). Tested models contained 1, 2, or 3 parameters and the best model was based on the Akaike Information Criterion adjusted for small sample size ($\text{AIC}_c$; Burnham and Anderson 2002).
The redundant proportion of a single dog’s path \(R_1\) was determined according to
\[
R_1 = \frac{T - A_1}{T}
\]
where
\[
T = \text{straight-line path length (Chapter 2) times 2ESW (area covered by a bird dog if it had moved in a straight line with no redundancy)} \quad \text{and}
\]
\[
A_1 = \text{the area of the actual path of a dog buffered by ESW}.
\]
I described between- and among-dog redundancy using the notation of set theory (Ghahramani 1996). For 2 dogs, proportional redundancy in the area covered \(R_2\) was
\[
R_2 = \frac{A_1 \cap A_2}{A_1 \cup A_2}
\]
where
\[
A_i = \text{the area of the actual path of dog } i \text{ buffered by ESW},
\]
\[
A_1 \cap A_2 = \text{the intersection of the } A_i \text{ or the area covered redundantly by both dogs},
\]
and
\[
A_1 \cup A_2 = \text{the union of the } A_i \text{ or the total area non-redundantly hunted by both dogs (the sum of areas less the intersection)}.
\]
For 3 dogs, proportional redundancy \(R_3\) was
\[
R_3 = \frac{[A_1 \cap A_2 + A_1 \cap A_3 + A_2 \cap A_3 - 2(A_1 \cap A_2 \cap A_3)]}{[A_1 \cup A_2 \cup A_3]}.
\]
The same type of reasoning held for \(>3\) dogs. The redundant area of a dog’s search pattern was estimated using the buffer distance function of ArcView 3.3® and ArcGIS 9.1® (Environmental Systems Research Institute, Redlands, CA, USA) and the estimated ESW (Burnham et al. 1980, Guthery 1988). Redundancy within a dog track and between
dog tracks was analyzed using Pearson’s correlation analysis against the number of dogs hunted and velocity. Redundancy was also analyzed using descriptive statistics.

I used the non-redundant area hunted to estimate the exploration rate (m²/sec) of dogs. The average exploration rate was calculated for each dog on a hunt, as well as for the area hunted by teams of 2, 3, and 4 dogs.

The number of birds flushed during a hunt ($B$) was divided by the area covered during the hunt ($A_1$ for 1 dog, $\bigcup (A_i)$ for $\geq 2$ dogs) to estimate density. Only coveys with $>7$ birds were summed to estimate $B$. This protocol prevented redundant inclusion of birds followed and flushed after the original covey had flushed. I compared density between years.

**RESULTS**

I obtained 155 PFDs over 2 field seasons (Chapter 2). Truncation to coveys of $>7$ birds resulted in 58 distance observations. A $\chi^2$ test for different sets of cut points indicated the detection function was described well ($CV = 9\%, P \geq 0.17$) as a half-normal key function with a cosine series expansion. Effective strip width was estimated at $13.2$ m ($95\%$ CI = 11.1–15.6 m). This result indicated that a bird dog effectively covered a width of $26.4$ m ($95\%$ CI = 22.2–31.2 m). Although I only used coveys flushes with $>7$ birds to estimate density, I estimated the ESWs for different size groups of bobwhites (Figure 3.1). The ESW for single bird and 2–7 bird flushes was $3.9$ m ($95\%$ CI = 2.3–5.5 m) and $7.2$ m ($95\%$ CI = 6.0–8.7 m), respectively. The ESW for pairs and singles combined was $5.09$ m ($95\%$ CI = 4.4–5.9 m).
Figure 3.1. Frequency distributions of point-to-flush distances for different size groups of northern bobwhites in Texas and Oklahoma during the 2005–2006 and 2006–2007 hunting seasons.

Redundancy

During the 2005–2006 season redundancy within a dog’s path averaged 38.4% ± 1.64 SE (n = 57, range = 12.0–69.0%, 95% CI = 35.2–41.6%). Redundancy between dogs, when multiple dogs were hunted, averaged 36.2% ± 1.77 SE (n = 23, range = 22.0–53.0%, 95% CI = 32.5–39.9%). During the 2005–2006 multiple dog hunts consisted of 2 dogs.

Redundancy within a dog’s path for the 2006–2007 season averaged 30.2% ± 0.87 SE (n = 97, range = 9.0–64.0%, 95% CI = 28.5–31.9%). Redundancy between dogs,
when multiple dogs were hunted, averaged 56.7% ± 4.03 SE (n = 32, range = 24.0–98.0%). Multiple dog hunts for 2006–2007 consisted of 2, 3, and 4 dogs. The redundancy between dogs on a 2-dog hunts averaged 37.4% ± 2.14 SE (n = 17, range = 24.0–58.0%, 95% CI = 32.9–41.9%). Redundancy for ≥3-dog hunts averaged 77.3% ± 3.50 SE (n = 15, range = 53.0–98.0%, 95% CI = 68.4–85.6%). A Pearson’s correlation analysis indicated a strong positive relationship (r = 0.85, P < 0.001) between number of dogs hunting and percent redundancy.

A hunt on the Sutter Ranch in western Oklahoma provided an example of redundancy between 2 dogs (Fig. 3.2). This hunt took place between 1553 and 1635 on 1 February 2006. Between-dog redundancy accounted for 32.0% of the area hunted.

Within dog redundancy indicated that for both seasons there was a weak positive relationship (r = 0.13 and r = 0.34 respectively) between the proportion of redundancy within a dog’s path of travel and the average velocity of the dog during the hunt.

**Exploration rate**

During the 2005–2006 season single dogs had a mean exploration rate of 35.0 m²/sec ± 1.63 SE (n = 57, range = 16.5–63.7 m²/sec, CI = 31.8–38.2 m²/sec). The mean exploration rate when 2 dogs were hunting was 49.6 m²/sec ± 3.63 SE (n = 23, range = 24.0–89.3 m²/sec, CI = 42.1–57.1 m²/sec).

During the 2006–2007 season single dogs had a mean exploration rate of 46.7 m²/sec ± 1.37 SE (n = 97, range = 15.7–87.3 m²/sec, CI = 44.1–49.3 m²/sec). The mean exploration rate when 2 dogs were hunting was 62.8 m²/sec ± 3.85 SE (n = 17, range = 42.4–112.3 m²/sec, CI = 54.6–71.0 m²/sec). For hunts with ≥3 dogs, the mean
exploration rate was 87.8 m$^2$/sec ± 2.89 SE ($n = 15$, range = 69.6–113.0 m$^2$/sec, CI = 81.6–94.0 m$^2$/sec).

Figure 3.2. Example of redundancy between 2 dogs while hunting northern bobwhites on Sutter Ranch, Ellis County, Oklahoma, February 2006 as shown through GPS tracks buffered by the effective strip width. Blackened areas indicate areas hunted by both dogs.
Density

Thirty-three density estimates were made during 2005–2006 on 8 study sites. Each site was sampled (hunted) 2–5 times during a 24-hr period. Three sites were sampled on multiple days. The mean density for the hunted areas was 1.4 birds/ha ± 0.28 SE (range = 0.0–7.4 birds/ha, 95% CI = 0.9–2.0 birds/ha).

Forty-six density estimates were made on 10 study sites during the 2006–2007 season. Each study site was sampled 1–8 times during a 24-hr period. Two sites were hunted on multiple days. The mean density for the areas hunted was 0.2 birds/ha ± 0.07 SE (range = 0.0–2.16 birds/ha, 95% CI = 0.1–0.3 birds/ha).

DISCUSSION

One pattern that emerged was ESW decreased as group size decreased (Fig. 2.5). A possible explanation for this pattern is based on a dog’s ability to detect and locate bobwhites. Like people (Syrotuck 1972), bobwhites shed dead skin and feather cells. These cells have bacteria feeding on them. A by-product of the bacteria’s metabolism is the production of scent molecules. These molecules are carried by the wind to the olfactory organs of dogs. However, detecting the presence of scent of a bobwhite cannot be enough to elicit a point or a dog would be able to determine a bobwhite’s presence but not its location (Holloway 1961). There may be a threshold concentration of scent molecules needed to evoke the pointing response. While this threshold is not known, it no doubt varies between breeds and individual dogs. Without knowing this threshold it was still possible to speculate larger coveys were detected and located at greater distances than smaller coveys because they gave off higher concentrations of scent molecules, thus
producing the threshold for the pointing behavior at greater distances then smaller coveys or singles.

In addition to scent concentration in an area as function of the number of birds in a group, ground scent concentration may also be a product of how long a bird or birds has been in an area since it was flushed. Once a bird has flushed it is likely that its scent has become temporarily reduced due to increased air movement over its skin during flight. When a bird lands it takes time for skin to be shed and scent molecules to build up in an area. Thus the ability of a dog to locate a recently flushed bird may be reduced.

**Redundancy**

The mean percent redundancy within a dog’s path decreased from the 2005–2006 season to the 2006–2007 season. One possible explanation for this pattern was the decline in bobwhite population densities from the 2005–2006 season to the 2006–2007 season. The decline corresponded with a decline in all dog behaviors associated with the presence of birds (searching-for-downed birds, pointing, and honoring points) (Table 2.5). These behaviors were associated with flushes and tended to temporarily reduce velocity and distance traveled, therefore concentrating dogs in the area where birds flushed until the behaviors had passed (Fig. 2.1, Fig. 3.2).

Correlation analysis comparing number of dogs hunted simultaneously and the redundancy between dogs indicated a strong positive relationship between the 2 factors. This suggests there is a law of diminishing returns for hunting >1 dogs, at least in terms of locating bobwhites.
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**Exploration rate**

The mean exploration rates of single dogs increased from the 2005–2006 to the 2006–2007 hunting seasons. Like the observed decline in redundancy between the 2 seasons, a possible explanation for this pattern was the decline in bobwhite density. The exploration rate of dogs was estimated based on the non-redundant area hunted. Consequently, events (flushes) or behaviors (searching-for-downed birds and pointing) that caused an increase in redundancy (Fig. 2.1, Fig. 3.2) had the combined effect of reducing a dog’s exploration rate. The mean exploration rates for different size teams of dogs indicated that there is a law of diminishing returns for hunting >1 dog.

**Density**

Bobwhite population densities were not estimated with any other density estimators prior to hunting, so the reliability of my technique cannot be determined through site-specific comparisons. Line-transect theory has several underlying assumptions that must be met to obtain unbiased estimates of density (Burnham et al. 1980). My method would seem to be plausible if it fulfilled those assumptions.

*Assumption 1.* — Animals on the line are detected with certainty. This appears to be a reasonable assumption given the use of bird dogs. Of the 155 flushes that occurred during the study, the shortest PFD was 0.3 m. It seems unlikely a dog could get within such a short distance and not detect a covey.

*Assumption 2.* — Animals are detected at their initial location. The frequency distribution of PFDs (Figure 3.1) indicated this assumption appeared valid because there was an orderly decline in detection probability. If this assumption failed it would result
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in overestimation of ESW resulting in underestimation of bobwhite density (Guthery 1988).

Assumption 3. — Distance measurements are accurate. While experimenter judgment was involved in determining where bobwhites flushed, birds within a covey were usually located in close proximity to each other. Due to this pattern it was possible to use the center of the flush location as representative of the location where the group flushed.

Assumption 4.— Birds are counted once. Counting flushed birds more than once could result in an overestimate of density. To prevent recounting, I based density estimates only on flushes that contained >7 birds. Single bird flushes and coveys consisting of ≤7 birds were not used to estimate density because they often represented coveys that had been previously flushed.

Assumption 5. — Flushing observations are independent. This assumption is necessary to estimate theoretical variance of density. I determined the variance empirically. Therefore, this assumption was not necessary.

Assumption 6. — Probability of detection is independent of group size. If this assumption fails estimates of mean group size and density will be biased (Guthery 1988). The sampling distributions of PFDs of different size groups of bobwhites and estimates of ESWs reported earlier clearly showed the assumption failed (Fig. 3.1). However, I used groups of >7 birds for estimating density, and this protocol satisfied the assumption because there was no effect of group size for >7 birds.
Assumption 7. — The creation of transect lines does not influence the distribution of bobwhites. This assumption does not apply because no alterations were made to areas where bird dogs hunted.

Additionally, the use of GPS made it possible to measure the length of a dog’s path. Thus, an additional assumption for this research was that the length of a dog’s path was accurately measured. The Foretrex 201s used to measure the length of a dog’s path apparently were biased (Chapter 1). However, the bias manifested as a translocation of a dog’s path on the Cartesian plane and this should not affect accuracy in determining length of the path traveled (Fig. 1.1). The Foretrex units also were inaccurate (Chapter 1). This problem would tend to resolve itself because the inaccuracy for 1 location would be small relative to the total path of a dog. Thus, the assumptions underlying my density estimator seemed to hold, at least approximately.

Another evaluation of the plausibility of this methodology was the densities estimated. Density estimates ranged from 0.0–7.4 birds/ha with an average density of 1.4 birds/ha during the first season and 0.2 birds/ha in the second. Thus, there was an 85.7% decline in bobwhite densities on the regions sampled. The majority of density estimates were made on areas in the Northwest region of Oklahoma. The Oklahoma Department of Wildlife Conservation 2006 roadside index indicated that bobwhite populations in the Northwest region declined 83% from 2005–2006 to 2006–2007 (D. Schoeling, Oklahoma Department of Wildlife Conservation, unpublished data). Additionally, the GPS based line-transect method for estimating bobwhite densities generated plausible bobwhite densities compared to those reported by Guthery (1988).
MANAGEMENT IMPLICATIONS

Estimating bobwhite density with a pooling of technology (GIS, GPS), line-transect theory, and recreational hunting with bird dogs potentially has broad management implications. Of course, the method needs considerable testing and refining before it can be accepted as a valid estimator. If the method proves reliable it will provide an inexpensive method of estimating bobwhite populations for research and management. An example application in harvest management involves taking a bobwhite population down to a predetermined breeding population objective to maximize sustainable harvest (Guthery 2002).

Additionally, this methodology is not bobwhite specific and could be applied to other species. Whether or not this estimator is appropriate to the desired target species will depend on their social structure and response to pointing dogs. Species that form relatively stable, seasonal social groups and will hold (remain stationary) for pointing dogs are candidates for this technique. As with all density estimation techniques, the researcher must have sufficient knowledge about the area where the estimate is conducted and the characteristic of the species being censused.
LITERATURE CITED


Mecozzi


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Management 68:672–683.

Survey, Reston, Virginia, USA.
Grant Mecozzi
008C Ag. Hall
Oklahoma State University
Stillwater, OK 74078

Dear Quail Hunter:

Thank you for your voluntary participation in this project studying the behaviors of hunters and bird dogs. This study is sponsored by Oklahoma State University. Through this study we hope to gain valuable insights about the complex set of behaviors that makeup quail hunting. These insights may serve to improve quail management and restoration techniques.

If you choose to participate in the research project you and your dog(s) will be fitted with Garmin Foretrex 201® GPS units and asked to carry them out in the field while hunting. Please return the units at the end of your hunt. In addition, a member of the research team will be accompanying you on your hunt. The researcher will be fitted with a hand held audio recording device and will record the behaviors of both you and your dog(s) in 60-second intervals. The behaviors we are interested in are those associated with quail hunting. Any behavior not specific to quail hunting will be recorded as, “other”.

Participation in this project is purely voluntary. This project is designed to maintain your anonymity and therefore no identification will be linked to either the GPS or the behavioral sampling data. There are no known risks with this project which are greater than those ordinarily encountered in daily life. If at anytime you feel any apprehension you are free to withdraw your participation with no penalty.

The results of the behavioral sampling and GPS units will be used to further advance knowledge about quail and quail hunting. Access to the data will be restricted to the members of the research team. Analyses of this data will be published in a Masters thesis and scientific journals but your anonymity will be maintained. The Oklahoma State University IRB has the authority to inspect consent records and data files to assure compliance with approved procedures.

If you have any questions or would like a summary of this report you may contact me at the address provided. For information on subjects’ rights, contact Dr. Sue C. Jacobs, IRB Chair, 415 Whitehurst Hall, 405-744-1676.

I have read and fully understood the consent form. I sign it freely and voluntarily. A copy of this form has been given to me.

Signature of Participant ____________________ Date ____________________

I certify that I have personally explained this document before requesting that the participant sign it.

Signature of Researcher ____________________ Date ____________________
APPENDIX B. Institutional Review Board Permit

Oklahoma State University Institutional Review Board

Date: Wednesday, July 19, 2006
IRB Application No: AS0618
Proposal Title: Northern Bobwhite Hunting: Behavior of Hunters and Dogs

Reviewed and Processed as: Exempt
Continuation

Status Recommended by Reviewer(s): Approved

Principal Investigator(s):
Grant E. Mecozzi
103 N. Univ. Place, Apt. 1C
Stillwater, OK 74075

Joshua Lee Richardson
2323 Country Side Dr.
Stillwater, OK 74074

Fred S. Guthery
303F Ag Hall
Stillwater, OK 74078

Approvals are valid for one calendar year, after which time a request for continuation must be submitted. Any modifications to the research project approved by the IRB must be submitted for approval with the advisor's signature. The IRB office MUST be notified in writing when a project is complete. Approved projects are subject to monitoring by the IRB. Expedited and exempt projects may be reviewed by the full Institutional Review Board.

The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

Signature: [Signature]
Sue C. Jacobs, Chair, Institutional Review Board

Wednesday, July 19, 2006
Date
APPENDIX C. Hunts of Pen-Reared Birds

During the 2005–2006 season I collected data on 4 guided hunts with pen-raised bobwhites. The same methods used for data collection and data analysis on hunts with wild birds were implemented. Data were collected in Marland, Oklahoma, on 16 January 2006. Sites were highly modified grassland habitat with mowed strips for ease of access. Bobwhites were placed prior to the hunt by the guide. Bobwhite placement was in tall-grass areas adjacent to mowed strips. The average duration for a hunt was 43 min ± 1.58 SE (range = 39.0–46.0 min).

The first characteristic of hunts with pen-raised birds that was markedly different from hunts with wild bids was the number of flushes that occurred. The 4 hunts generated 64 flushes. In comparison, the 93 hunts with wild birds generated 155 flushes. The flush/time hunted ratio was therefore much higher on hunts with pen-reared birds. An average flush consisted of 1.4 birds ± 0.10 SE (range 1.0–5.0). The average PFD was 0.9 m ± 0.10 SE (range = 0.3–6.1 m). In comparison, the average PFD for wild bird flushes during the 2005–2006 season was 5.6 m ± 0.47 SE. Hunters shot on average 1.1 ± 0.06 SE birds/flush (range = 0.0–2.0) and averaged 0.76 ± 0.06 SE shots/hunter/flush (range = 0.0–2.0).

Small sample size (n = 8) made it difficult to compare dog movement of guided hunts with pen-raised bobwhites to wild bird hunts. Additionally, GPS error precluded these hunts from being analyzed for distance between dogs and hunters. Again, this was due to non-adherence to the 7-sec recording interval.

Average distance traveled during a hunt was 4,354.6 m ± 143.8 SE (n = 8, range = 3,996.9–5,257.9 m). The average velocity of a dog during a hunt was 2.2 m/sec ± 0.11
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SE \( (n = 8, \text{ range } = 1.8–2.7 \text{ m/sec}) \). Redundancy within a dog’s path and between 2 dogs was 55.4\% \pm 1.6 \text{ SE} \( (n = 8, \text{ range } = 47.0–61.0\%) \) and 55.3\% \pm 5.5 \text{ SE} \( (n = 4, \text{ range } = 46.0–71.0\%) \).

Both hunter and dog behavior (Table C.1, Table C.2) indicated behavior on pen-raised hunts were different than those on wild bird hunts (Table 2.4, Table 2.5).

### Table C. 1. Activity budget of dog behaviors while hunting pen-raised northern bobwhites in Marland, Oklahoma, January 2006 \( (n = 8) \).

<table>
<thead>
<tr>
<th>Behavior (%)</th>
<th>( \bar{x} )</th>
<th>SE</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ranging</td>
<td>24.0</td>
<td>3.00</td>
<td>13.0–36.0</td>
</tr>
<tr>
<td>Investigation</td>
<td>21.4</td>
<td>1.48</td>
<td>4.4–17.4</td>
</tr>
<tr>
<td>Searching for downed birds</td>
<td>21.2</td>
<td>1.30</td>
<td>17.8–36.2</td>
</tr>
<tr>
<td>Pointing</td>
<td>14.9</td>
<td>2.13</td>
<td>7.1–23.1</td>
</tr>
<tr>
<td>Honoring point</td>
<td>14.4</td>
<td>2.90</td>
<td>2.4–23.1</td>
</tr>
<tr>
<td>Hunting for live singles</td>
<td>5.3</td>
<td>1.80</td>
<td>0.0–13.0</td>
</tr>
<tr>
<td>Other</td>
<td>5.1</td>
<td>1.38</td>
<td>2.2–11.9</td>
</tr>
<tr>
<td>False point</td>
<td>2.7</td>
<td>1.21</td>
<td>0.0–10.3</td>
</tr>
<tr>
<td>Watering</td>
<td>1.9</td>
<td>1.95</td>
<td>0.0–4.8</td>
</tr>
<tr>
<td>Being tended</td>
<td>0.0</td>
<td>0.00</td>
<td>na</td>
</tr>
<tr>
<td>Out of sight</td>
<td>0.3</td>
<td>0.30</td>
<td>0.0–2.4</td>
</tr>
</tbody>
</table>

The obvious difference in dog behavior was a more even distribution of the proportion of time spent in ranging, investigation, and searching for downed birds. Hunters, on the other hand, showed an increase in the proportion of a hunt spent approaching points.

### Table C. 2. Activity budget of hunter behaviors while hunting pen-raised northern bobwhites in Marland, Oklahoma, January 2006 \( (n = 3) \).

<table>
<thead>
<tr>
<th>Behavior (%)</th>
<th>( \bar{x} )</th>
<th>SE</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking</td>
<td>30.6</td>
<td>4.69</td>
<td>20.5–42.2</td>
</tr>
<tr>
<td>Approaching point</td>
<td>42.0</td>
<td>6.75</td>
<td>32.6–61.5</td>
</tr>
<tr>
<td>Other</td>
<td>12.2</td>
<td>3.13</td>
<td>7.7–21.4</td>
</tr>
<tr>
<td>Hunting for live singles</td>
<td>7.8</td>
<td>3.36</td>
<td>0.0–15.2</td>
</tr>
<tr>
<td>Searching for downed birds</td>
<td>7.5</td>
<td>3.33</td>
<td>0.0–15.2</td>
</tr>
<tr>
<td>Resting</td>
<td>0.0</td>
<td>0.00</td>
<td>na</td>
</tr>
<tr>
<td>Tending dog</td>
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differences in mean percentage of time spent in each behavior were an obvious function of the increase in number of birds encountered on a hunt.

As with wild hunts, behaviors and movements on pen-raised hunts were closely tied with the presence or absence of bobwhites. While pen-raised, guided bobwhite hunts preserve the aesthetics of wild-bobwhite hunts, beyond the superficial they are only remotely similar. For example, both distance traveled and duration were indicators that a great deal of the variability found in wild bobwhite hunts had been removed. Following this homogeneous trend was the presence of birds.

While hunts using pen-raised birds are not a true substitute for wild-bird hunts, they provide several benefits to sportsman. First, they help to preserve the traditions of quail hunting. The initial cost and level of expertise needed to train bird dogs is a deterrent that makes recruitment into the sport difficult. Second, pen-raised birds can be used to supplement hunting when populations are low. They also keep dog and hunter interested and in shape for next season. Lastly, with the ever-increasing human population and urban sprawl, the large, rural tracts of quality habitat required to hunt quail may be out of the budget for many quail hunters. If suitable public land is not readily accessible, a guided hunt where birds are guaranteed may be preferable to traveling several hours to hunt an area that has elevated hunting pressure.
VITA

Grant Elliot Mecozzi

Candidate for the degree of

Master of Science

Thesis: NORTHERN BOBWHITE HUNTING: BEHAVIOR OF HUNTERS AND DOGS

Major Field: Wildlife and Fisheries Ecology

Biographical:

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Candidate for the Degree of Master of Science

Major Field: Wildlife and Fisheries Ecology

Scope and Method of Study: I collected Global Positioning System (GPS) track logs and recorded behavioral observations on 93 northern bobwhite (Colinus virginianus) hunts in Oklahoma, Texas, and Missouri during the 2005–2006 and 2006–2007 hunting seasons to obtain 1) descriptions of hunter and dog behaviors and 2) empirical data for the hunter-covey interface (HCI) models. I also developed a method of estimating bobwhite population density using GPS, Geographic Information System (GIS) technology, and line-transect theory during recreational hunts with bird dogs.

Findings and Conclusions: Most of a dog’s time during a hunt was spent searching for bobwhites (50.5% ± 2.15 SE and 82.0% ± 1.26 SE during 2005–2006 and 2006–2007 respectively). There was a negative relationship between mean dog velocity and flushes/km for both seasons ($r = -0.40$, $P = 0.002$ and $r = -0.20$, $P = 0.04$, respectively). Hunter velocity was consistent with a mean of 0.8 m/sec ± 0.03 SE for both seasons. The 2005–2006 data indicated an average flush consisted of 6.7 birds ± 0.62 SE. During the 2006–2007 season an average flush consisted of 5.9 birds ± 0.84 SE. With regards to the HCI models, the empirical data collected can be used in planning and managing hunting under the HCI model. Density estimates using bird dogs indicated during the 2005–2006 hunting season, average bobwhite density was 1.4 birds/ha ± 0.28 SE ($n = 33$). Density declined to 0.2 birds/ha ± 0.07 SE during 2006–2007 ($n = 46$). The technique of estimating bobwhite density with bird dogs needs further testing and development, but it might prove useful in research and management.

ADVISER’S APPROVAL: Fred S. Guthery