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Progress Report

THE INFLUENCE OF HABITAT VARIABLES ON PRONGHORN RECRUITMENT

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STATEWIDE WILDLIFE RESEARCH

STATE: Idaho
JOB TITLE: Pronghorn Recruitment at the Population Scale
STUDY NAME: Pronghorn Recruitment vs. Habitat Variables
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THE INFLUENCE OF HABITAT VARIABLES ON PRONGHORN RECRUITMENT

Abstract

This project is comprised of 2 sub-investigations. The population scale analysis explores the relationship between site-specific habitat variables and pronghorn recruitment rate as assessed through pre-harvest fawn:doe ratios. The variables addressed in this analysis include the frequency of spring weather events which may lead to fawn death due to exposure, nutritional indices measured throughout the lactation season, and relative coyote densities assessed during the peak of fawn vulnerability. The broad scale analysis uses a rich historic dataset gathered by Wyoming Game and Fish with further analysis in the state of Idaho to relate population productivity (fawn:doe) to coarse scale habitat variables.

Subproject I: Population Scale Analysis

Background

Wildlife managers throughout the state of Idaho are observing falling pronghorn numbers. Estimated abundance for Idaho's pronghorn population has decreased from 23,500 in 1984 to 12,000 in 1997 (Yoakum and O'Gara 2000). Despite a recent marked reduction in harvest pressure, many pronghorn populations are not showing signs of rebound. In order to effectively manage pronghorn, biologists must have an understanding of the factors regulating population size and growth. A classic density-dependent relationship suggests that as populations decrease, growth rate increases with more per capita resources becoming available. Given that populations have not shown signs of recovery, a closer look into population regulation is warranted.

One symptom of declining populations is poor recruitment, as defined by the incorporation of new individuals into the reproductive age class. Despite the fact that the overall population trend for pronghorn in the state of Idaho is downward, managers are observing great variability in local recruitment rates assessed through pre-harvest composition counts, suggesting some populations are growing. We use pre-harvest fawn:doe ratios as our measure of recruitment as: 1) fawn:doe ratios are a sensitive measure of population response, while precise measures of abundance in low-density habitats are extremely difficult to obtain (Whittaker et al. 2003) and 2) fawns surviving to weaning realize a survival rate similar to adults with the exception of severe winters (Byers 1997). The use of fawn:doe ratios is inherently limited in that it is a function of both fecundity and survival. We make the assumption that fecundity, 'the potential level of reproductive performance' (Johnson 1996), is equal across all populations within the study. In pronghorn, most females first come into estrus at 18 months. Of those few individuals that come into estrus at 6 months, fawn survival is very poor and will likely not influence recruitment. Further, we make the assumption that pregnancy rate is similar across all habitats and the difference in fawn:mature doe ratios observed in August is solely a function of survival from the time of conception to pre-harvest counts. We feel the assumption of equal pregnancy rate is valid given the number of reports identifying a consistent and high pregnancy rate in pronghorn. At the National Bison Range, Byers (1997:6) observed 100% conception in females at the age of 18 months with a near 100% twinning rate. Larsen (1964, 1965, 1966) observed consistently high ratios of fetuses:mature does over areas which support both high and low fawn recruitment.

Research at a fine spatial scale has identified a number of factors that influence pronghorn recruitment. The goal of this study is to build upon previous fine-scale research to explore relationships at the population scale between lactation season environmental variables and recruitment. Representing the breadth of both habitat and recruitment, 5 pronghorn populations have been selected in Idaho: Eastern Owyhee, Camas Prairie, Little Wood Basin, Pahsimeroi/Little Lost Valley, and Lemhi/Birch Creek Valley. Within these areas, we will be monitoring temporally- and spatially-specific environmental variables that we feel (based on previous fine-scale studies) may influence recruitment.

<u>Complementary/competing hypotheses which influence pronghorn fawn recruitment throughout the state of Idaho</u>:

Hypothesis 1: Weather/climate factors influence fawn:doe ratios.

Hypothesis 2: Pronghorn are energetically constrained by the quality and quantity of forage, contributing to low recruitment.

Hypothesis 3: Survival of pronghorn fawns is limited by predation.

1. Weather/Climate factors influence fawn:doe ratios.

Climatic variables and weather events have been documented to impact recruitment by altering pregnancy rate during years of severe winter. Barrett (1984:549) summarizes a number of factors influencing pronghorn populations in his statement, "Severe winters appear to be one of the primary factors controlling pronghorn numbers in Alberta. Periodic large die-offs in winter reduce population density to levels where density-dependent mortality has no consistent impact on a provincial basis. Predation on fawns may limit recruitment and retard population recovery but it does not regulate population size." The energetic stresses of severe winters can lead to fetal mummification. Of the 82 fetuses examined by Barrett (1982:998) from mature females killed by starvation and exposure during a severe winter, only 14 were normal; the remaining 68 showed signs of desiccation and reduction in soft tissue. Similarly Martinka (1967:164) observed a reduction in fall fawn:doe ratios from 90-110 in typical years to 39 in the fall following a severe winter in Montana. Similar factors may contribute to population dynamics throughout Idaho.

Additionally, spring weather conditions on the western grasslands of North America are unpredictable. Snow or freezing rain are not uncommon in the months of May and early June. The small body size of fawns during this timeframe leaves them susceptible to death due to exposure as ambient temperatures approach the freezing point.

2. Pronghorn are energetically constrained by the quality and quantity of forage, contributing to low recruitment.

Pronghorn may be energetically stressed several times during the year which may influence recruitment. The size and viability of offspring is related to the nutritional status of pregnant females in a number of herbivores (Ellis 1970:25). Following parturition, females face the high energy demands of lactation. Variable summer rains may influence forage production and, thus, energy available for lactating mothers and fawns, perhaps influencing fawn survival. Additionally, the conversion of native range to exotic annuals, unpalatable during portions of the year, may further reduce energy available for milk production.

3. Survival of pronghorn fawns is limited by predation.

Predation has been documented as a significant cause of fawn mortality in a number of studies (Barrett 1984, Trainer et al. 1983, Byers 1997, Gregg et al. 2001). Barrett (1984) observed 67.5% of fawn mortalities within the first 3 months of life to be related to predation, a large majority of which were the result of coyotes. In a similar study conducted by Gregg et al. (2001), of the 87 fawn mortality events observed at Hart Mountain through the summers of 1996 and 1997, 86% were due to predation. The majority of mortality events occurred within the first week of life and 95% of the observed mortality events occurred within the first 18 days. In western Utah, Beale and Smith (1973) report of the 44 radio-marked carcasses retrieved, 27 were the victims of predation (largely caused by bobcat), 5 lost to disease, 4 to starvation, 1 to injury, and 5 unknown. Byers (1997) states, “With few exceptions, the cause of fawn mortality is predation by coyotes and to some extent by golden eagles” (Byers 1997:167-168).

Corroborative evidence for a strong predation influence can be gathered from a number of management programs and controlled studies that have realized an increase in fawn recruitment associated with coyote and other predator removal (Ellis 1970, Byers 1997:52). In Arizona, biologists observed dramatic increases associated with predator control with fawn:doe ratios of 0.04 fawns:doe in uncontrolled areas relative to 0.52 fawns:doe in controlled areas.

While high mortality rates associated with predation are often observed in pronghorn, it remains unknown whether predation is truly the ultimate or rather the proximal cause of death. The low abundance of pronghorn throughout the study areas and the ‘speed refuge’ enjoyed by adults suggests that coyotes and other predator populations are limited by other prey sources and feed upon vulnerable fawns opportunistically (Ellis 1970:24). Such prey-switching has been observed with mule deer fawns, such that when alternative food items are less available, coyotes take a greater portion of fawns (Ellis 1970:24, Hamlin et al. 1984). While the common cause of death, predation may work in concert with other habitat variables, predisposing some populations to high predation rates (Ellis 1970).

Objective

The objective of this study is to evaluate the influence of environmental variables on pronghorn recruitment as observed through pre-harvest fawn:doe ratios at the spatial scale of the population. Relative to this measure of population productivity, we will assess:

1. Frequency of spring weather events which may lead to fawn death due to exposure.

2. Forage quality throughout the lactation season.

3. Relative coyote densities within the Camas Prairie and Eastern Owyhee study areas.

Methods

Weather Events

Cold or inclement weather may have a negative effect on fawn survival, as death due to exposure for a small-bodied ungulate is a realistic mortality risk, particularly within the first 2 weeks of life. Therefore, using nearest possible weather stations, we assessed the frequency of days between 15 May and 15 June with minimum temperatures falling below 2ºC (Ellis 1970).

Relative Coyote Densities

Predator scat transects were conducted within the Eastern Owyhee and Camas Prairie study areas in both 2003 and 2004. Scat transects coincided with the 2-week post-parturition period in which pronghorn fawns are most vulnerable to coyote predation. Using the system of roads, 25 half-mile transects were randomly identified in each site in 2003, and in 2004, 25 half-mile transects were conducted in Eastern Owyhee and 30 half-mile transects were surveyed in Camas Prairie. Roads were walked on foot in both directions removing all scat or objects that could be mistaken for scat. Transects were revisited 7-8 days later enumerating the scat of coyote, red fox, and other predators.

Forage Quality

Fresh fecal samples were collected from groups of pronghorn throughout the lactation season. In the field, groups were identified largely from the road. Using spotting scopes and binoculars, a group would be monitored until a defecation event was observed, at which time, using 2-way radios, an individual remaining at the road would direct a second observer to the defecation site. In appropriate topographical settings, bedded groups would be approached on foot to hasten the defecation process. Each study site was visited during a 2-week period. An effort was made to spatially segregate groups from which scats were collected so as to obtain a representative sample from the entire population and avoid re-sampling the same group. Groups were potentially re-sampled in subsequent 2-week intervals. Using a latex glove, scat piles were deposited in paper bags in 2003 and resealable bags in 2004. In the event that more than a single scat was located from a group site, additional scats were bagged independently and homogenized in the laboratory. All samples were frozen upon returning from the field. Samples were kept frozen until drying. All scats were transferred to paper bags and dried in a drying oven at 40ºC for 2 days or until dry. Scats were then ground using a home coffee grinder. Samples were sent to Washington State University's Wildlife Habitat Lab for fecal nitrogen and 2, 6 diaminopimelic acid (DAPA) analysis. These 2 measures provide an index of forage quality and energy intake, and have been applied previously to pronghorn to characterize nutritional plane (fecal nitrogen, Robinson et al. *unpublished*; and DAPA, Robinson et al. *unpublished*, Dennehy 2001). Scat was collected from Eastern Owyhee and Camas Prairie in 2003 and from Eastern Owyhee, Camas Prairie, Little Wood Basin, Pahsimeroi/Little Wood Valley, and Lemhi/Birch Creek Valley in 2004.

Statistical Analysis

For the weather and coyote data, we evaluated differences between sites using the day and the transect as the replicate. Following between site comparisons, we used linear regression to evaluate the influence of these variables on fawn:doe ratios.

For fecal analysis, we used a MANOVA to evaluate what the influence site and date have on the measures of nutrition (FN and DAPA). Combining all data and correcting for site, we developed a model depicting change in nutritional measures over the lactation season. We were then able to estimate the average nutritional plane for each site, correcting for bias in date of sampling. We then used these values in linear regression to evaluate the influence of nutritional plane on recruitment rate.

Current Progress

Composition Surveys

For flights conducted in 2003, the range of fawn:doe ratios was from 33:100 in the Lemhi/Birch Creek population to 76:100 in the Camas Prairie population (Table 1). A chi-squared test of recruitment rates indicates significant deviance from uniformity (X^2 value = 33.82, P value < 0.0001, df = 5).

Weather Events and Coyote Transects

As might be expected, the high plains have a much more severe climate in both winter and spring than the lower deserts of Idaho. Frequency of potentially lethal spring temperature has failed to indicate a strong pattern. Similarly, coyote transects conducted within Eastern Owyhee and Camas Prairie are inconclusive, showing little difference in relative coyote densities (Table 2).

The laboratory analysis component for scats collected from 2003 is nearing completion. Results from the fecal nitrogen measure have shown profound differences and resolution. Scats collected during summer 2004 are undergoing preparation for analysis (drying and grinding). These samples will be sent out for processing in the near future.

As an exploratory analysis, a 2-way ANOVA was conducted with variables site (Camas Prairie or Eastern Owyhee), rotation (1-4), and the interaction of site and rotation (site*rotation). The interaction term was significant (p-value < 0.1); therefore, the most complex model was used throughout. The complete model represents a significant improvement over the null model (F = 41.66, p-value <0.0001). Results by site and time are summarized in Figure 1 and Table 3. Comparing our limited results to captive feeding trials suggests extreme differences in nutritional plane are realized between the Eastern Owyhee and Camas Prairie populations. In Robinson et al.'s (*unpublished*) captive feeding trials, individuals fed at the 100% ad libitum level had a mean fecal nitrogen value of 2.82 over three 2-week repetitions. The Camas Prairie population realized greater fecal nitrogen scores than this 100% feeding level throughout the lactation season. Alternatively, pronghorn limited to a 50% ad libitum diet in Robinson et al.'s (*unpublished*) study had an average fecal nitrogen score of 2.29 which is greater than that observed for the Eastern Owyhee population throughout the lactation season. While Robinson et al. (*unpublished*) provide the caveat that results are preliminary and require additional laboratory testing, comparisons to their results strongly suggest that the Camas Prairie and Eastern Owyhee populations are experiencing dramatic differences in nutritional plane which may influence population productivity.

Subproject 2: Broad Scale Analysis

Background

Habitat variables may influence population processes at different scales. Building on a foundation of fine-scale research and questions addressed at the population scale, we will explore relationships between broad-scale patterns of pronghorn recruitment and landscape heterogeneity. To investigate these relationships, we will evaluate recruitment rate (fawn:doe) as observed in pre-harvest composition surveys collected throughout Idaho and Wyoming against a number of habitat characteristics deemed influential to productivity based on fine-scale results. We will use principle components analysis to consolidate correlated variables. Two models will be developed. The first will correlate average reproductive rates for a given site (herd unit/GMU) against average environmental conditions (i.e., average annual precipitation). The second model will regress fawn:doe ratios against temporally explicit variables (i.e., 1999 precipitation, number of days between 15 May and 15 June with lows below 2ºC). The goal of this study is to evaluate the influence of summer range habitat variables on pronghorn recruitment as assessed through pre-harvest fawn:doe ratios. Identifying key habitat variables, we hope to develop a predictive model for population level response to a suite of habitat characteristics which can be applied to management action.

Objectives

1. Using the extensive dataset available from pronghorn monitoring in the state of Wyoming, evaluate a broad suite of habitat variables assessed at the herd unit level, believed to influence population growth based on fine-scale studies.

2. Develop a simplified model relating influential habitat variables to recruitment rate. Evaluate this model against the limited pronghorn monitoring data available for the state of Idaho.

Methods

Study Area

We assessed the relationship of pronghorn recruitment rate to site-specific habitat variables throughout pronghorn range within the state of Wyoming. Populations within national parks are excluded as these herds are not managed or monitored by the Wyoming Game and Fish Department. We limited our analysis to the summer range of pronghorn, delineated by local managers as the habitat used between March and August.

Unlike Wyoming, pronghorn in Idaho inhabit only a portion of the state. Data is available from the Lemhi/Birch Creek Valley in the northeast to the Eastern Owyhee desert in the south-central portion of the state.

Pronghorn Data

Wyoming Game and Fish use routine composition surveys as part of their pronghorn monitoring program. Low elevation fixed-wing flights are conducted, post-weaning and prior to the start of hunting season. Survey data from 1978-2001 has been compiled and published by Wyoming Game and Fish (Reeve et al. 2003). A mix of data is available from the state of Idaho. A recent increase in survey effort is represented by consistent composition surveys conducted over multiple populations for the past 2 years. Mixed topography and smaller disjunct populations requiring a higher sampling intensity necessitate the use of a helicopter for these surveys.

Of the extensive data available from Wyoming's pronghorn monitoring program, we selected pre-harvest fawn:doe ratios as the best measure of population recruitment. We prefer this measure as the data: 1) provides a more consistent measure than annual population change which is sensitive to yearly variation in animal movement producing biologically unreasonable growth rates, 2) more immediately addresses the question of population response, un-confounded by shifting harvest pressure, and 3) allows comparison with data available from the state of Idaho.

Habitat Data

Spatial datasets were used to depict average habitat conditions experienced by pronghorn populations in a given year. GIS habitat layers evaluated include:

- Land cover
- Net primary productivity
- Average annual precipitation
- Average growing season precipitation
- Geological nutrient availability
- Soil type
- Fence density
- Average number of days with minimum temperatures below 2ºC from 15 May to 15 June
- Coarse measure of coyote density between grassland and sage steppe.

A number of these layers are also considered on an annual basis for the temporally explicit model:

- Land cover
- Annual precipitation
- Growing season precipitation
- Geological nutrient availability
- Soil type
- Fence density
- Number of days with minimum temperatures below 2ºC from 15 May to 15 June
- Coarse measure of coyote density between grassland and sage steppe.

Statistical Methods

Using habitat characteristics within summer range, principle factor analysis was used to reduce the number of independent variables. We then used multiple regression to evaluate the influence of these principle factors on fawn:doe ratios. Models were selected with AIC.

Current Progress

Currently, we are working with individuals in Wyoming to prepare spatial data layers for analysis.

EVALUATION OF DOUBLE OBSERVERS WITHIN PRONGHORN LINE TRANSECT SURVEYS

Effective management of a species frequently requires an understanding of population size and the rate of population change. Line transect methodology has proven to be an effective means for density estimation in a number of species such as pronghorn (Johnson et al. 1991). The accuracy of estimates generated by this procedure are dependent upon the ability of the field protocols to meet 3 critical assumptions listed in order of importance: 1) objects directly on the line are always detected, 2) objects are detected at their initial location prior to response to the observer, and 3) distance to objects are measured accurately (Buckland et al. 2001). These assumptions have been simplified for application to pronghorn surveys from an aerial platform. Rather than accurately measuring the distance off the line of detected pronghorn clusters, groups are placed into 4 broad distance bands (A-D) representing distance classes from the line given the height above ground level (AGL). Field protocols thus require all clusters to be detected within the first distance band (A) rather than simply on the line. Anecdotally, pronghorn typically do not respond to the aircraft, run after the aircraft has passed overhead, or run parallel to the flight path.

Pronghorn are an ideal species for line transect population monitoring conducted from an aerial platform given that they largely occupy open country and sightability is greatly influenced by distance from aircraft. However, comparisons of population estimates generated from fixed-wing line transect surveys (Guenzel 1997) and helicopter quadrat surveys (Pojar et al. 1995) suggest line transect surveys are biased low (Pojar and Guenzel 1999). The prevalence of a low bias indicates that survey conditions prevent all of the critical assumptions from being met. While standard survey protocols (Guenzel 1997) require the observer to detect all individuals within the nearest distance band, surveying from an aerial platform is a dynamic activity with a number of external factors potentially contributing to the violation of this assumption. First, fixed-wing aircraft travel at a high rate of speed such that groups must be identified, counted, and placed into the appropriate distance band within a short period of time. This sequence of actions requires the observer to divert attention away from guarding the line and direct it toward the detected group; such that, the mental processing of groups detected in outer distance bands may lead to violations of the first assumption as groups in the near distance bands go undetected. Second, observers develop a search image to detect the object of interest. For example, in pronghorn surveys, the observer may cue to the contrast of the white rump and underbelly to the light brown coat or vegetated background. Different body postures of individuals relative to the passing aircraft may distort the search image (i.e., bedded pronghorn conceal white rump and underbelly) and lead to the failure of detection. Third, landscapes encountered during typical surveys differ in both complexity and spectral reflectance. The color signature of a pronghorn may be more pronounced against some backgrounds, and complex landscapes pose more opportunities to conceal individuals. Additionally, survey protocol requires flights early and late in the day when the observers may have to contend with low sun angles limiting optimal viewing. Finally, due to the configuration of the seats, struts, and windows within the aircraft, objects falling in near distance bands are within the viewable area for a shorter duration than objects falling in outer distance bands. These external factors as well as observer variability/fatigue may contribute to groups close to the line going undetected.

While it may be reasonable to assume for highly visible animals (such as pronghorn) that all clusters on the line are detected, missed individuals will cause a proportional bias in population estimates. Recent work in line transect theory has sought to incorporate additional explanatory variables beyond perpendicular distance to remove the limiting assumption of a known probability of detection at a given distance (Quang and Becker 1996, Borchers et al. 1998). If detection on the line is not certain, bias can be removed by modeling probability of detection or sightability (Borchers et al. 1998). A methodology using paired observers has proven to be successful in evaluating the assumption of 100% detection on the line while allowing for the incorporation of additional covariates into the probability of detection model. Paired observer methods have been successfully applied to a number of taxa (polar bears, Manly et al. 1996; Pacific and common loons, Quang and Becker 1996; Antarctic minke whales, Borchers et al. 1998; marbled murrelets, Mack et al. 2002; and song birds, Kissling and Garton, in press) producing improved population estimates over those generated from traditional distance sampling.

When Johnson et al. (1991) first presented a protocol for pronghorn population monitoring, they asserted that if the key assumptions could be met, then line transect sampling would provide a valid method for population estimation. By applying a double observer approach to their established pronghorn survey protocol, this experiment provides a rigorous test of the assumption that all clusters are detected within the nearest distance band. Additional group characteristic data collected allows us to evaluate the influence of variables beyond distance band believed to influence the probability of detection such as cluster size, activity class (bedded, standing, running), survey site, above ground level, and seat position.

Objectives

1. Evaluate the feasibility of paired observer flights as a means of surveying pronghorn and enumerating clusters as detected or missed by each observer independently.

2. Using this binary data, assess violations of absolute detection for groups on the line.

3. Estimate herd densities using traditional distance analysis methods.

4. Compare these density estimates to those derived from alternative analysis techniques designed to relax the assumption of absolute detection on the line while incorporating other variables believed to influence sightability.

Data Collection

Study Area

Flights were conducted on 16-17 June 2004 within the seasonal timeframe of maximal dispersion and highest uniformity in group size of pronghorn. Flights in Lincoln County north of the town of Kemmerer, Wyoming, were conducted in the general area of 41º 32' – 42º 58' latitude and 109º 46' – 110º 35' longitude. Flights in Sublette County west of the town of Pinedale, Wyoming, were conducted in the general area of 109º 50' – 110º 23' longitude and 42º 10' – 43º 11'. Transect lines were spaced at 3-minute intervals to provide adequate coverage of the study area while avoiding the possibility of detecting the same group in adjacent transects. Transects were oriented both east-west and north-south in order to capture the breadth of lighting conditions encountered during typical survey conditions.

Field Methods

Fixed-wing line transects were conducted in accordance with the protocol described in Johnson et al. (1991) with refinements detailed in Guenzel (1997). All transects were conducted in a Maule 5 aircraft with window and door modifications to increase visibility with observers' experience in pronghorn line transect surveys. A global positioning system (GPS) was used for transect and ferry navigation. With the assistance of a radar altimeter, the pilot attempted to maintain a constant AGL of 91.5 m. By aligning black tape on the window with dowel rods fitted to the dual strut of the aircraft, observers could consistently delineate the geographic center of detected groups to 1 of 4 distance bands. Important alterations to the established methodology include: 1) both observers were seated on the right side of the aircraft, 2) the activity class (bedded, standing, or running) of each group detected was recorded, and 3) whether the group was detected by the front, rear, or both observers was recorded. In typical pronghorn surveys, observers relay group detection to the pilot for data recording as the group is encountered. With a paired observer set up, observers were instructed to delay the indication of detection until the group had passed out of the viewable area for both observers. At this point, an observer would indicate to the pilot that a group had been detected. Following the listing of the group characteristics, the other observer would indicate whether the group had been detected by the front, rear, or both observers. An opaque cloth was hung between the 2 observers to prevent the transfer of visual cues. If the activity class of a pronghorn cluster was not consistent amongst all individuals within the group, the cluster was defined as having the activity class deemed most easily detected (favoring running to standing and standing to bedded). The chief objective of these protocol modifications was to evaluate the ability of observers to detect all individuals on the line (within the first distance band). Therefore, in the rare instances in which observers disagreed on either distance band or group size, differences were reconciled prior to data entry.

Analysis

In accord with standard analysis protocol of pronghorn line transect surveys, program Distance was used to model the relationship between detection and distance off the line (detection function). Data from the rear and front observer was combined to simulate a survey in which the sampling fraction was 1. AIC was used to select to the best model from which density and associated variance estimates are reported.

Following Borchers et al. (1998), we repeated analysis with program Distance independently for each seat position with a sampling fraction equal to 0.5. Again AIC was used to select the most parsimonious detection function. This detection function was then evaluated to determine the perpendicular distance of perfect detection (i.e., the width from zero to an unknown distance in which the probability of detection equals 1). Data was then truncated at this width. With the reduced dataset, logistic regression was used to evaluate the influence of variables beyond distance on the probability of detection. This permits the estimation of a correction factor for the probability of detection at distance zero (g[0]), reducing the bias in the density estimate. Variance of this density estimate then becomes a sum for the variances associated with sampling, effective survey width, visibility, the logistic model, and cluster size.

A third method for density estimation is modeled after Manly et al.'s (1996) logistic model. In this method, we use the logistic function to model the probability of detection for each seat independently, incorporating all variables recorded which may influence sightability. Models with all combinations of variables were run and AIC was used to determine the best model. Having derived the probability of detection for each seat position based on the observed group characteristics, abundance can then be estimated as:

$$\hat{N}_1 = \sum_{i=1}^{n} g_i / \{\hat{P}_{i1} + \hat{P}_{i2} - \hat{P}_{i1}\hat{P}_{i2}\}$$

where $\hat{P}_{ij}$ is the estimated sighting probability for group *i* from seat *j*. g_i is the size of the *i*th group.

Current Progress

Logistically, the established line transect protocol easily accommodated the double observer modifications. The opaque curtain was sufficient to prevent visual cues from being passed between observers. Further, the pilot was able to easily incorporate the additional group characteristics (activity) into the data recording process.

Currently, we are working on the analysis of this dataset. The traditional line transect protocol established for pronghorn requires the assumption that all of the individuals within the 'A' band are detected. Independent observations from dual observers did identify violations of this assumption; of the 46 groups detected within the 'A' band, 36 were observed from the rear seat while 45 were observed from the front seat. These missed detections have the potential to bias density estimates from the rear seat and the front seat downward by 22% and 2%, respectively. This suggests that double observer methods may represent real improvements in survey protocol and reduced bias in the density estimates.

Analysis is in very preliminary stages, although the evaluation of logistic regression has identified models incorporating additional variables which outperform either the null model or the distance band model (Table 4). Additionally, logistic regression within the 'A' band (the assumed width of perfect detection) of the rear seat has identified the model incorporating altitude as the best predictor of probability of detection (Table 5).

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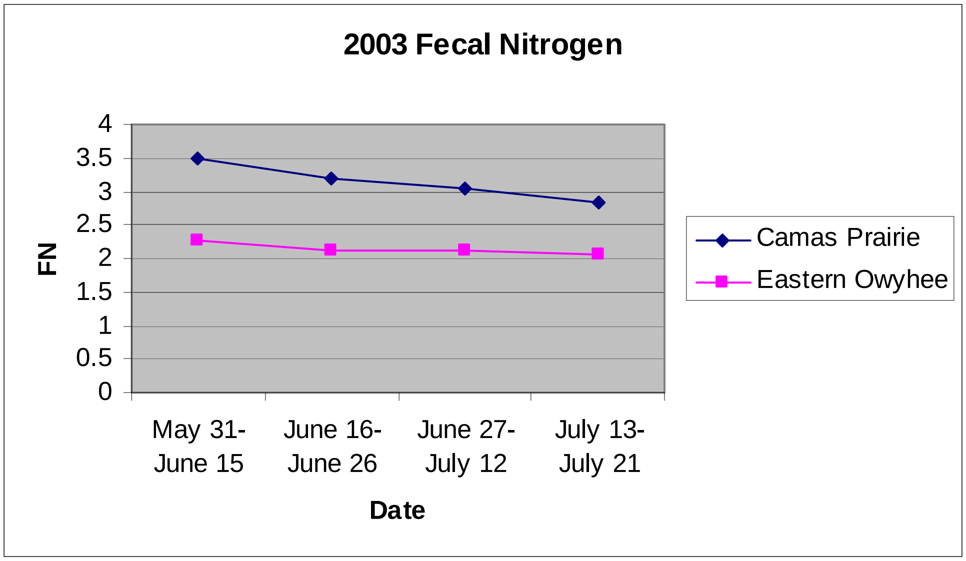

Figure 1. Fecal nitrogen values by sampling rotation for Camas Prairie and Eastern Owyhee, 2003.

Table 1. Fawn:doe ratios for 2003 pre-harvest pronghorn aerial surveys.

Site	Number observed	Fawn:doe estimate	95% CI
Lemhi/Birch Creek	301	33:100	(25:100, 40:100)
Pahsimeroi/ Little Lost	396	41:100	(33:100, 50:100)
Little Wood	403	73:100	(63:100, 83:100)
Camas Prairie	347	76:100	(71:100, 82:100)
Eastern Owyhee	234	40:100	(26:100, 54:100)

Table 2. Coyote scat transect results within the Eastern Owyhee and Camas Prairie study areas, 2003 and 2004.

	2003		2004	
Study area Location	# Coyote scats	# ½ mile transects	# Coyote scats	# ½ mile transects
Eastern Owyhee				
Brown's Bench	26	25	6	25
Shoshone Basin	19	25		
Deposition rate	0.25714		0.06400	
Camas Prairie				
Camas Prairie	19	25	10	30
Deposition rate	0.19000		0.09524	

Table 3. Fecal nitrogen results summarized by 2-week rotation period, Camas Prairie and Eastern Owyhee sites, 2003 lactation season.

Site	Date	*n*	Mean	Standard deviation
Camas Prairie	31 May-15 Jun	13	3.486923	0.412076
	16-26 Jun	22	3.197727	0.408702
	27 Jun - 12 Jul	17	3.048235	0.409668
	13-21 Jul	21	2.822381	0.358788
Eastern Owyhee	31 May-15 Jun	9	2.265556	0.318634
	16-26 Jun	21	2.108095	0.302252
	27 Jun - 12 Jul	17	2.122353	0.388354
	13-21 Jul	23	2.062174	0.319032

Table 4. Competing logistic models relating detection by a given position to explanatory variables, evaluated based on AIC.

Seat position	Variables	AIC	Delta AIC
Front	Distance band, study site	204.027	0.000
	Distance band, study site, altitude	204.953	0.926
	Distance band, study site, group size	204.998	0.971
	Distance band, altitude	204.999	0.972
	Distance band, altitude, group size	205.490	1.463
Rear	Distance band, study site, group size	240.123	0.000
	Distance band, study site	241.236	1.113
	Study site, group size	241.207	1.084
	Study site	241.315	1.192

Table 5. Competing logistic models evaluating variables which influence the probability of detection within the 'width of perfect detection.'

Variables	AIC	Delta AIC
Altitude	49.244	0.000
Null	50.170	0.926
Group size, altitude	50.970	1.726
Study site, altitude	51.168	1.924
Act, altitude	51.447	2.203

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