Greater Sage-grouse Population Estimation Study:
Deseret Land and Livestock and Parker Mountain

Preliminary Report
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By

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Introduction

Historically, greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse) populations and range has been generally declining (Connelly et al. 2004, Schroeder et al. 2004). These declines are largely attributed to loss and/or degradation of habitat (Connelly et al. 2004). Sage-grouse mating strategies (i.e., lekking behavior) have provided managers with an opportunity to collect information about the status of populations by counting the number of males at display areas known as leks (Patterson 1952). Habitat around lek sites is typically low in visual obscurity, and this combined with the prominent visual and auditory displays of male sage-grouse make lek sites relatively easy to find (Schroeder et al. 1999). Additionally, lek locations are relatively temporally persistent (Dalke et al. 1963). Male lek counts have been conducted by many western states since the mid-twentieth century, including the Utah Division of Wildlife Resources (UDWR). A general decline in the number of males counted on leks has been reported from that time to the 1990's (Braun 1998).

However, using sage-grouse lek counts to estimate population size and trends is controversial (Beck and Braun 1980, Walsh et al. 2004, Reese and Bowyer 2007). One issue confounding the use of lek counts to estimate population trends is male lek attendance rates, in other words the number of males which are detectable in a given sampling period. Emmons and Braun (1984) and Walsh et al. (2004) reported very different rates of individual male lek attendance. These differences may have been due to sample sizes and experimental approach (see Connelly and Schroeder 2007). However, both studies showed marked differences in yearling versus adult lek attendance rates. Additionally, each age class may attend leks during a different time within the lekking season. Johnson and Rowland (2007) reported adults and yearlings show up early and late, respectively. Furthermore, not all males attending a lek have the same probability of being detected, which may vary by size of lek, behavior, and/or individual location within the lek. Moreover, it is likely that not all observers have the same ability to detect male sage-grouse. Thus the resultant indices or estimates may also reflect this bias. Using the above techniques to estimate numbers of male sage-grouse in a population is ineffectual given no valid technique to assess the precision of such estimates (Anderson 2001).

The use of lek routes (as defined in Connelly and Schroeder 2007) has been suggested as an alternative method for obtaining reliable indices to breeding sage-grouse males (Connelly et al. 2000a). The lek route count method involves: 1) locating (aerially or ground-based) all or a portion of leks within a breeding population, 2) identification of groups of leks that form a route, and 3) counting a sample of males at each lek within a route the same morning (0.5 hour before to 1.5 hour after sunrise) at least four times throughout the spring displaying season (Connelly et al. 2003). The estimate used is the maximum number of males counted for each route by year. However, these counts may only provide an index to breeding population size, and may be termed "convenient sampling" (Anderson 2001).

Using lek route counts as an index is problematic given the following assumptions: 1) the sample is proportional to the population; 2) the proportion remains constant among years when trends are assessed; 3) the proportion remains constant among comparable sites; and 4) the detection probability is the same for all observers (Anderson 2001). The realistic nature of these assumptions is questionable. The violation of these assumptions creates the risk of reporting highly biased results (White 2005). Additionally, lek route counts may be further biased by age class based on time of sampling, which may vary annually. Therefore obtaining reliable population estimates, rather than indices, provides improved population assessment.

There is also a need to determine sex ratio within a population, which is relatively unknown for sage-grouse populations across their range (personal communication, J. Connelly, Idaho Fish and Game). Winter is the time where population mixing (no segregation according to sex) occurs (Beck 1977). Winter pellet collection and subsequent DNA or hormonal analysis may yield representative sex ratios within a population.

Currently, the UDWR uses a 0.75 male attendance probability and a 2:1 female to male ratio for sage-grouse breeding population estimation, and bases management on this estimation (personal communication, D. Olsen, UDWR Upland Game Program Coordinator). Based on Emmons and Braun (1984) results, this assumption is conservative, however based on Walsh et al. (2004) it may be considered liberal. Additionally, the 2:1 sex ratio is arbitrary (J. Connelly, Idaho Fish and Game, personal communication), and sex ratios may vary between populations considerably given variable sage-grouse juvenile sex ratios based on habitat quality (Swenson 1986) and harvest history (Connelly et al. 2000b). Therefore, there is no concrete evidence to support the above computation of population estimates for management purposes.

Clearly, there is a need to rigorously document male lek attendance rates, sex ratios, and lek count error rates, and how these parameters may vary by population. Population estimation, with valid confidence intervals, will be possible once these objectives are met.

This project will directly address one of the top research needs identified in the 2009 Utah Sage-Grouse Plan (UDWR 2009). Additionally, local working groups (LWG) have identified the need to better assess individual sage-grouse populations and their trends. This research will fit within both statewide and LWG objectives for sage-grouse conservation within Utah. This research is also being coordinated with similar studies in Idaho, which will result in an interstate assessment of sage-grouse populations, and valid population estimates.

Objectives:

The major project objectives are:

1. Assess male sage-grouse lek attendance rates.
2. Assess sex ratios for sage-grouse populations
3. Assess lek count error rates for observers
4. Calculate valid population estimates for two sage-grouse populations

Expected Results and Benefits:

Objective 1 – Male Lek Attendance Rates

By marking and monitoring male sage-grouse during the spring breeding season, we will be able to obtain lek attendance rates for both juveniles and adults. We will also be able monitor inter-lek movements of male sage-grouse and better assess lek complexes (leks associated with each other), which enable lek counts/routes to occur within complexes and avoid double sampling.

Objective 2 – Sex Ratio
Obtaining valid sex ratios for these sage-grouse populations will allow comparison between populations, including harvested and unharvested populations, and lead to valid population estimation. If this objective is met, it will be the first time for any sage-grouse population.

Objective 3 – Lek Count Error Rates
Having lek count error rates will allow precision estimates for this data, and result in population estimates with confidence limits. This will provide information for one of the significant critiques of lek count data.

Objective 4 – Population Estimation
Once the above 3 objectives are met, it will be possible to produce valid population estimates with confidence limits. Not only will biologists be able to monitor population change better, but also be able to use these estimates for better management. The impacts of management actions on a population may be evaluated more precisely, as well as setting harvest goals and regulations. Sage-grouse biologists will be able to align sage-grouse harvest with more defendable management, similar to the North American Waterfowl Harvest Management Model.

Study Area

This project took place on Deseret Land and Livestock (DLL) in Rich County and Parker Mountain (PM) in Wayne County, Utah. Rich County contains one of four remaining sage-grouse populations with > 500 breeding adults in Utah (Beck et al. 2003). Rich County, in extreme northeastern Utah, has elevations that range from ~6000-9500 feet. Lek locations typically occur at the lower elevations. Rich County is characterized by large contiguous tracts of sagebrush consisting of Wyoming big sagebrush (*A. tridentata wyomingensis*), basin big sagebrush (*A. t. tridentata*), black sagebrush (*A. nova*), low sagebrush (*A. arbuscula*), and mountain big sagebrush (*A. t. vaseyana*) from low to high elevations, respectively. Parker Mountain (Awapa Plateau) is located in south-central Utah, and is on the extreme southern boundary of sage-grouse range. Parker Mountain is also one of the four remaining sage-grouse populations with > 500 breeding adults in Utah (Beck et al. 2003). Parker Mountain is a unique high elevation sagebrush plateau (7000-10000 feet), which is dominated by black sagebrush, but has some mountain big sagebrush and silver sagebrush (*A. cana*) at the highest elevations. Both areas contain stable sage-grouse populations representing some of the largest contiguous tracts of sagebrush in Utah (Beck et al. 2003), and are noted as important conservation areas for Utah's sage-grouse (UDWR 2002).

Methods

Male lek attendance
We captured male sage-grouse on each study site during fall, winter, and early spring and marked them with necklace style radios and aluminum leg bands (Geisen et al. 1982). Capturing male sage-grouse that are unassociated with a particular lek (herein termed "unbiased") is assumed to ensure unbiased results for attendance probabilities. A male captured during the lekking season (herein termed "biased") may already have a defined territory within the lek, and

therefore may have a higher probability of attendance. When biased males were radio-marked their attendance rates were initially analyzed separately to test for differences. All birds were measured according to age, sex, weight, wing cord, and tarsus length. Eventually, sample sizes may need to be combined across years for statistical procedures.

Lek routes were delineated based on known lek locations in each study area. Trapping of male sage-grouse occurred within a general proximity to chosen lek routes to try and keep marked grouse within consistent areas. However, some flexibility was needed to: create lek routes that represent real lek complexes based on marked male inter-lek movements; locate use of possible unknown leks and incorporate those leks into experimental lek routes; and to make the work load logistically feasible within a single morning (0.5 hour before to 1.5 hour after sunrise).

For this preliminary report "apparent" lek attendance rates were used. Apparent lek attendance is calculated by determining all available (radio-marked males known to occur on the study area) males, then dividing the number of marked males detected on a lek by the total available during a single period (sampling occasion). However, upon project completion (2011) mark-recapture methods will be employed where attendance at a lek (re-sighting occasion) will be used as recaptures. These methods address many of the previously discussed assumptions and precision can be estimated (Nichols 1992, White 2005).

Sampling began around mid-March and continued through mid May. DLL had 8 7-day sampling occasions (periods) and PM had 3 10-day sampling occasions. PM sampling periods were longer because PM has more leks and lek complexes than DLL. PM climatic conditions (extreme snowpack) prevented access to leks prior to mid-April, precluding our observation of all leks on the study area until April 19. Leks were put into groups of 3 or 4 (according to proximity) allowing for sampling (15 minutes) of three leks per morning (1.5 hours) and travel time. A sighting occasion or period was defined as all leks within chosen lek routes being sampled once, where leks within groups were sampled in a random order, and the order of the occasion remained constant. Sampling only occurred during no clouds to partly cloudy and zero to extremely low wind weather conditions. One observer approached the lek at 3 predetermined locations (providing the best view of the lek) set at ~90 degrees apart. The observer counted the lek at the first location recording adult males, yearling males, and hens. Each observer scanned through all available frequencies, and noted the compass bearing for each signal at each of the 3 predetermined locations. Signal direction was then triangulated from each location. Lek boundaries were predetermined for each lek, and compass bearings to the two widest angles from the observer location were determined prior to sampling. Individual radio-marked grouse signal triangulation and strength that results in locations within the lek boundary were assumed attending the lek. Signals not detected or with unreasonable bearings were assumed not attending the lek. Items recorded were date, weather conditions, starting time, observer location, and observer's name for each count, and number and frequency of radioed birds indicating positive attendance.

Lek Count Error Rates

We attempted to evaluate detection ability bias in each study area. However, due to climatic conditions (late snowpack) influencing field work, Parker Mountain blind data was used sparingly and with caution. Blinds were located near the edge of a lek and were used to compare counts conducted during lek routes using the assumption that counts from the blinds will include 100% of attending birds.

Leks were chosen from a stratified-random sample based on relative size (males/lek) in each study representing a small, medium, and large lek. One observer counted from a blind, while a second observer simulated a normal lek count. A normal lek count is where an observer approaches the lek to a predetermined location in a vehicle (truck), and counts the lek from within the truck 3 times within 15 minutes, and uses the maximum count. Blinds were erected prior to lekking season at each lek to allow adequate habituation for the birds. Observers entered the blinds two hours prior to sunrise to avoid disturbing lekking birds. Sampling from the blinds began at 0.5 hours before sunrise. Sampling took place every 15 minutes, with a corrected count to match the time of the "normal" count (a simultaneous count). Data recorded included observer's name, date, general weather conditions, time of each count, number of each segment of the population visually counted, number of displaying males, and number and frequency of radios heard. The final count occurred at 1 hour after sunrise. If birds flush upon exit of the blind, a count of airborne birds was taken.

Sex ratio

Pellet sampling and subsequent DNA or hormonal analysis is currently in progress for both the DLL and PM populations. We followed radio-marked individuals of both sexes from December to mid-March to locate nocturnal roost sites. We then systematically searched the area for sage-grouse pellets to obtain an unbiased sample by selecting from separate roost piles. Only "fresh" pellets were collected and frozen or dried to ensure sample quality. Pellets are currently being analyzed for DNA to assess sex of each pellet, and representative sex ratios will be determined. This assumes that sampling was not biased by sex, and flocks were equally mixed according to representative sex ratios.

Results

We trapped a total of 71 males on DLL, of which 29 were adults (10 unbiased [trapped prior to lekking season]; 19 biased [trapped during the lekking season]) and 20 were yearlings (15 unbiased; 5 biased) available for sampling from March 22 to May16, 2010. We trapped a total of 39 males on PM, of which 26 were adults (all biased) and 10 yearling males (all unbiased) available for sample from April 19 to May 18, 2010.

Male lek attendance

Our data does not support the hypothesis that biased males have higher lek attendance rates because of previously established territories (Figure 1). Our data would suggest that male lek attendance rates vary naturally whether adult or yearling males are trapped prior to or during the lekking season (note: this could change given another year of data). DLL adult male lek attendance rate (apparent estimates) averaged 0.58 (SE = 0.07), and peaked at 0.88 during period 6 (April 26 – May 2; Figure 2). DLL yearling male lek attendance rate averaged 0.30 (SE = 0.08), and peaked at 0.67 during period 7 (May 3 – 9; Figure 2). PM adult male lek attendance rate averaged 0.44 (SE = 0.04), and peaked at 0.50 during period 2 (April 29 – May 8; Figure 2). PM yearling male lek attendance rate averaged 0.03 (SE = 0.03), and peaked at 0.10 during period 2.

There was very little inter-lek movements for our radio-marked adult males. On DLL if an adult male was detected on a given lek he was always detected (if attending) during subsequent periods on the same lek. On Parker Mountain we detected 2 adult males that moved between 2 leks (the same movement for each individual) within the same lek route (complex). There was no inter-lek movement by yearling males on Parker Mountain, however only 2 yearling males (low sample size) were detected attending leks for the entire season. On DLL ~ 50% of yearling males that were detected at a given lek had inter-lek and inter-complex (lek route) movements. One yearling male attended 3 different leks in 3 different complexes. The other 50% of yearling males on DLL were consistently detected attending or in the vicinity (not attending, but nearby) of a single lek.

Lek Count Error Rates

Blind counts reported herein are primarily from the DLL study area. For the 3 leks with blinds, the observer conducting the normal count (from truck) was able to detect on average 0.80 (SE = 0.10) of the males observed by the person in the blind. One lek (East McKay Ridge) averaged 0.95 (SE = 0.05) while another (North Dip) averaged 0.60 (SE = 0.10). Topography seemed to be the most significant factor influencing the differences in detection rates. For example, the observation point for East McKay Ridge lek is higher in elevation and gives an entire view of the lek, while the observation point for North Dip lek is lower in elevation than the lek, and does not give a clear view of the entire lek. GIS analysis using digital elevation models and sighting analysis might give the most accurate information concerning detection differences at various leks. These relationships will be analyzed with more confidence with increased sample sizes from another year (2011) of data.

The time at which maximum counts occurred, within a given morning, varied by study area (Figures 3 – 4). On DLL the max count for both sexes occurred at higher frequency before sunrise, while on PM the max count for both sexes seemed more evenly distributed across the entire morning (0.5 hours before to 1.0 hours after sunrise). The predation pressure on leks was much greater on DLL compared to PM. Eagle (primarily golden eagles) abundance was much higher on DLL than PM. Because of the observations from the blinds, we were able to monitor predation pressure without influencing individual predators. We observed multiple predator prey interactions. For example; 1) coyotes walking through leks without disturbing the grouse, 2) buteo hawks attacking the leks while the grouse avoided them and began displaying again immediately following the predation attempt, and 3) eagle attacks on the leks that resulted in complete abandonment of the lek for that morning in nearly every case. Sage-grouse's behavioral reaction to eagles was completely different than other predators, and always resulted in seeking cover and a dismissal of lekking activity. We believe this influenced the results reported in Figures 3 – 4. In other words, eagle pressure caused max counts on DLL to occur earlier than on PM. Additionally, on DLL and PM we had 7 and 5, respectively, mortalities of our radio-marked grouse. All DLL mortalities were suspected avian predators (remains included intact skeleton), while PM mortalities were suspected a mix of avian and mammalian predators. On DLL 25 of the 162 (15%) individual lek counts (from a truck) an eagle or buteo was observed influencing lekking behavior, and in 11 of the 25 (44%) cases of avian predator encounters we witnessed golden eagles attacking grouse on the lek. Conversely, on PM of the 131 individual lek counts (truck) on only 2 (1.5%) occasions golden eagles were detected, and attacks at leks were never witnessed. However, our observations on PM were limited by climatic conditions.

There seemed to be no relationship between time of morning and how well the normal count (truck) was able to detect (proportionally) male sage-grouse (Figure 5). However, the closer the numbers of males that showed up to a lek in a given morning was to the mean males/lek for the entire season, the more accurate the normal count (truck) detected males (Figure 6). For example, if a lek has an average of 30 males for the entire lekking season, and $\geq$ 25 males show up in a given morning, the truck count was much more accurate than if at the same lek $\leq$ 20 males showed up in a given morning.

Discussion

We strongly caution the results gathered from the PM study area. The 2010 lekking season on PM was an anomaly compared to historic springs. Snowpack on PM far exceed normal conditions. Our concurrent reproductive studies would concur with this assessment. Based on field observations, the peak of lekking activity occurred the week just prior to our ability to access all the leks across the study area (April 19). We believe we were precluded in 2010 from gathering the necessary information to meet the objectives of this research (reliable population estimation) for this population. Hopefully 2011 will be a more “normal” year on PM, and a reliable dataset will result to compare to 2010.

On DLL a heavy snow storm (> 12 inches at higher elevations) occurred the first week of April, affecting lek attendance and blind counts during periods 2 and 3. We believe this was the cause of the slight decline in lek attendance rates for this population during these periods (Figure 2). However, we feel the information gathered on DLL in 2010 was a representative year for this population, and provided reliable estimates to proceed with population estimation analysis. Our lek attendance rates are comparable to J. Baumgardt’s data (identical study design conducted 2008 – 2010) in south-central Idaho, and possibly provides the first reliable (better sample sizes) information for yearling male lek attendance rates.

There are interesting predator-prey dynamics affecting our data, as well as the unique behavioral observations we were able to record. In general, on DLL if an eagle was visible from the lek the grouse reacted quickly, took to cover without hesitation, and did not resume lekking behavior in a given morning. However, buteo or mammalian (primarily coyote) activity seem a mere annoyance at best, and the grouse continued with their mating behaviors. We also documented interesting hen behaviors. At peak activity (male displaying usually prior to sunrise) occasionally we observed hens “displaying.” They would act much like a male sharptailed grouse, fanning their tails and bending over parallel to the ground, though not with the regular foot/stepping patterns of sharptailed grouse.

On DLL, multiple radio-marked males (yearlings and adults) left the study area just prior to lekking activities (censored from the dataset). Movement varied from a few kilometers to 2 adult males that moved 36 km north for their lekking activity. All males that moved off the study area were caught during the fall or winter prior to the 2010 lekking season. One adult male on DLL left the study area just after the sampling period began, but came back during the last 2 periods, and attended a lek for both periods.

When time permitted within a sampling period, researchers would search for radio-marked males, that were not detected on a lek during the sampling period, during a morning display period (0.5 hours prior and 1 hours after sunrise). In all cases (n = 4) the males were using non-lekking habitat, not displaying, and alone or with females. These observations are extremely important and could be looked at more regularly by increasing technician staff in 2011.

Five previously unknown leks were found (by DLL and USU personnel) on DLL property or in adjacent properties (to the north) during our study period. One of the primary assumptions of this research is that all leks in a study area are known and observed. Some of these leks were found by driving and looking for them specifically. Some were found by following non-attending radio-marked males. This effort should continue in 2011 because of these underlying assumptions. If funding or opportunity presents itself, helicopter lek surveys for the DLL and PM study areas would be beneficial to this research and the UDWR in general.

Sex ratio sampling and DNA analysis has been slower than anticipated. We have been relatively unsuccessful so far at extracting DNA from sage-grouse pellets. However, research in Idaho (J. Connelly et al.) has been very encouraging, and K. Mock's genetic lab (USU) will be using their protocols this fall and winter. We have been very successful at collecting a large sample size of winter pellets from roost sites and foresee much information coming from our efforts in the near future.

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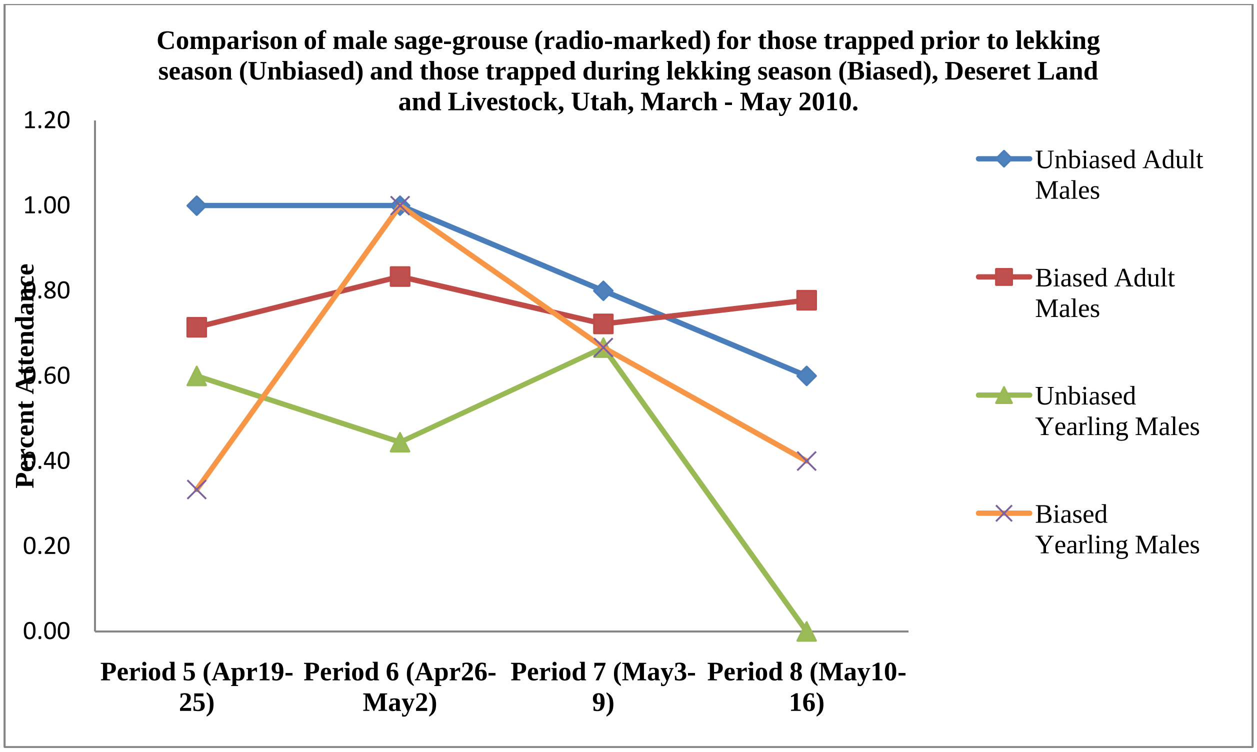
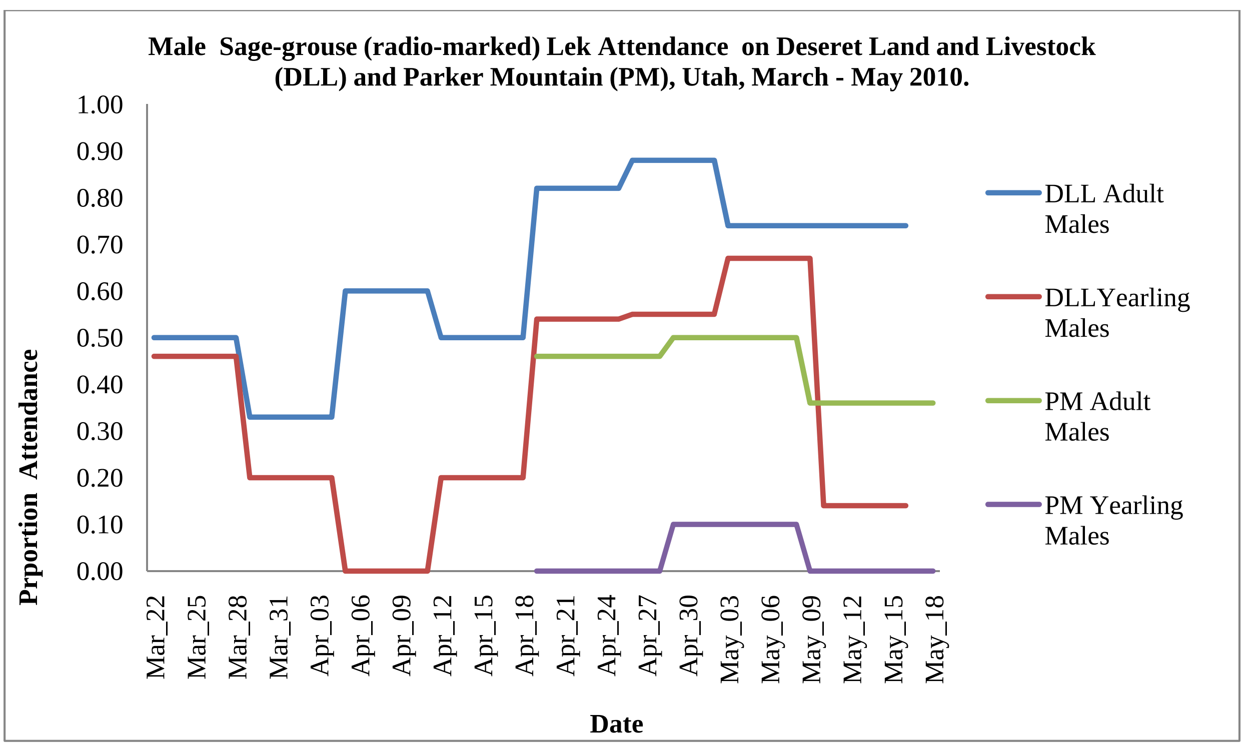


Figure1.



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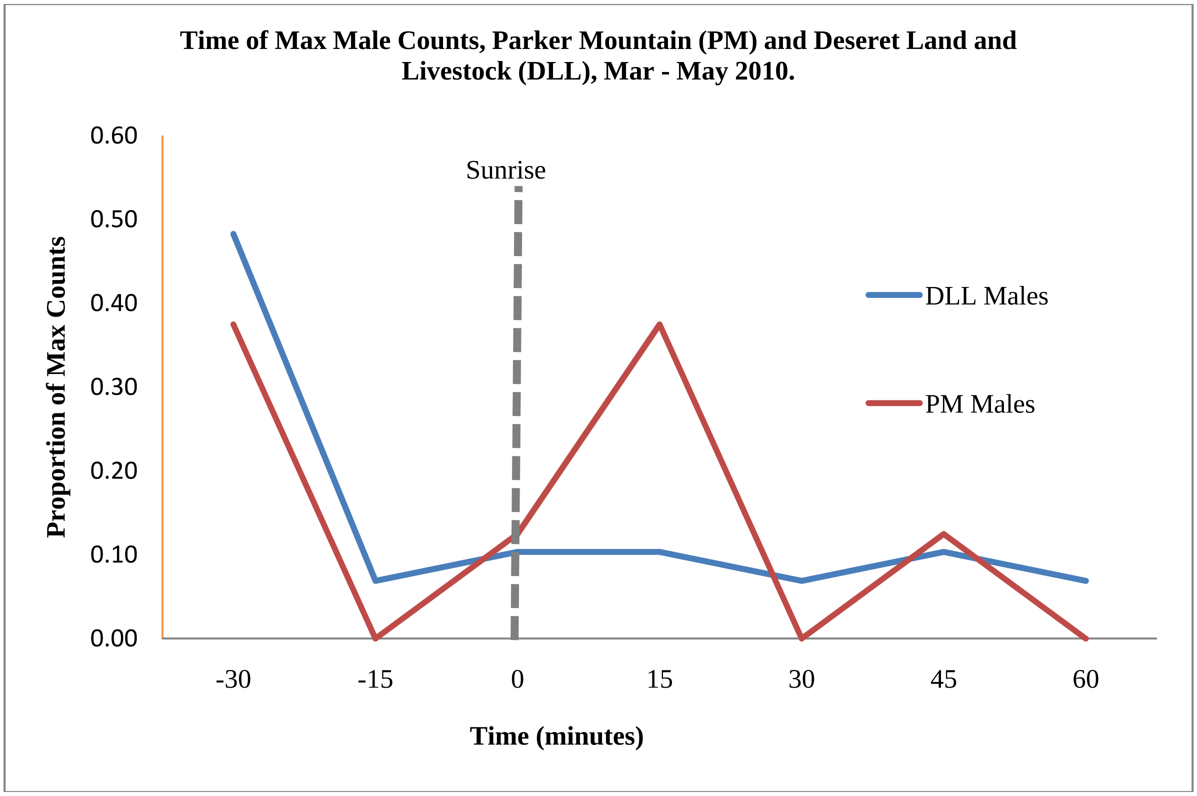

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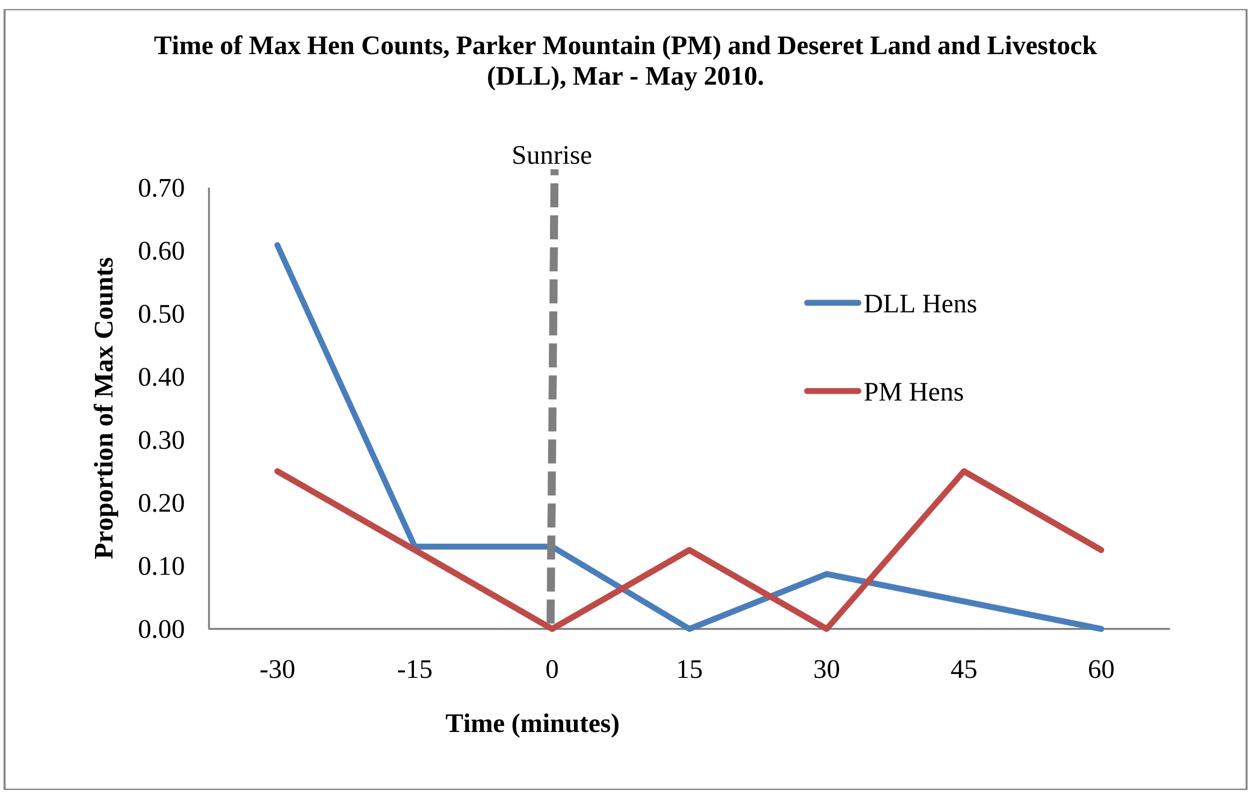

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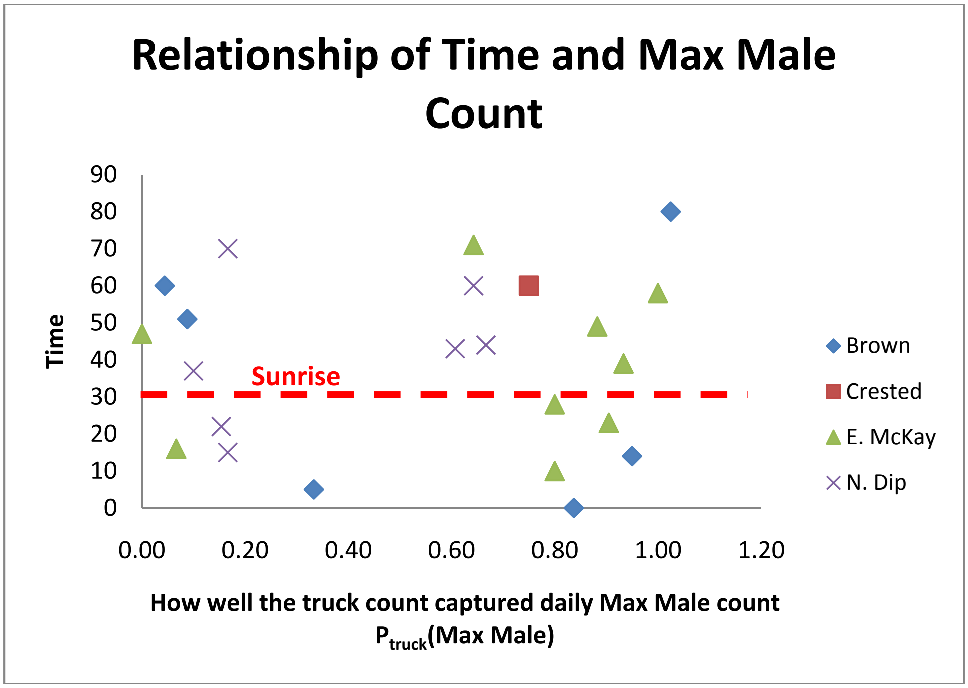

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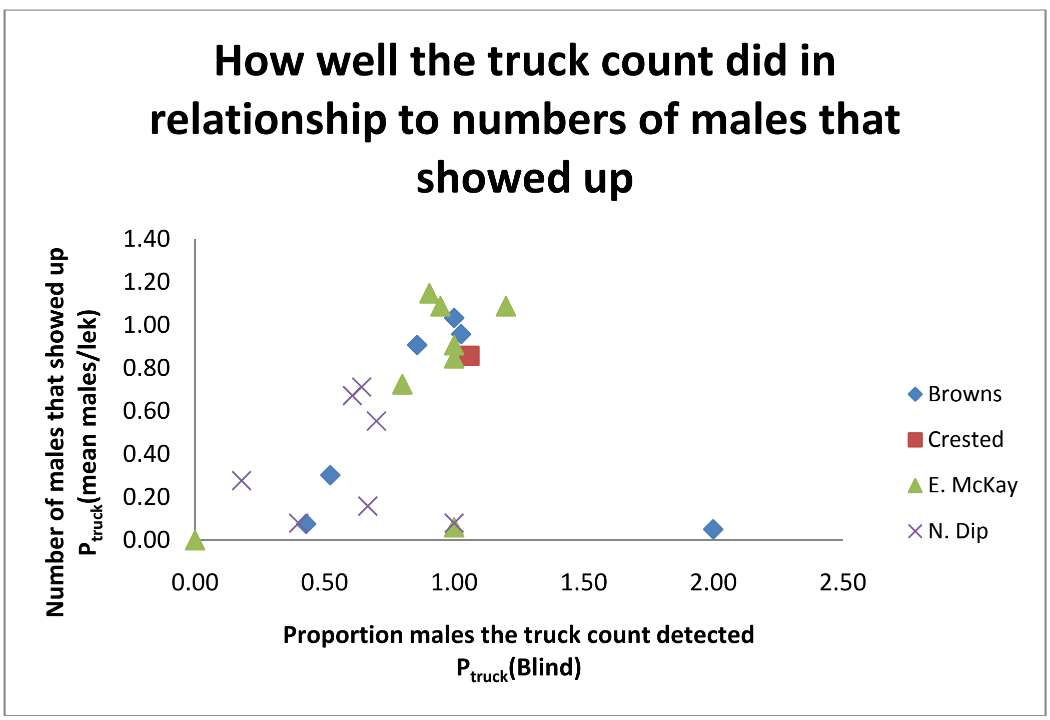

Figure 6.