Using Mark-Resight Techniques to Estimate Numbers of Greater Prairie-Chickens in Tallgrass Prairie, Flint Hills, Kansas
Using Mark-Resight Techniques to Estimate Numbers of Greater Prairie-Chickens in Tallgrass Prairie, Flint Hills, Kansas

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By

Amy M. Clifton, B. S.
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University of Arkansas
This thesis is approved for recommendation to the Graduate Council

Thesis Adviser:

__________________________________
David G. Krementz

Thesis Committee:

__________________________________
Douglas A. James

__________________________________
Edward E. Gbur, Jr.

__________________________________
Abby N. Powell
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Abstract: Current monitoring efforts for greater prairie-chicken (*Tympanuchus cupido pinnatus*) populations indicate that populations are declining across their range. Monitoring the population status of greater prairie-chickens is based on traditional lek surveys (TLS) that provide an index without considering detectability. Estimators, such as immigration/emigration joint maximum likelihood estimator from a hypergeometric distribution (IEJHE), can account for detectability and provide reliable population estimates based on resightings. I evaluated the use of mark-resight methods using radio-telemetry to estimate population size and density of greater prairie-chickens on 2 sites at a tallgrass prairie in the Flint Hills of Kansas. I used average distances traveled from lek of capture to estimate density. Population estimates and confidence intervals at the 2 sites were 54 (CI 50-59) on 529 km² and 87 (CI 82-94) on 736 km². TLS performed at the same sites resulted in population ranges of 7-34 and 36-63 and always produced a lower population index than the mark-resight population estimate with a larger range. Mark-resight simulations with varying male:female ratios of marks indicated that this ratio was important in designing a population study on prairie-chickens. Confidence intervals for estimates when no marks were placed on females at the 2 sites (CI 46-50, 76-84) did not overlap confidence intervals when 40% of marks were placed on females (CI 54-64, 91-109). Population estimates derived using this mark-resight technique were more accurate than traditional methods and would be more effective in detecting changes in prairie-chicken populations.
INTRODUCTION

Once found throughout the prairies of the Great Plain Region, greater prairie-chickens have declined extensively since the late 1800’s due to habitat loss (Schroeder and Robb 1993). Greater prairie-chickens initially experienced range expansion following European settlement due to increased forage availability from crop production (Schroeder and Robb 1993). This increase was soon reversed because of prairie habitat loss and the greater prairie-chicken range receded to smaller than the original size. All 3 subspecies of this pinnated grouse have experienced range reductions. Heath hens (T.c.cupido) once found in pine and oak scrub barrens on the East Coast went extinct in the 1930’s (Johnsgard 2002). Attwater’s prairie-chicken (T.c.attwateri) is endangered and occupies in a very limited range in south Texas (Johnsgard 2002). Captive breeding has prevented Attwater’s extinction. Greater prairie-chickens (T.c.pinnatus) are extirpated or declining in most states where it occurs (Fig. 1) (Schroeder and Robb 1993, Sauer et al. 1999).

Prairie chickens have distinct habitat preferences for lek and nest locations. Heavily grazed and frequently burned habitats are preferred for leks (Horak and Applegate 1998, Ryan et al. 1998). Nest habitat should have little to no grazing and a 3 to 4 year rotational burn program as this provides adequate living and dead standing vegetation for optimal nest concealment (Riley et al. 1992).

Johnsgard (2002) estimated total for greater prairie-chicken populations in the late 1990’s ranged between 200,000 and 250,000 birds with Nebraska, Kansas, and South Dakota supporting the highest numbers of birds. This estimate is considerably lower compared to estimates of 1 million in 1970 and 500,000 in 1980 (Johnsgard 2002).

Declines of greater prairie-chickens have become of interest to many conservation groups. National Audubon Society lists greater prairie-chickens on the 2002 watchlist and Partners in Flight (PIF) has listed greater prairie-chicken on the 2000 watchlist of extremely high priority species (Pashley et al. 2000). PIF recommends monitoring species on this list closely because of threats to population status.

Johnsgard (2002) suggested that uncultivated prairies in the Flint Hills of Kansas, Nebraska, and Oklahoma support a core population of greater prairie-chickens. However, lek survey data for the Flint Hills in Kansas indicate population decline since the 1980’s (Fig. 2; Kansas Department of Wildlife and Parks, unpublished data). This decline has been attributed to changes in land use practices, such as annual burning and early intensive grazing (Robbins et al. 2002). Vickery et al. (1999) suggested grazing regimes that do not imitate those found in nature might be a contributing factor to habitat degradation for grassland birds. Alternatively, Cartwright (2000) has suggested that land-use practices such as grazing densities and timing and length of grazing periods are not contributing to prairie-chicken declines.

**Grazing**

The Flint Hills region has a long history of grazing that increased after expansion of the railroad. In the 1880’s, after removal of native grazers, like bison (*Bison bison*), a cattle boom occurred fueled by the relatively easy transport of livestock via rail.
Continuous light- to medium-stocking regimes (SLS) were common until the 1980’s when intensive, early-stocking regimes (IES) became popular in the Flint Hills. Research by Launchbaugh and Ownesby (1978) indicated that yearling steers gained 67% of their total weight from 1 May-July after an early burn. By stocking more cattle during this period, total beef production per hectare was increased but gains dropped off in late summer (Launchbaugh and Owensby 1978). Instead of SLS with a stocking rate of 1.2-2 ha per head, IES employed stocking rates of approximately 0.7 ha per head for 90-120 days beginning in early May.

Fire

Once, summer fires caused by lightened strikes were common on the prairie, and the prairie ecosystem evolved with fire as an integral aspect (Collins and Gibson 1990). Annual controlled burning in the Flint Hills has been a popular land-use practice since the late 1800’s (Collins and Gibson 1990). Burning removes standing dead stems that block light and precipitation from reaching new shoots of grass (Collins and Gibson 1990). Burn efficiency and timing has improved over the past 20 years with increased use of all-terrain vehicles and modern fire equipment that allows ranchers access to unburned patches. Early spring burns, instead of summer burns, have become common in the Flint Hills region because spring burning increases grass production (Collins and Gibson 1990). Big bluestem (*Andropogon gerardi*) sprouts at twice the density following a spring burn compared to later burns and cattle prefer to forage on new growth instead of unburned areas (Collins and Gibson 1990).

Annual spring burning in combination with IES could impact prairie-chicken population dynamics. Although male prairie-chickens prefer display areas with little
standing vegetation that are burned annually, both sexes need some standing dead and tall grass for escape cover and nesting (Horak and Applegate 1998). In addition to the possible impacts of burning, cattle are introduced to pastures a few weeks post-burn. The intensive grazing period between May and June coincides with prairie-chicken nest initiation, and cattle foraging during this time may disturb egg-laying and nesting female prairie-chickens (Schroeder and Robb 1993).

High nest success is associated with light to medium grazing and a 3 to 4 year rotational burn program as this provides adequate living and dead standing vegetation for optimal nest concealment (Horak and Applegate 1998). Little is known about effects of IES in combination with annual burning on grassland bird reproduction in the Flint Hills region. However, low nest success due to reduced availability of high quality nesting habitat and cattle disturbance may be a contributing factor in local population declines. To detect variables that may be affecting prairie-chicken reproduction, a reliable population estimate is needed to document a trend (Thompson et al. 1998, Applegate 2000).

**Survey Methods**

Lek surveys are a common method used to estimate population size of prairie-chickens (Cannon and Knopf 1981, Horak and Applegate 1998, Bibby et al. 2000), and are used by state agencies (e.g. Kansas Department of Wildlife and Parks) to monitor prairie-chicken populations. Protocols for TLS exist in Kansas to control for variables thought to affect population estimates (Kansas Department of Wildlife and Parks, unpublished data). TLS are performed twice during 20 March – 20 April each year. Surveys are conducted by driving along a 16-km route and stopping every 1.6 km to
listen for 3 minutes for prairie-chicken booming. The listening portion of the survey to locate leks is started 40 minutes before sunrise. After the 16 km route is surveyed, the surveyor drives back along the route and birds are flushed and counted at each lek. Thus, 32 km are driven in total. It is assumed that the surveyor can hear prairie-chickens booming on leks within 1.6 km on either side of the survey road. The total number of birds or leks is divided into a \(3.2 \times 16\) km area. Results are expressed as a density estimate either as number of leks/km\(^2\) or number of prairie-chickens/km\(^2\). The TLS is considered an all-male count since sexing of birds is not attempted.

The TLS method does not account for the probability of detecting all prairie-chickens using a lek since the number of birds not visiting leks is not addressed (Applegate 2000). To achieve a population estimate, a reliable count is necessary; and without an estimate of probability of detection, neither an index nor trend can be estimated (Thompson et al. 1998). Also, density estimates derived from TLS may be misleading since the total area used by the population of interest is not known.

Mark-resight techniques are commonly used to estimate animal populations based on sighting frequencies of marked individuals (Nichols 1992, Neal et al. 1993, Bowden and Kufeld 1995). Population estimates are derived from resightings of marked animals and the number of unmarked animals counted on each survey. Estimators, such as IEJHE, can account for detectability and provide reliable population estimates based on resightings (Thompson et al. 1998).

Greater prairie-chicken biology may affect population estimates. Differences in male and female visitation rates might affect a population estimate because females could be undercounted or in TLS, females could be counted as males.
My research goals were to: (1) test the feasibility and accuracy of a population estimate based on mark-resight techniques for greater prairie-chickens, (2) compare mark-resight population estimates to TLS methods used in the Flint Hills of Kansas, and (3) examine the effects of female greater prairie-chicken lek visitation frequency on population estimates by simulating mark-resight surveys with different sex ratios.

STUDY AREA

The Flint Hills cover more than 1.6 million ha in east-central Kansas, southern Nebraska, and northeast Oklahoma. The region remains mostly uncultivated, and the tallgrass prairie has persisted more or less intact (Brown 1998). For this reason, greater prairie-chickens are thought to maintain a stronghold in this region (Johnsgard 2002). Tallgrass prairie is characterized by warm season grasses such as big bluestem (*Andropogon gerardi*), little bluestem (*Andropogon scoparius*), Indian grass (*Sorghastrum nutans*), and switchgrass (*Panicum virgatum*) (Brown 1998). I chose two study areas within this region, located within eastern Kansas.

One study area, the Tallgrass Prairie National Preserve (TAPR) in the Flint Hills region in Chase County, Kansas, is a mostly unplowed 4,398 ha prairie (forage crops were planted in the Brome pasture, Fig. 3) and was purchased by the National Park Trust (NPT) in 1996. NPT currently owns most of TAPR while National Park Service (NPS) manages it. The preserve is broken up into nine pastures of about 400 ha each (Fig. 3). A private landowner retains a 35-year grazing lease with NPT through 2031 for 98% of the property. Some areas of the preserve were quarried in the past for limestone and a gas lease is maintained.
Ranching history at TAPR dates back over 100 years. In the late 1800's, free-range style cattle grazing changed as fences became commonly used so that herds under different ownership could be isolated. During the 1980's, a new grazing method, IES, came into common use in Chase County. Chase County has a long history of annual burning that persists today. All pastures have been burned every year in late April or early March for optimum grass production, and then cattle are brought on in about two weeks after burning (Launchbaugh and Owensby 1978). This burn regime was recently changed at TAPR; Red House pasture was not burned in 2000 and 2001 and Crusher Hill pasture was not burned in 2002.

The second study area, Lips Ranch, was a privately owned 3,640 ha cattle ranch located 12 km west of TAPR (Fig. 4). National Farms manages grazing on TAPR and Lips Ranch. IES and annual spring burning regimes are implemented on both sites but in addition to gas mining, an oil operation is also maintained on the Lips Ranch.

METHODS

Sampling Design

I used simulation analysis in program NOREMARK (White 1996) to estimate the number of transmitters, survey occasions, and proportion of the population that needed to be marked to produce a population estimate with low percent bias (<20%) for each site prior to the 2001 field season (Table 1). Percent bias of >50% would be too imprecise (W. L. Thompson, U.S.G.S. Arkansas Cooperative Fish and Wildlife Research Unit, personal communication). Using preliminary information taken during pilot work in the 2001 field season for numbers of prairie-chickens observed on seven leks at each site, I estimated the population at TAPR and Lips Ranch to be about 25 and 60, respectively. I
then ran simulations in program NOREMARK using these preliminary estimates to
design my study. In these simulations, I varied the number of surveys conducted in one
field season, proportion of the population radio-marked, and proportion of total
population observed on each visit. Each variation produced a different estimate of bias.
Based on simulation results, I could put transmitters on 20-30% of populations at each
site and conduct 15 surveys to estimate the population with an acceptable level of bias. I
allocated 35 transmitters between the 2 sites according to population estimates based on
2001 field observations, 15 to TAPR and 20 to Lips Ranch. I then placed transmitters on
birds at each site according to number of prairie-chickens observed at each lek. I
attempted to put >1 transmitter at each lek within a site, however, birds on smaller leks
were reluctant to approach leks if traps were present. Thus I was unable to put
transmitters on birds at leks of <5 birds.

Trapping/Radio Marking

I used radio telemetry to obtain mark recapture data to use in my population
estimates. I trapped prairie-chickens on seven leks at both sites using drop nets and walk-
in funnel traps during the springs of 2001 and 2002. Drop nets consisted of 15 × 7.4 m
and 30 × 15 m No. 208 multifilament nylon gill netting stretched between four poles and
a rope that could be cut to drop the net (Silvy et al. 1990). Funnel traps were constructed
of 12.5 gauge 5 × 10 cm welded wire and a funnel made from 2.5 cm poultry wire was
added to each trap (Schroeder and Braun 1991). Trap dimensions were 1 m × 1 m × 65
cm. Leads, 25 m long and 60 cm tall, made from poultry wire, were placed on both sides
of the trap opening and guided birds into traps. I also added 60 × 30 cm rebound fences
to wire leads, 65 cm from trap entrance. If birds turn away from trap entrance, rebound
fences served to guide them back. Rebound fences increase trapping efficiency for both greater and lesser prairie-chickens (D. Wolfe, George Miksch Sutton Avian Research Center, personal communication). I placed a radio transmitter (~ 450 day life, <3% bird’s body weight) attached to a modified necklace harness (Amstrup 1980) and an aluminum leg band with the inscription “Arkansas Cooperative Fish and Wildlife Research Unit” on each captured bird.

*Population Surveys*

A prairie chicken survey route had been set up previously at TAPR by NPS as an annual lek survey route for the purpose of population monitoring (S. Miller, National Park Service, personal communication). I used this predefined route for my TLS and mark-resight surveys at this study area. The survey route at TAPR and Lips Ranch were both 16 km in length. I chose the route used on the Lips Ranch because it dissected study area.

I performed two types of prairie-chicken surveys in 2002, TLS and mark-resight surveys. I performed 13 and 18 TLS at TAPR and Lips Ranch in 2002, respectively. Only birds flushed at leks were included in surveys. Marked birds detected away from leks were not counted because in a TLS, marked birds would only be detected if flushed from a lek.

I performed mark-resight surveys similar to TLS protocol with the following exceptions. I counted birds seen and detected with telemetry along survey routes between leks. Marked and unmarked totals were recorded and marked birds were individually identified. My survey period was longer (28 March – 5 May 2002) than the TLS period (20 March – 20 April), because I wanted to include as many resight occasions
as possible and lek attendance did not drop off until early May. Excluding these differences, my mark-resight surveys were identical to TLS.

There were some gaps between survey dates of both types. These gaps were caused by weather conditions and controlled burning. Surveys were cancelled in cases of heavy rain, dense fog, high winds or tornado warnings. Also, I was not allowed onto my field sites when fields were being burned.

For the mark-resight population estimate surveys, I used a truck-mounted 4-element yagi antenna to detect radio-marked birds along the 16 km survey route. I determined detection distances were approximately 1.6 km because I could detect radioed birds within a distance of 1.6 km in any direction. For leks that were \( \leq 1.6 \) km apart, I was able to detect marked birds on one lek from another lek. I was able to detect all radioed birds \( \leq 2 \) km on the highest point at TAPR.

**Area of Inference**

I located birds using leks in the morning for mark-resight population estimate surveys, then located marked birds during the day after birds had left the lek, in order to determine amount of area used by birds. After determining general locations of marked birds using a truck-mounted antenna, I used hand held 3-element yagi antenna to locate each bird daily. I did not want to flush marked birds as a result of locating them. Based on trial and error, I determined that I could approach a marked prairie-chicken to within 20-50 m before it would flush, depending on vegetation density. If the bird was in dense vegetation cover, I could approach within 20 m of the bird to take a location reading. If the bird was in sparse vegetation cover, the bird could be approached within 50 m. Thus, during daily tracking, I recorded GPS locations within 20 to 50 m for each bird and
adjusted for the estimated distance and direction to the bird. Occasionally, triangulations were required to estimate locations. A technician and I took two simultaneous azimuths at 90° angles to each other. I used a script in Arc View to calculate triangulated locations. Since some leks did not have any marked birds, I averaged distances traveled by marked birds from lek of capture to the area used by the birds during the day and used the averaged distances to create a buffer around each lek.

I used IEJHE in program NOREMARK to analyze my mark-resight data. This version allows for immigration onto and emigration off of study sites. The IEJHE estimate is based on resighting frequencies of marked birds and assumes resighting frequencies of unmarked birds are the same as marked birds. Assumptions for this estimator are: (1) samples were randomly selected from the total population of animals, (2) marks were individually identifiable, (3) resightings were independent of marks, (4) resightings were recorded without error, (5) sighting effort was adequate, and (6) the population was demographically closed within occasions (White 1996). This estimator does not require a unique encounter occasion, just counts of unmarked individuals and number of resights during some time period. The random sample assumption may have been violated since birds were trapped on leks where males congregated and maintained territories. This could bias results since males that visited leks less frequently or did not maintain a territory on the lek (such as juveniles) may be less likely to be captured (Ballard and Robel 1974). I placed traps and drop nets in various areas of the lek and moved them around the lek often in order to capture different birds to address the random sample assumption.
I ran simulations in program NOREMARK to determine if varying the sex ratio of marked birds would affect the mark-resight population estimate. I used original data but varied number of transmitters placed on females to imitate different sex ratios.

RESULTS

I captured 55 prairie-chickens in 70 days of trapping from mid-March through late-April in 2001 and 2002 at both field sites. This amounts to a trapping effort of 0.20 birds/hour. I caught most birds in 2002 using the drop net method, whereby I was able to capture multiple birds, sometimes males and females together, with fewer incidents of injuries than with funnel traps. I rarely captured >1 bird during a session using funnel traps. Injuries were more common in funnel traps than with drop nets and consisted of head and wing abrasions.

During spring 2001, I put transmitters on seven females at both sites. Based on the results of my simulation model, I put three transmitters on females and ten transmitters on males at TAPR in the spring of 2002. One marked female returned from spring 2001, making a total of four marked females at TAPR. I placed two transmitters on females and 17 transmitters on males at Lips Ranch in the spring of 2002. One marked female returned from spring 2001, making a total of 3 marked females at Lips Ranch. The number of transmitters placed on females was lower than I had planned, because females were more difficult to trap than males.

I captured more males than females because they attended leks daily and remained on leks from sunrise until about four hours thereafter. Peak booming activity occurred from sunrise until about two hours after sunrise. After this time, males boomed less often than earlier in the season and moved short distances away from lek (about 50 m) unless
females were present. If females were present booming continued until females left. Females attended leks sporadically, sometimes remained outside the leks, and usually attended <4 hours. Visitation rates from March – May 2002 were approximately 30% and 90% for females and males, respectively.

Burning of TAPR and Lips Ranch took place in late March and early April of both years. Different pastures were burned on various occasions according to weather conditions and burning did not appear to affect lek activity. Males were observed booming on a lek at TAPR within 100 m of a fire line on one occasion in 2001.

Initiation of grazing appeared to have an impact on lek activity. Upon introduction of cattle, about 30% of leks had no prairie-chickens present. Because of this reduction in attendance, I discontinued lek surveys on 5 May 2002 when cattle were brought onto each field site.

Results of my TLS in 2002 ranged from 7-34 at TAPR and 36-63 at Lips Ranch (Figs. 5, 6). These estimates were variable and substantially lower than my mark-resight population estimates. Numbers of prairie-chickens seen on leks declined over time.

My estimated population size using mark-recapture methods was 54 (95% CI 50 – 59) at TAPR and 87 (95% CI 82 – 94) at Lips (Table 2) in 2002.

To estimate density, I used average distances traveled from lek (1.5 km) of capture by each marked bird to create a buffer using Arc View. The inference area for the population estimate was 529 km² at TAPR and 736 km² at Lips Ranch (Figs. 7,8). The density estimate was 1 prairie chicken/5.29 km² at TAPR and 1 prairie chicken/7.36 km² at Lips Ranch.
I ran simulations based on my original data to determine effects of sex ratios on population estimates (30% and 15% of transmitters placed on females at TAPR and Lips Ranch, respectively). For TAPR data, I ran separate simulated estimates for 0, 10, 20, 30 (original data), and 40% of transmittered females (Table 3). For Lips Ranch data, I ran separate simulated estimates for 0, 10, 15 (original data), 20, 30 and 40% of transmittered females (Table 3). Simulations ran with no transmittered females resulted in lower population estimates than those with more females. Since confidence intervals for estimates when no females were marked at the 2 sites (CI 46-50, 76-84) do not overlap with confidence intervals when 40% of females are marked (CI 54-64, 91-109); therefore these are significantly different. Resighting frequencies for females were lower because females attended leks less often than males. A higher percentage of less frequently sighted birds (females) was associated with higher population estimates.

DISCUSSION

Although TLS is the precedence for monitoring prairie-chicken populations, it is suspect and should be reconsidered in favor of better techniques, such as mark-resight. TLS are commonly used because they require little planning and design. In addition, TLS costs are low since manpower and a vehicle are the only expenses and analysis is relatively straightforward and simple. However, there are several problems with using TLS for monitoring greater prairie-chicken populations, including disregarding sex ratio in survey design, ignoring sex differentiation when counting birds, no distinct reference area, not addressing estimation of detectability, and the downward trend of lek attendance over time. Therefore trend estimates would be undependable and inferences are ambiguous. Problems with timing of surveys and inference area (addressed in TLS
protocol) have been dealt with to some extent, however, other concerns, such as detectability, have been recognized but not addressed because of cost and manpower requirements. However, TLS provides an index of population size without any estimate of variance. The disadvantage of these indices is that management decisions may be based on questionable data. The mark-resight approach may be costly in terms of expense, manpower, and time; but this method produces more reliable results upon which to manage a declining species. Biologists should consider addressing these issues in survey design, estimate precision, and variance estimate to produce valid population trends.

My TLS results were variable (especially at TAPR) and consistently lower than mark-resight estimates. Because there was a general decline in the TLS counts over the season, earlier lek surveys would yield higher counts than those performed later. In addition to overall reductions in the number of chickens visiting a lek over the breeding season, other potential factors may be confounding counts. For example, peaks in male lek surveys may coincide with female attendance on lek and female groups may be counted as males.

Unlike lek surveys, mark-resight techniques take detectability into account (Thompson et al. 1998). I used mark-resight techniques to estimate the population and inference area of greater prairie-chickens at two sites in Kansas. I found that inference area for the population estimate can estimated by creating buffered areas around leks using radio-telemetry location data when not all leks have radio-marked birds.

My study also demonstrated that the proportion of transmitters allotted to females for mark-resight surveys was important. Detectability of females was very different from
that of males. This difference in detectability was evident in that the population estimate with no females marked was significantly lower than the population estimate with 40% of marks on females. Since proportion of females marked was important in population estimation of greater prairie-chickens, the sex ratios of marked birds should be similar to that of the local population. Local sex ratios may not reflect those in different regions. Heavy predation on females during nesting periods due to lack of good quality habitat may lower female numbers. Pilot field observations and trapping results indicate that sex ratios at my field sites were not similar to other areas. Typical percentages range from 40% - 50% females (Schroeder and Robb 1993), which were different from my sites (30 - 40%). Effort should be made to determine local sex ratios before designing a mark-resight study on prairie-chickens.

Managers interested in monitoring greater prairie-chicken populations have several alternatives. 1) A full-scale telemetry mark-resight method similar to my research may be done. This would provide information on detectability and more thorough information on inference area. 2) A color-band mark-resight approach could be used to estimate populations. Inference area could be calculated using the lek buffer technique. This method would provide information on detectability. 3) A combination of color band and telemetry mark-resight method could be used. Mark-resight studies performed in different prairie-chicken population regions (North, South, East, and West) could provide detectability averages. This could be used as a correction factor for other lek surveys. This would provide information on detectability and inference area. However, differences in land-use practices within these population regions could cause variation in detectabilities and therefore a misleading population estimate. Equal
detectability in a region would have to be proven before this technique could be used. 4) Continue using TLS as the primary method. These indices would provide faulty and misleading information concerning status and trends of prairie-chickens. Detectability and inference area would not be adequately addressed.

Greater prairie-chickens have experienced serious habitat loss and population declines since the late 1800’s (Schroeder and Robb 1993, Johnsgard 2002). It is imperative to determine a reliable population estimate in order to detect changes in population status over time. Trends based on reliable estimates could be correlated with land use practices for making management decisions. My study demonstrated that mark-resight methods provide a more accurate way to determine population status of greater prairie-chickens. Use of color bands in combination with transmitters is an alternative method. Pilot studies of local populations would be integral to study design (i.e. sex ratios and female peak visitation periods). State and federal agencies interested in monitoring greater prairie-chickens should consider using mark-resight methods, especially in local areas of severe decline, where accurate population estimates are crucial in making management decisions.
LITERATURE CITED


Figure 1. The range of the greater prairie-chicken based the results of the North American breeding bird survey (Sauer et al. 1999).
Figure 2. Lek survey results for greater prairie-chickens in the Flint Hills region, Kansas, 1963-2002 (Kansas Department of Wildlife and Parks, unpublished data).
Figure 3. Map of the survey route, known leks and pasture boundaries at Tallgrass Prairie National Preserve in the Flint Hills, Kansas.
Pastures
1. West branch
2. Gas house
3. Windmill
4. Red house*
5. Crusher hill**
6. West traps
7. Brome
8. East traps
9. Two sections
*Not burned in 2000 and 2001
**Not burned in 2002
Figure 4. Map of the survey roads, known leks, and pasture boundaries at Lips Ranch in the Flint Hills, Kansas.
Figure 5. Number of greater prairie-chickens counted using traditional lek survey in 2002 at Tallgrass Prairie National Preserve in the Flint Hills, Kansas.
Number of greater prairie-chickens

Date

28-Mar  2-Apr  7-Apr  12-Apr  17-Apr  22-Apr  27-Apr  2-May  7-May
Figure 6. Number of greater prairie-chickens counted using traditional lek survey in 2002 at Lips Ranch in the Flint Hills, Kansas.
Number of greater prairie-chickens

Date

6-Apr 11-Apr 16-Apr 21-Apr 26-Apr 1-May 6-May

0 10 20 30 40 50 60 70
Figure 7. The enclosed region represents the area of inference for the greater prairie-chicken population estimate at Tallgrass Prairie National Preserve in the Flint Hills, Kansas. Total area for population estimate is 529 km².
Figure 8. The enclosed region represents the area of inference for the greater prairie-chicken population estimate at Lips Ranch in the Flint Hills, Kansas. Total area for the population estimate is 736 km².
Table 1. Monte carlo simulations (100 repetitions) of IEJHE (immigration-emigration joint maximum likelihood estimator) calculated prior to the 2002 field season. These results were used to determine the number of transmitters and sighting occasions required for a reliable (<20% bias) estimate with an alpha of 0.05 when 100% of marked birds are identifiable. Population size estimates were based on pilot information taken from the 2001 field season at TAPR and Lips Ranch in the Flint Hills, Kansas.
<table>
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<th>Population Size</th>
<th>No. Sighting Occasions</th>
<th>Percent of Population Marked</th>
<th>Percent Seen on Each Occasion</th>
<th>Percent Bias</th>
<th>Average CI Length</th>
<th>Percent of CI Coverage</th>
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Table 2. Greater prairie-chicken population estimates with confidence intervals at Tallgrass Prairie National Preserve and Lips Ranch in the Flint Hills, Kansas, spring 2002.
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<th>Percent of Marks on Females</th>
<th>Population Estimate</th>
<th>CI</th>
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Table 3. Simulated and actual greater prairie-chicken population estimates with confidence intervals at Tallgrass Prairie National Preserve and Lips Ranch in the Flint Hills, Kansas, spring 2002. Simulated population estimates marked with an asterisk are based on the original data.
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