**An interim assessment of LEPC Population Dynamics and Trends—1 June 2012**

**An Assessment of Population Dynamics and Persistence of Lesser Prairie-Chickens**

**A Recommendation and analysis to The Lesser Prairie-Chicken Interstate Working Group**

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**Issue:** Each state monitors spring populations of lesser prairie-chickens (LEPCs) with similar (but not exact) methods to detect and count birds on leks. Additionally, sampling effort has varied overtime with generally more extensive efforts in recent years. Thus far, comparison between or among states has not been possible because of these facts.

**Need:** A unifying analytic method for assessing trend of LEPC populations among states and geographic regions is needed to evaluate past and future population performance as a result of conservation actions or changes in land use.

**A proposed method:** There have been 3 range-wide assessments of greater sage-grouse population dynamics and persistence (Connelly et al. 2004, WAFWA 2008, Garton et al. 2010), and similar issues of data consistency and variation in sampling effort were common to all three studies. Garton et al. (2010) is the only peer reviewed published article from the three, and was largely based on the analytic methods in Connelly et al (2004). Using population reconstruction from annual counts at leks, density dependent (Dennis et al. 1991) and independent (Staples et al. 2004) models of population growth can be fit and population parameters of growth ($\lambda_t$), population equilibrium, and quasi-extinction probabilities can be estimated.

In this example, data were pooled by 4 geographic regions, sand sagebrush (CO, KS), CRP-shortgrass prairie (KS), mixed grass prairie (SE KS, OK, TX-Panhandle), and shinnery oak (NM, TX west) in which to estimate annual rates of change ($\lambda_t$), average growth rate (trend from 1997-2011), variation of ($\lambda_t$), quasi-extinction probability (population drops to 25% of equilibrium), and population equilibrium. Data across all regions was pooled to assess trend and estimate population parameters for the entire LEPC range. Finally, concern has been generated regarding declines in populations in 2012. To address this concern, a worked example assuming a 50% decline (2012 trends have not been finalized yet) in trend rangewide occurred is provided to demonstrate what affect it may have on the entire range.

LEPC lek counts reported by individual states were summarized within ecologic regions and used to reconstruct an index to the historical abundance of the population within each zone. We treated the number of LEPC counted at leks in the final year as an index to the minimum number of LPEC attending leks. Lek counts in each year were a cluster sample of LEPC and thus treated by standard finite population sampling procedures (Scheafer et al. 1996: 297).

Sampling effort devoted to counting leks has varied enormously from year to year and grown appreciably in the last 5 years. To standardize estimates and remove bias due to variable sample sizes we treated the number of LEPCs counted in the initial count (or another base year if final year counts were inadequate) as the standard for projecting later counts by applying a ratio estimator (Scheafer et al. 1996: 200) to estimate the finite rate of change ($\lambda_t$) for the population between successive years as follows. Beginning with the initial year of a route (1997 or more recent), LEPC counted along each route censused in both 1997 and 1998 were treated as cluster samples of individual LEPCs in successive years. The ratio of LEPCs counted in a pair of successive years estimates the finite rate of change at each route in that one year interval ($\lambda_t$). These ratios were combined across routes within a region for each year to estimate the finite rate of change for the entire population within a zone to estimate the finite rate of change for that management zone between successive years (e.g. 1997 to 1998):
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\[
\lambda(t) = \frac{\sum_{i=1}^{n} M_i(t + 1)}{\sum_{i=1}^{n} M_i(t)}
\]

\[\text{where } M_i(t) = \text{number of LEPC counted along route } i \text{ in year } t, \text{ across } n \text{ routes counted in both years } t \text{ and } t+1,\]

Because methodologies were not exact, an average \( \lambda_i \) was calculated among routes and states for each region. Unlike previous methods, that reconstructed populations from the penultimate year backwards, in this method the index to population size was projected forward from 1997 to assess trend since LEPC were classified as a candidate as a threatened or endangered species. This approach does not affect the rates of change or persistence estimates, but provides a baseline more meaningful to the conservation question at hand. Because population sizes were not well described in 1997, and the method is based on proportional changes of ratios, all trends were assessed as a percentage of the 1997 index which was set to 100% (See Connelly et al. 2004). The index to population size for subsequent years was then calculated by taking the number of LEPCs counted in the initial year (1997) as a baseline estimate of population size within a region and projecting the next year’s minimum LEPC abundance by multiplying the 1997 abundance by the ratio estimator of the finite rate of change from 1997 to 1998 (e.g. finite rate of change of 0.81 between 1998 and 1999 suggested that the 19% fewer LEPC were counted at leks in 2000 than in 1999). This process was repeated for the change from 2000 to 2001 (finite rate of change of 1.015) yielding a breeding population index for a given zone in 2001 and so on up to 2011. Repeating this process for each management zone yielded a population index for each zone stretching from 1997 to 2011 for populations in all regions. These population indices provided the basis for all further analyses and modeling.

**Fitting population growth models**

Using the time series of population indices for each region, 2 stochastic population growth models were fit including: (1) exponential growth with process error (EGPE, Dennis et al. 1991), (2) exponential growth state space (EGSS, Staples et al. 2004) which incorporates both process and sampling error, and most importantly allows for the parsing of these error rates for more precise estimates of population persistence.

**Results:**

CRP-shortgrass.—There were 3 routes established to monitor trends of LEPC in the CRP grasslands north of the Arkansas River in Kansas beginning in 2000. The 10-yr average annual finite rate of population change (\( \lambda_\text{CRP} \)) indicated population growth of 4.4% annually (Figure 1A; Table 1). The equilibrium of a density dependent population was approximately 99% of the baseline in 2000, and the probability of extinction (declining to 25% of equilibrium) was 2%.

Mixed-grass prairie.— There were 6 routes to monitor LEPC in the mixed-grass prairies of KS, OK, and TX, 2 of which began in 1980 in KS. The 10-yr average annual finite rate of population change (\( \lambda_\text{MG} \)) indicated population growth of 7.0% annually (Figure 1B; Table 1). The equilibrium of a density dependent population was approximately 229% of the baseline in 1997, and the probability of extinction (declining to 25% of equilibrium) was <0.0001%.

Sand sagebrush prairie.— There were 7 routes to monitor LEPC in the mixed-grass prairies of KS and CO both of which began prior to 1980 in KS. The 10-yr average annual finite rate of population change (\( \lambda_\text{SS} \))
indicated population growth of 2.0% annually (Figure 1C; Table 1). The equilibrium of a density dependent population was approximately 183% of the baseline in 1997, and the probability of extinction (declining to 25% of equilibrium) was 48%.

Sand shinnery oak.—There were 29 routes to monitor LEPC in shinnery oak habitat of NM and TX. The 10-yr average annual finite rate of population change ($\lambda_t$) indicated population growth of 5.1% annually (Figure 1D; Table 1). The equilibrium of a density dependent population was approximately 196% of the baseline in 1997, and the probability of extinction (declining to 25% of equilibrium) was < 0.0001%.

Range-wide.—There were 45 routes to monitor LEPC across the range. The 10-yr average annual finite rate of population change ($\lambda_t$) indicated population growth of 10.6% annually (Figure 1E; Table 1). The equilibrium of a density dependent population was approximately 276% of the baseline in 1997, and the probability of extinction (declining to 25% of equilibrium) was < 0.0001%.

Range-wide 2012.—Assuming a 50% decline in trend across the range, the 10-yr average annual finite rate of population change ($\lambda_t$) indicated population growth of 6.4% annually (Figure 1F; Table 1). The equilibrium of a density dependent population was approximately 262% of the baseline in 1997, and the probability of extinction (declining to 25% of equilibrium) was 3.3%.

Summary.—Regionally populations continue to show significant signs of population growth, however, because of low rates of growth and large variation in estimates of lambda, sand sagebrush habitat (14% of species distribution) was one region that indicated the greatest likelihood of reaching 25% or less of the equilibrium population size. Thus, 86% of the species’ distribution exhibits population growth (>2% annually) with low probability of extinction. Range-wide analysis indicates the species as whole has grown at a rate of 10.6% since 1997 with low probability of extinction. Lastly, if the range-wide population trends did decrease by as much as 50% in 2012, populations are projected to be 73% greater than in 1997, and likelihood of population persistence remains high (>96%).

A peripheral examination of population trends prior to the 1997 candidate status recommendation, indicates that on average populations from 1980-1997 were declining at an average annual rate of 3.7%, post candidate status population growth was 6.9% increase annually.

**Further refinements:** There are 3 recommendations to make this modeling approach more rigorous with the existing data: 1) to analyze the data on a lek by lek analysis rather than at the route or county scale, 2) where longer term data exist develop models for longer time periods that specifically identify significant transitions in trend (upwards or downwards), to better understand temporal factors that may be affecting different historic periods and changes in land use, and 3) once population estimates are available from aerial surveys in 2012 then trend analyses and PVA can be conducted relative to population size and trends beginning in 2012 and projecting backwards. This approach would be almost identical to that of greater sage-grouse PVA conducted by Garton et al. (2010).

Literature cited.


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Figures

Figure 1A. Lesser prairie-population index for CRP Landscapes from 2001-2011, quantified as a percentage of the 2001 baseline population.

Figure 1B. LEPC in Mixed Grass Prairie.
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Figure 1B. Lesser prairie-chicken population index for mixed grass-prairie landscapes from 1997-2011, quantified as a percentage of the 1997 baseline population.

Figure 1C. Lesser prairie-chicken population index for sand sagebrush landscapes from 1997-2011, quantified as a percentage of the 1997 baseline population.

Figure 1D. Lesser prairie-chicken population index for sand shinnery oak landscapes from 1997-2011, quantified as a percentage of the 1997 baseline population.
Figure 1E. Lesser prairie-chicken Range-wide population index from 1997-2011, quantified as a percentage of the 1997 baseline population.

Figure 1F. Hypothetical lesser prairie-chicken Range-wide population index from 1997-2012 assuming a 50% decline from 2011-2012, quantified as a percentage of the 1997 baseline population.
Table 1. Parameter estimates from density dependent (Dennis et al. 1991) and independent (Staples et al. 2004) population models for Lesser Prairie-Chickens in 4 regional areas 1997-2011. Range-wide estimates are provided for the same time period, and a hypothetical example demonstrating what a 50% decline in 2012 might forecast for the species. Where, $r =$ instantaneous rate of growth adjusted for sampling variation, $se(r)$ standard error of $r$, $r' = $ unadjusted instantaneous rate of growth, $\lambda =$ finite rate of population growth ($\exp(r)$), $n_q =$ population equilibrium under density dependent model, $n_e(n_u) =$ quasi-extinction threshold (25% of of $n_q$), $pi =$ probability of population reaching $n_e(n_u)$, $\theta =$ time in which $n_e(n_u)$ would be reached if threshold was reached, and $\%EOR =$ percentage of the Estimated Occupied Range these trend results represent.

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<th>Region</th>
<th>$r$</th>
<th>$se(r)$</th>
<th>$r'$</th>
<th>lambda</th>
<th>$n_q$</th>
<th>$n_e(n_u)$</th>
<th>$pi$</th>
<th>$\theta$</th>
<th>$%EOR$</th>
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