DEPARTMENT OF MATHEMATICS
TECHNICAL REPORT

DECADAL DECLINE (1992-2002)OF LOGGERHEAD SHRIKES ON CHRISTMAS BIRD COUNTS IN ALABAMA, MISSISSIPPI, AND TENNESSEE

DR. STEPHEN J. STEDMAN
AND
DR. MICHAEL ALLEN

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TENNESSEE TECHNOLOGICAL UNIVERSITY
Cookeville, TN 38505

Decadal Decline (1992-2002) of Loggerhead Shrikes on Christmas Bird Counts in Alabama, Mississippi, and Tennessee

Stephen J. Stedman, Department of English, Box 5053, Tennessee Technological University, Cookeville, TN 38505

Michael R. Allen, Department of Mathematics, Box 5054, Tennessee Technological University, Cookeville, TN 38505

Introduction

Most major works discussing the population status of the Loggerhead Shrike *(Lanius ludovicianus*) in North America indicate that this predatory songbird has declined in population numbers at a rate of >2%/year since at least the mid-1960s through the mid-1980s or later (Root 1988; Price *et al*. 1995; Yosef 1996; Lefranc 1997; Pardieck and Sauer 2000). The most recent major works discussing the status of the shrike in Alabama (Imhof 1976) and Tennessee (Robinson 1990; Nicholson 1997) also refer to its declining population numbers; the major work for Mississippi (Toups and Jackson 1987) does not deal with the species' population status as a focal point and so does not mention this matter. Nearly all the aforementioned works offering discussions about the population status of this species base comments on various population data, mainly from Breeding Bird Surveys (BBS) and Christmas Bird Counts (CBC), acquired no later than the mid-1990s; only one source (Pardieck and Sauer 2000) provides commentary based on data acquired during the late 1990s, and in this case the data are derived from the BBS. Therefore, an update of the shrike's status in Alabama, Mississippi, and Tennessee based on the most recent CBC data appears warranted, especially in light of the continuing decline in the shrike's population numbers.

Methods

To provide a basis for statistical analysis, CBC data from each these states were collected from the "Historical Results" section of the National Audubon Society (2002) website. Data were used from counts that were conducted every year from 1992 to 2002, resulting in a dataset derived from 11 years of counts from 11 sites in Alabama, 11 in Mississippi, and 15 in Tennessee. The total number of shrikes counted during each year for each state and for the three states combined was obtained (Table 1).

Statistical Analysis

The statistical objective of this study was to determine if there was a significant downward trend in Loggerhead Shrike population counts for the years 1992 through 2002. These 11 years of count data were collected from 11 sites in Alabama, 15 in Tennessee and 11 in

Mississippi for a total of 37 sites and 407 overall observations. Although the yearly counts per site resemble a time series both graphically (Figure 1) and intuitively, this time dependent structure was weak enough to avoid the use of a more complicated time series model. Hence, multiple regression analysis was the method of choice because of its simplicity and robustness. Also, combining all the sites from the three states into one data set increased the power of the resultant hypothesis test, and the diagnostics showed that the assumptions of normality and independence were only slightly violated, if at all.

Second, the original count data Y was transformed using the natural log to alleviate the problem of exploding variance and non-normality (Neter *et al*. 1996).

Finally, the multiple regression model used in this study to test for the possible downward trend in Loggerhead Shrike populations is given as

$$Y_i = b_0 + b_1 X_{1i} + b_2 X_{2i} + b_3 X_{3i} + b_4 X_{1i} X_{2i} + b_5 X_{1i} X_{3i} + e_i$$

where

Y_i is the log of the number of shrikes recorded at each site,
b_0 is the y intercept
b_1 is the change per year of the average of Y_i, called $E(Y_i)$
b_2 is the change in b_0 for sites in Tennessee
b_3 is the change in b_0 for sites in Mississippi
b_4 is the change in $E(Y_i)$ for sites in Tennessee
b_5 is the change in $E(Y_i)$ for sites in Mississippi
X_{1i} is the year,
X_{2i} is 1 if a Tennessee site, 0 otherwise,
X_{3i} is 1 if a Mississippi site, 0 otherwise,
e_i is the error term for the i^{th} data point, and
$i = 1,...,407$.

In the above model it is obvious that no parameters seem associated with Alabama. This, in fact, is not the case. If any of the extra parameters (b_2 - b_5) are found to be significant, then b_0 and b_1 would represent the intercept and slope for Alabama. Conversely, if all of the extra parameters are not found to be significant, then b_0 and b_1 simply represent the overall intercept and slope.

Results

Graphically, the data indicate a downward trend in the shrike population sampled by Alabama CBCs (Figures 1 and 2). Although similar trends were realized in the graphs for the Tennessee data and slightly less so for the Mississippi data, those figures are not presented here

because the Alabama set was a good representative. Data from all three states are plotted along with the line of best fit and a 95% confidence band (Figure 3).

Statistically, the above model as applied to the data gave these results:

Parameter	Estimate	Standard Error	p-value	Dropped from the model?
b_0	128.46	51.96	0.0138	No
b_1	-0.06	0.03	0.0158	No
b_2	-41.15	73.48	0.5758	Yes
b_3	25.08	68.40	0.7141	Yes
b_4	-0.01	0.03	0.6995	Yes
b_5	0.02	0.04	0.5733	Yes

In summary, the results indicate that for the years 1992 through 2002 there is no significant difference among the three states (*i.e.*, the three states have about the same shrike population sizes and if any trend in the size of the shrike population exists, all three states reflect roughly the same trend). Second and most importantly, there appears to be a slight downward trend in the average population count, giving an estimated decrease of 6% per year after untransforming the data. In fact, when parameters b_2 - b_5 in the above table are removed from the model, the p-value for b_1 becomes 0.0007, indicating substantially stronger statistical significance than if they remain.

Discussion

Data were analyzed for years beginning in 1992, but it should not be assumed that the shrike population in these states in 1992 represented a baseline of population abundance. Rather, this year was selected because the number of counts with continuous coverage was greatest if the data were derived from that point in time onward. Shrikes have been decreasing in population numbers for many decades; the current analysis covers only the decrease occurring within the past decade.

Conclusion

The wintering Loggerhead Shrike population sampled by CBCs in Alabama, Mississippi, and Tennessee showed, roughly, a 6% decrease per year from1992 through 2002. As for any future population counts, regression analysis of this type does not lend itself well to prediction beyond the range of the explanatory variables. Hence, the above decrease cannot be relied upon as a good estimate of future population counts but does show cause for continuing concern about this predatory songbird.

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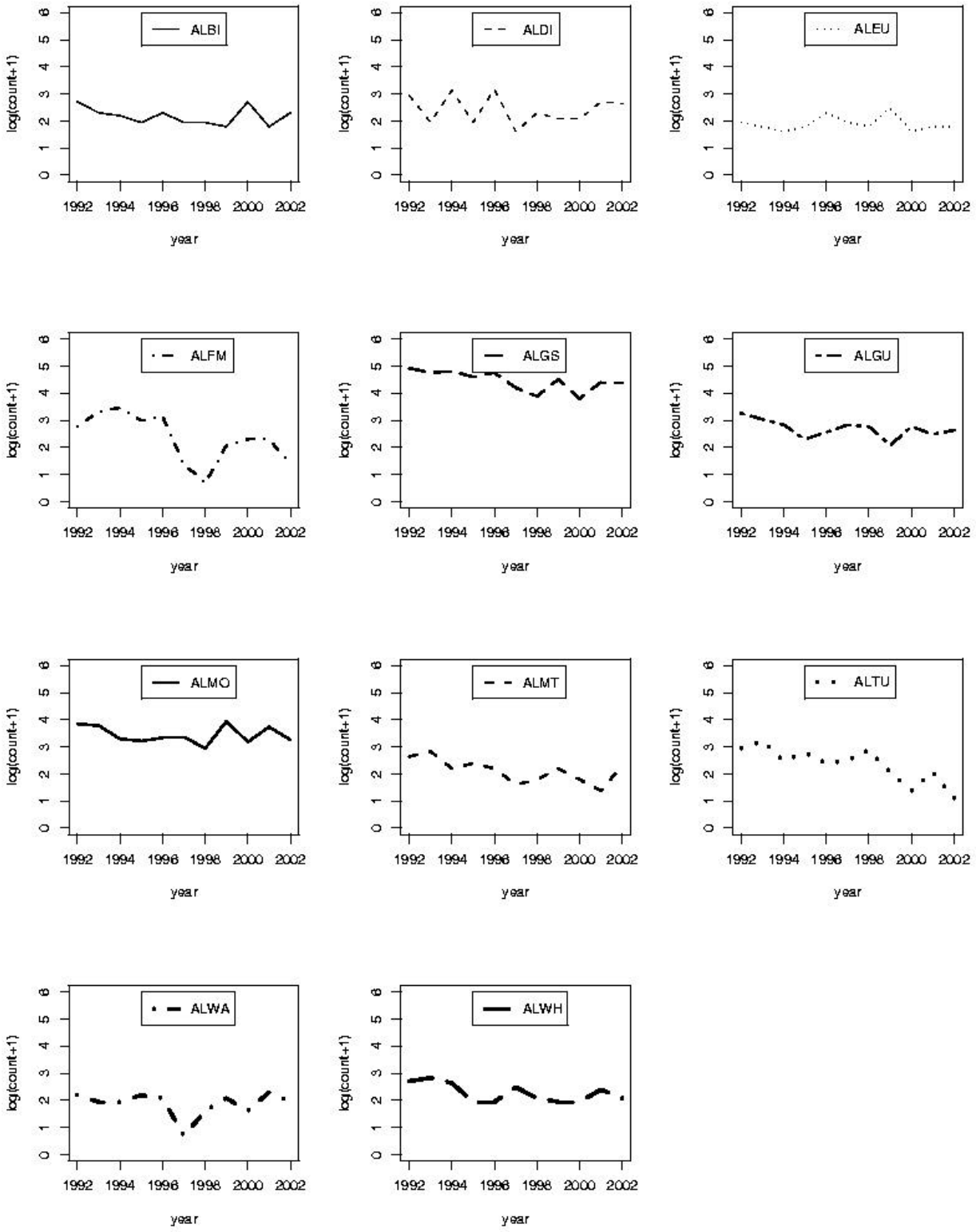
Table 1. Total Loggerhead Shrikes recorded on Christmas Bird Counts in Alabama, Mississippi, and Tennessee 1992-2002.

	1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Tennessee	144	78	97	81	53	49	57	72	51	52	56
Mississippi	283	262	250	213	249	237	211	214	173	183	246
Alabama	314	288	268	207	249	156	135	207	134	195	173
3-State Total	**741**	**628**	**615**	**501**	**551**	**442**	**403**	**493**	**358**	**430**	**475**



Figures 1a-k. Line graphs presenting Loggerhead Shrike data for all Alabama CBCs conducted in all years 1992-2002.

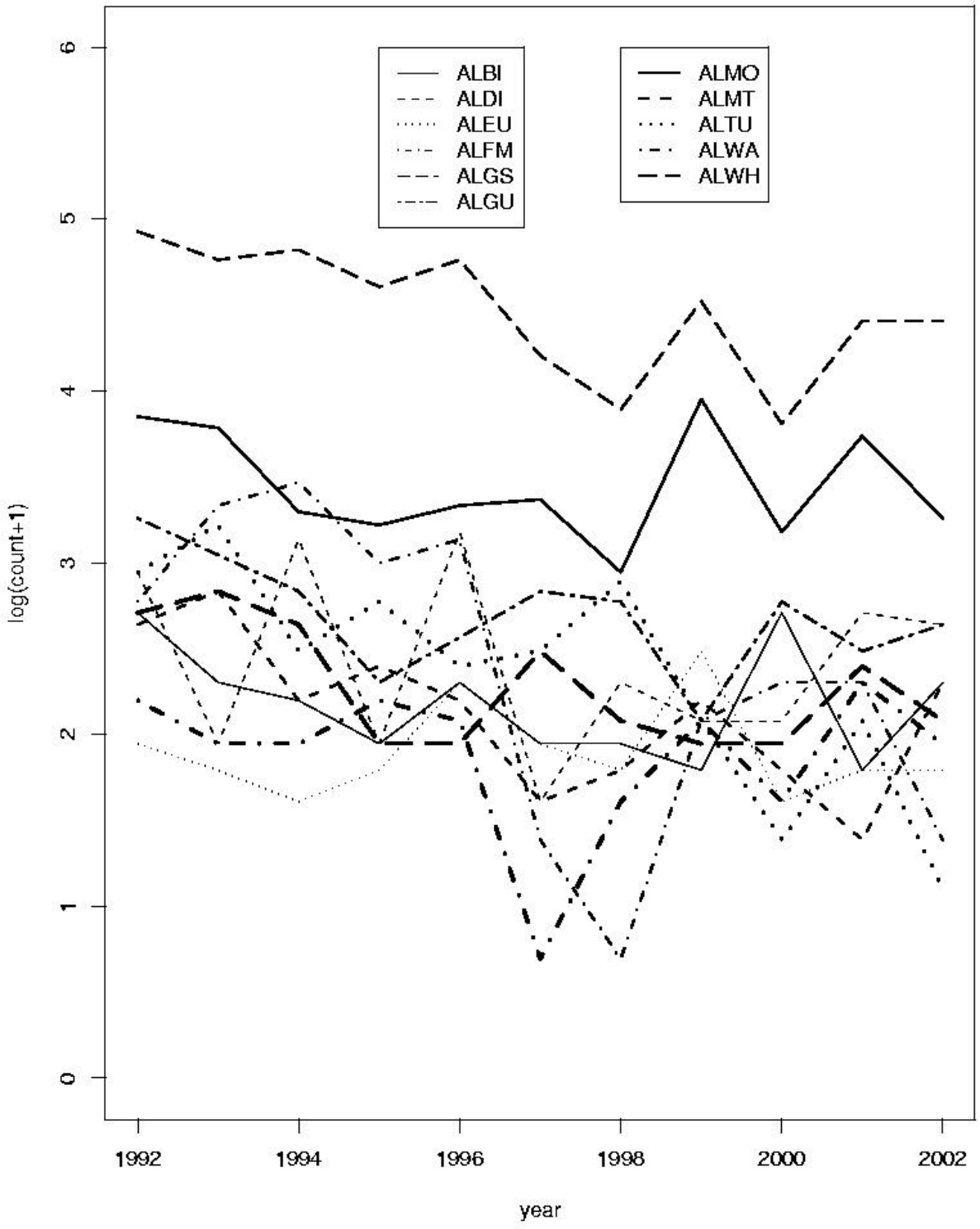


Figure 2. Multiple line graph for all Alabama CBC Loggerhead Shrike data 1992-2002.

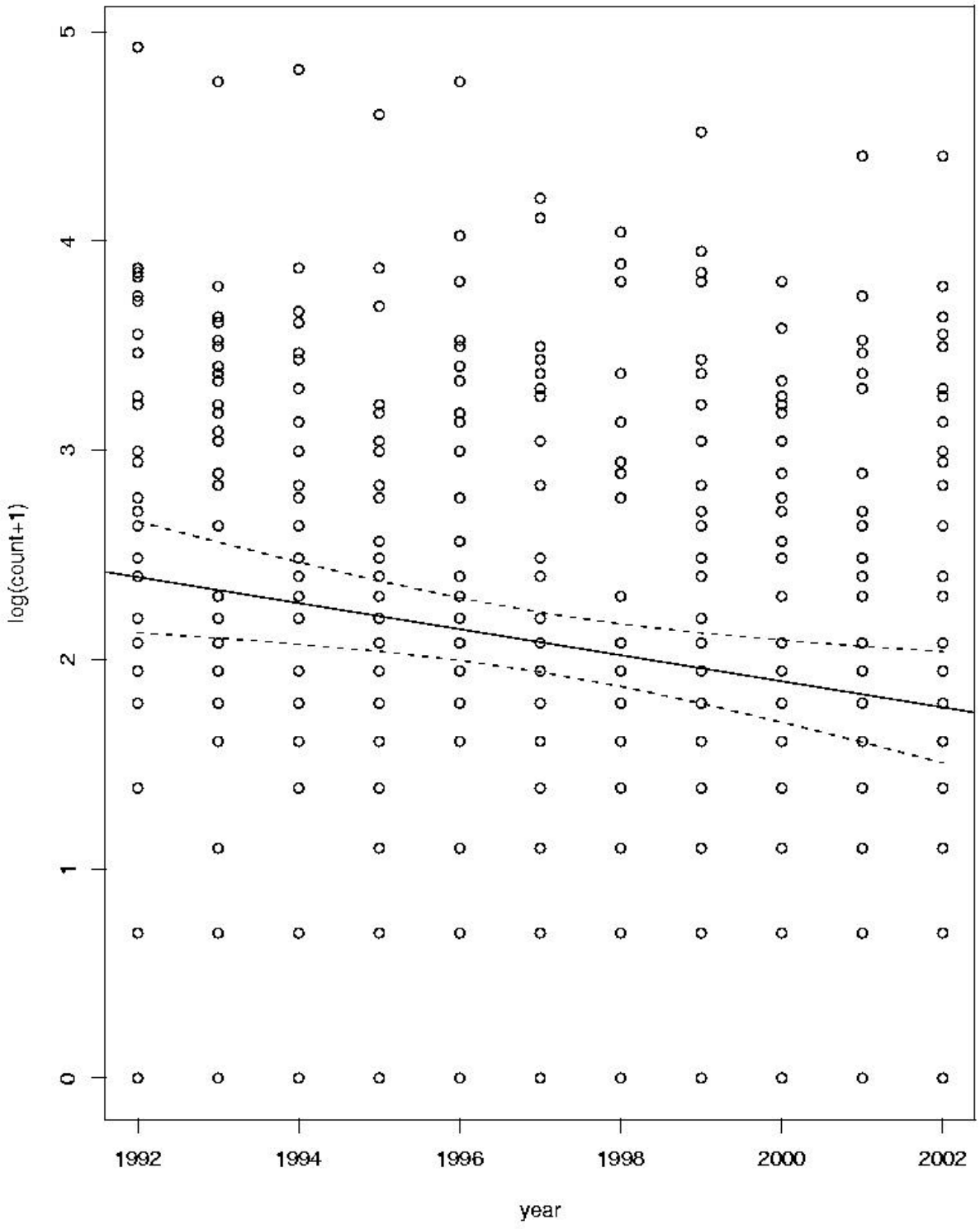


Figure 3. Scatter plot presenting all CBC 1992-2002 Loggerhead Shrike data for Alabama, Mississippi, and Tennessee with regression line estimate and 95%-confidence band.