Population Trends of the Loggerhead Shrike in California: Possible Impact of West Nile Virus in the Central Valley

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INTRODUCTION

The Loggerhead Shrike (*Lanius ludovicianus*) is of significant conservation concern across nearly all its range (Yosef 1996, U.S. Fish and Wildlife Service 2002). This species shows long-term, widespread, and highly significant population declines (Morrison 1981, Peterjohn and Sauer 1995, Cade and Woods 1997). Christmas Bird Count (CBC) and Breeding Bird Survey (BBS) data document declines in most of California (Sauer et al. 1995, Humple 2008), including the Central Valley (CV) (Sauer et al. 2005, Pandolfino 2006). Various authors cite habitat loss, pesticides, or other environmental contaminants as possible causes for the decline of this species in North America (Yosef 1996).

Following its introduction in 1999, West Nile Virus (WNV) spread rapidly across North America (McLean 2006) reaching California in 2002 (Reisen et al. 2004). During the summer of 2004, California Public Health agencies documented thousands of WNV-infected birds (http://www.westnile.ca.gov/). Rates of infection peaked in the CV during the summer of 2005 and declined in subsequent years. Airola et al. (2007) and Crosbie et al. (in press) documented the impacts of WNV on populations of the Yellow-billed Magpie (*Pica nuttalli*), Western Scrub Jay (*Aphelocoma californica*), American Crow (*Corvus brachyrhynchos*), and Oak Titmouse (*Baeolophus inornatus*) in the CV. The Loggerhead Shrike is also susceptible to WNV (Bertelsen et al. 2004, Tesh et al. 2004). However, to date, no published studies document impacts of WNV on populations this species.

METHODS

To look for possible effects of WNV on Loggerhead Shrike numbers, I used two approaches. First, I analyzed trends in the numbers of Loggerhead Shrikes recorded on CBCs and BBS routes within the CV to look for statistically significant changes after WNV first appeared in California. Second, I divided counties into areas of high or low WNV infection and then compared trends in CBC data from those counties.

Data Sources

I obtained CBC data from the National Audubon Society's online data base (http://www.audubon.org/bird/cbc/index.html) and BBS data from the U.S. Geological Survey North American Breeding Bird Survey online data base (http://www.pwrc.usgs.gov/bbs/). For analyses of CBC data, I used count circles with an average of at least 5 Loggerhead Shrikes per year from Count Year 77 (winter 1976-77) through Count Year 108 (winter 2007-08). I normalized CBC data using party hours. I used BBS data from routes that were run in either 2006 or 2007 and that averaged at least 1 Loggerhead Shrike per year from 1976 through 2007. I obtained data on number and percent of dead birds that tested positive for WNV by county from the California Department of Public Heath West Nile Virus web site (http://www.westnile.ca.gov/). Banding data were obtained from the U.S. Geological Survey Bird Banding Laboratory (http://www.pwrc.usgs.gov/BBL/homepage/start.htm).

CV CBC Circles

For analysis of CV trends, I used data from the following CBC circles: Bakersfield, Benicia, Caswell-Westley, Chico, East Contra Costa, Folsom, Kern-Buena Vista, La Grande-Waterford, Lincoln, Los Banos, Lost Lake-Fresno, Marysville, Milburn-Fresno, Oroville, Peace Valley, Putah Creek, Rio Cosumnes, Sacramento, Stockton, and Wallace Bellota. However, I omitted data from Marysville prior to Count Year 101 because the number of party hours for those years was inadequate (average <13 party hours/count).

Assignment of CBC Circles to high and low WNV Infection Regions

To analyze CBC data from areas with high levels of WNV infection, I first determined the counties throughout the state from which more than 40% of dead birds were confirmed as positive for WNV during 2005, 2006, or 2007. Of the state's 58 counties, 23 met that criterion. I then used the following CBC circles located within those counties to represent areas of high WNV infection: Calero-Morgan Hill, Caswell-Westley, Chico, Folsom, Idylwild, La Grange-Waterford, La, Purisima, Lincoln, Los Banos, Marysville, Orange County Coast, Orange County Northeast, Oroville, Palo Alto, Peace Valley, Putah Creek, Rio Cosumnes, Sacramento, San Jacinto Lake, San Jose, San Juan Capistrano, Santa Ana River Valley, Santa Barbara, Santa Maria-Guadalupe, Spring Valley, Stockton, and Wallace-Bellota.

To analyze CBC data from areas with low levels of WNV infection, I first determined the counties from which the percent of dead birds confirmed as positive for WNV never reached 25% in any of the three years (2005, 2006, and 2007). Thirteen counties met these criteria. I then used the following CBC circles located within those counties to represent areas of low WNV infection: Año Nuevo, Claremont, Contra Costa, Crystal Springs, East Contra Costa

County, Hayward-Fremont, Joshua Tree, Lancaster, Long Beach, Los Angeles Basin, Malibu, Mojave River Valley, Morongo Valley, Oakland, Palos Verdes, Pasadena-San Gabriel Valley, Redlands, San Bernadino Valley, San Fernando Valley, Santa Cruz, Thousand Oaks, and Ventura.

The criteria for assigning counties as areas of high or low WNV infection were more or less arbitrary. The intent was to include in the high infection category only those counties that experienced at least one year of high levels of WNV infections and to include in the low infection category only those counties that did not experience significant levels of infection in any of the three years. In addition, I selected infection rates for categories to provide similar numbers of CBC circles in each group for analysis.

Deviations from Historical Trends

I evaluated the deviation of the abundance of Loggerhead Shrikes during the years after the summer of 2005 from historical trends using multiple regression analysis by a method analogous to that of Airola et al. (2007). While those authors used a second order polynomial to represent historical trends, I used a linear equation. Analyses were performed using the Data Analysis Package of Microsoft Excel.

Comparison of CV and Other Statewide Counts

To compare the general rates of infection of birds in the CV to other areas of the state, I used the χ^2 goodness-of-fit test to compare CV to non-CV counties using both the percent of dead birds that were confirmed to be infected with WNV and the total number of infected birds as a function of county population (based on 2006 California Department of Finance data http://www.csac.counties.org/default.asp?id=399). Therefore, the percent of dead birds infected or the total infected birds as function of county population were compared for CBCs within CV and non-CV counties.

Banding data

I examined banding data on Loggerhead Shrikes in California, including 52 encounters with banded Loggerhead Shrikes which had either been banded or encountered within California (data from USGS Bird Banding Laboratory: http://www.pwrc.usgs.gov/bbl/.).

RESULTS AND DISCUSSION

The winter abundance of the Loggerhead Shrike in the CV dropped dramatically in the three years following the summer of 2005 (Figure 1). The decline was substantial and statistically significant for two of those three years (Table 1), with the decline in Count Year 106 approaching significance. The analysis of abundance data from California CBC circles in counties with high and low WNV infection levels (Figure 2) showed that the CBC circles from high-WNV counties showed consistently larger declines than the circles from low-WNV counties, although none of the observed declines were statistically significant (Table 1). The Loggerhead Shrike abundance from California BBS routes for the two years after 2005 is below the historical trend line (Figure 3), but this difference was not statistically significant (Table 1). It was not possible to compare BBS routes from high-WNV to low-WNV counties because the inconsistent coverage of many BBS routes produced a very small number of routes with data suitable for analysis.

A review of data from selected CV CBC circles shows the widespread nature of the decline of the last three years: Lincoln averaged 39 shrikes per year for its first three years (Count Years 103-105), and dropped to 9 per year for the last three (Count Years 106-108); Peace Valley averaged 36 shrikes for the ten years prior to Count Year 106, but only 16 for the last three years; Rio Cosumnes averaged 63 for that same ten-year period and 30 in the past three years; Lost Lake-Fresno went from a ten-year average of 25 shrikes to 7; Kern-Buena Vista from 41 to 12 (not run Count Years 93-99); and Bakersfield dropped from a ten-year average of 28 shrikes per year to 7.

The observation that the declines in shrike abundance were more significant in the CV than elsewhere in the state is consistent with the observation that the 11 counties that comprise the CV were more highly impacted by WNV than non-CV counties. The comparison of infection rates of birds in the CV and

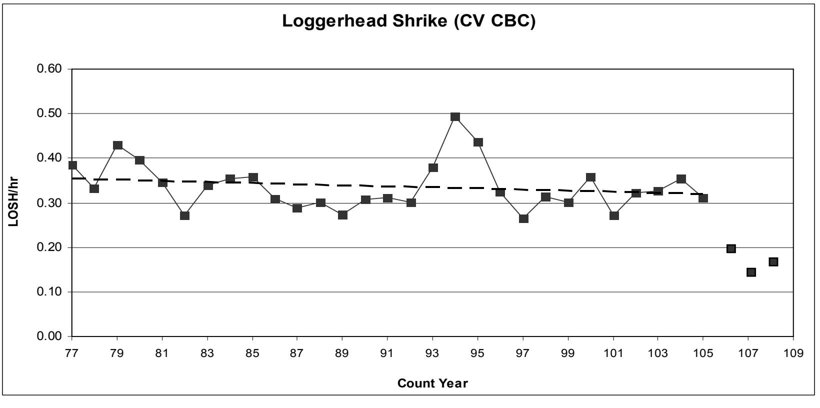
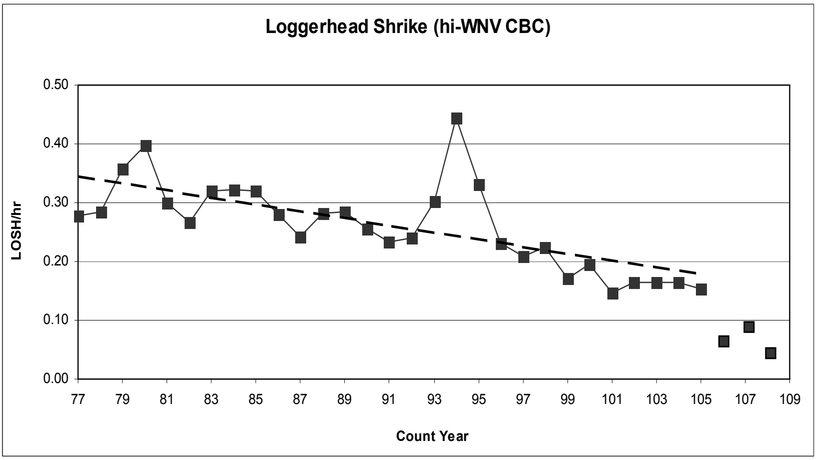


Figure 1: Loggerhead Shrike abundance from CV CBC circles with trend line for Count Years 77-105 and values for Count Years 106, 107, and 108.



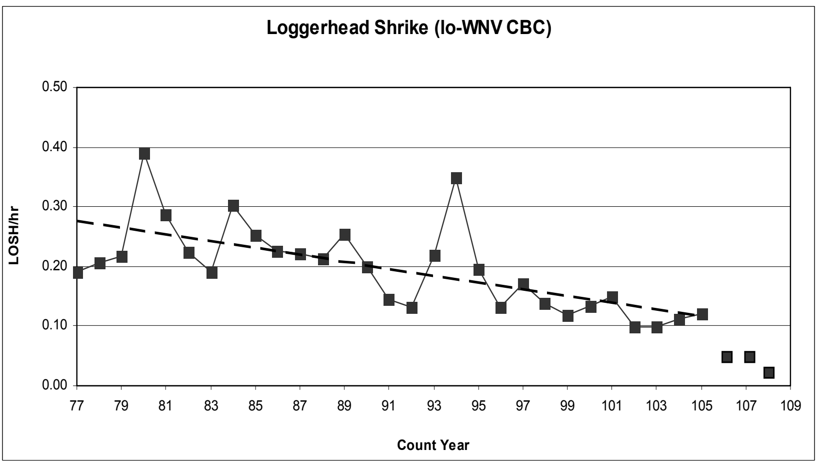


Table 1. Changes in Loggerhead Shrike abundance recorded on selected Christmas Bird Counts (CBCs) and Breeding Bird Surveys (BBS) over three years compared to the abundance predicted from the historical trend (see Figures 1, 2, and 3).

	Count Year 106 (2005) change vs. predicted	p	Count Year 107 (2006) change vs. predicted	p	Count Year 108 (2007) change vs. predicted	p
CV CBCs	-31%	0.09	-44%	0.02	-42%	0.03
Hi-WNV CBCs	-41%	0.24	-30%	0.41	-43%	0.26
Lo-WNV CBCs	-17%	0.76	-15%	0.80	-35%	0.58
BBS (all CA)			-17%	0.65	-45%	0.25

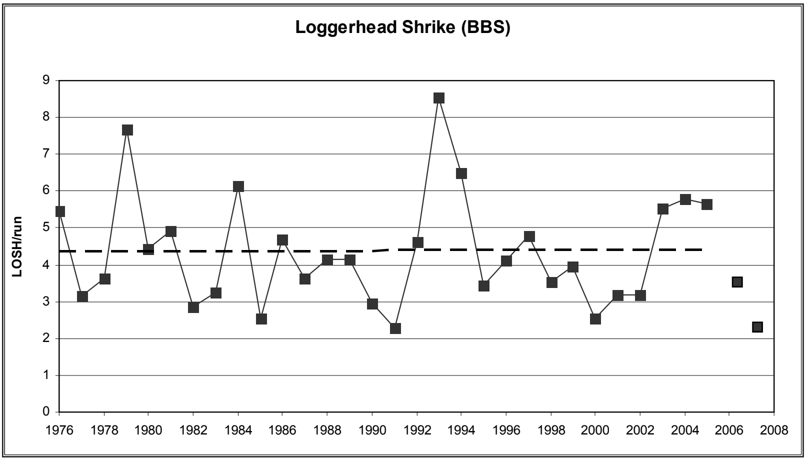


Figure 3: Loggerhead Shrike abundance from California BBS routes with trend line for years 1977-2005 and values for 2006 and 2007.

elsewhere showed that CV counties were more likely to have higher infection rates than non-CV counties, based on the percent infected birds ($\chi^2_{1\ d.f.} = 32.89$, $p<0.0001$) and infected birds found per capita ($\chi^2_{1\ d.f.} = 11.55$, $p = 0.0007$).

In order for this apparent correlation between levels of WNV infection and declines in Loggerhead Shrike numbers on CBCs to be significant, one must assume that this species is relatively sedentary. That is, the same individuals present during summer (when most WNV infections occur) must remain in the same area through winter (when CBCs are conducted). Examination of banding data showed that, in all cases, birds banded in the state were also encountered in the state and no bird found in California was banded elsewhere. After eliminating all encounters that occurred within 120 days of banding (to exclude within-season recaptures), 30 encounters remained. Of these, 24 (80%) were in the immediate vicinity of banding and only two encounters (6.7%) occurred more than 100 km from the banding site. These banding data suggest that this species is sedentary in most of the state.

Another observation that illustrates the sedentary nature of the Loggerhead Shrike population within California is the fact CBC and BBS data show spikes of Loggerhead Shrike abundance for the breeding season of 1979 and the following winter (1979-80) and for the breeding season of 1993 and the following winter (1993-94). The fact that two separate sets of CBC data from different circles (Figure 2) and the completely independent BBS data set (Figure 3) all show simultaneous spikes in abundance suggests a direct connection between the winter and summer populations. The cause of these peaks in abundance is unknown.

Although Corvids (members of the family Corvidae: crows, magpies, jays, etc.) are most frequently reported as victims of WNV (McLean 2006), many other species are susceptible to the virus. The lack of studies showing WNV impacts on the Loggerhead Shrike may reflect the fact that dead shrikes are less likely to be found and reported than Corvids. Most Corvids are larger, more conspicuous, and more abundant than shrikes. Corvids are also commonly found in urban and suburban areas where the chance of a carcass being discovered is greater than it would be in the rural areas frequented by shrikes.

The results presented here support the conclusion that WNV has had a role in the decline of the Loggerhead Shrike in the CV since 2005. Examination of the long-term average abundances, however, demonstrates a persistent decline for a considerable period before WNV arrival. This persistent decline is presumably due to other causes such as habitat loss or other unknown factors (Pandolfino 2006). Importantly, this analysis indicates that WNV effects have been additive to the previous factors and thereby accelerated the ongoing decline in the CV population. The impact of WNV on the Loggerhead Shrike demonstrated by this study, in the context of the conservation concern for this species across North America, warrants similar retrospective analyses focused on other areas of high WNV incidence. More attention to effects of WNV on the Loggerhead Shrike may reveal more precisely the significance of this threat.

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