Spatiotemporal Patterns of Decline of the Loggerhead Shrike in Virginia

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ABSTRACT

Loggerhead Shrikes (lanius ludovicianus) *have declined for decades and are a threatened species in Virginia. To understand when and where shrike population losses have occurred in Virginia, we analyzed Breeding Bird Survey (BBS) data for Loggerhead Shrikes from 1966-2013 (n=29 routes). The highest number of shrikes was reported by BBS in the central region (n=7 routes with 71 shrikes), south central region (n=4 routes with 90 shrikes) and southeast region (n=2 routes with 41 shrikes), accounting for 77% of total shrikes reported. Beginning in the late-1970's Loggerhead Shrikes began disappearing from BBS routes where their numbers had been highest. Losses of shrikes swept from east to west, with the last BBS reported shrike in the western region of Virginia in 2012. We compared BBS results to other sources of data on shrike distribution: the first Virginia Breeding Bird Atlas (VABBA) (1985-1989), Christmas Bird Count (CBC), bird banding records, and shrike sightings reported in* Virginia Birds. *The CBC shows exponential decline of Loggerhead Shrikes, with Virginia losing approximately half its wintering shrikes every 10 years. We discuss possible causes for the decline of Loggerhead Shrikes and present recommendations for shrike conservation.*

INTRODUCTION

True Shrikes (family laniidae) have declined globally in the past century (Yosef 1994). Found exclusively in North America, the Loggerhead Shrike is a predatory songbird that hunts, and often impales, a wide variety of prey: arthropods, amphibians, small reptiles, mammals and birds (Yosef 1996). Prime shrike habitat is grassland, open woodlands, and other open areas that usually have spiny vegetation or barbed wire for impaling prey. Loggerhead Shrikes formerly bred across most of the United States, southern Canada, and Mexico and were once considered "abundant" across much of North America (Miller 1931; Bent 1950). Loggerhead Shrike populations in eastern North America rapidly expanded during the 19th century as conversion of forests to agriculture increased; apparently peaking before 1920 (Peterjohn and Sauer 1995). Persistent and widespread declines of Loggerhead Shrikes began prior to the 1940's (Yosef 1996). USFWS designated the Loggerhead Shrike as a Migratory Nongame Bird of Management Concern in the United States in 1987.

Throughout Virginia, Maryland, Delaware, and West Virginia, shrikes are currently very rare to rare/uncommon (Pruitt 2000). Historically, shrikes were not evenly distributed in Virginia; a checklist describes shrikes as fairly common in the piedmont, uncommon in mountains, and rare in coastal areas (Murray 1952). Loss of Loggerhead Shrikes is well documented in Virginia where they have been listed as threatened since 1987 (Pruitt 2000). In 2014, the Virginia Department of Game and Inland Fisheries, along with the Smithsonian Conservation Biology Institute and West Virginia Department of Natural Resources, formed the Loggerhead Shrike Working Group for cross-disciplinary studies and conservation of the Loggerhead Shrike *(Virginia Working Landscapes).*

North American populations of Loggerhead Shrikes are regularly assessed through two surveys: Breeding Bird Survey (BBS) and Audubon's Christmas Bird Count (CBC). The BBS program is a long-term, large-scale, avian monitoring program established in 1966 with the primary objective to estimate bird population changes over broad regions (Robbins et al. 1986). BBS data are derived from standardized roadside surveys that are conducted at the peak of nesting, usually in June, in the continental US and southern Canada. The BBS produces an index of relative abundance rather than

a comprehensive accounting of all breeding bird populations. Bystrak (1981) discussed the utility of the BBS and defended its usefulness as an effective index of bird populations, both temporally and spatially. The data analyses assume that fluctuations in these indices of abundance are representative of the population as a whole (Sauer et al. 2014). Although there is annual variation in effort, BBS data are analyzed using a Hierarchical Bayesian model which smooths the effects of variation among observers and routes, first-year observer effects, variations in trend and abundance among strata, and annual variation around a long-term trend (Sauer and Link 2011). We also present confirmed breeding Loggerhead Shrike data from the first Virginia Breeding Bird Atlas (VABBA) conducted in 1985-1989 (Breeding Bird Atlas Explorer 2017). Another major source of ornithological population data is the CBC, an annual survey of wintering birds in North America that provides indicators of spatial abundance of avian species (Bock and Root 1981).

The objective of this paper is to present state-specific information on distributional and temporal losses of Loggerhead Shrikes to help landowners, non-governmental organizations and government agencies understand the spatiotemporal patterns of shrike decline throughout Virginia. Downward population trends for shrikes based on standardized surveys in Virginia is corroborated by bird banding records and sightings reported in Virginia Birds. Potential factors in the population decline of Loggerhead Shrikes are discussed as are specific recommendations for shrike conservation.

METHODS

Breeding Bird Survey data acquisition - Group summary results, indices of abundance chart, standard BBS raw data and route maps for Loggerhead Shrikes in Virginia were obtained from the BBS web site (Pardieck et al. 2015, US Geological Survey (USGS) North American Breeding Bird Survey). Methodology for BBS is described by others (Robbins et al. 1986, Peterjohn and Sauer 1995). In Virginia the average date for BBS is June 13th. One BBS route (# 27) reporting one shrike in 1967, was removed from the dataset because the latitude and longitude did not match the reported strata, and the reported strata (14 Highland Rim) did not occur in Virginia. We organized BBS data by the eight regions of the state as defined by the Virginia Society of Ornithology's (VSO) publication *Virginia Birds.*

Virginia Breeding Bird Atlas – Volunteers surveyed geographic blocks of Virginia during the breeding seasons of 1985-1989 for evidence of bird breeding activity. For this paper, we only used data for Loggerhead Shrikes with confirmed evidence of breeding; e.g., bird observed carrying nesting material, building a nest with physiological evidence of breeding, distraction display or injury feigning, used nests or egg shells found, flightless young, recently fledged young, adults entering or leaving a nest site, carrying food for young, feeding recently fledged young, carrying fecal sacs, observation of nests with egg(s), or young seen or heard.

Christmas Bird Count data acquisition - Historical CBC results for Loggerhead Shrikes in Virginia were obtained from the website National Audubon Society (2010). The Christmas Bird Count Historical Results [online]. Available http://www.christmasbirdcount.org [your access date] Number of shrikes per party hour was graphed by year for CBC counts in Virginia from 1966-2014 and the best fit curve, an exponential trend line, was applied using Microsoft Excel. Half-life, the time in which a decreasing quantity or population attains half its initial value, is calculated using the exponential decay formula online with Mini Web Tool:

$$P(t) = P0e^{-rt}$$

where:
P(t) = population at time t
P0 = initial population at time t = 0
e = natural log
r = decay rate
t = time (number of periods)

Other documentation of Loggerhead Shrikes in Virginia - Records for Loggerhead Shrikes banded in Virginia from 1966-2014 were provided by the US Geological Survey's (USGS) Patuxent Wildlife Research Center Bird Banding Laboratory. Loggerhead Shrike sightings in Virginia from 2004-2014 were gleaned from *Virginia Birds*, the quarterly journal of ornithological sightings published by The Virginia Society of Ornithology (VSO).

RESULTS

Loggerhead Shrike Abundance Indices in BBS Reports - Fig. 1 shows BBS annual index for Virginia Loggerhead Shrikes from 1966-2013. Indices are lower each year except for slight transient increases in 1972, 1977, 1980 and 1984. Precision-adjusted estimates of Loggerhead Shrikes detected by BBS in Virginia (n=29 routes) indicate a significant negative trend of -7.4 (Pardieck et al. 2015). This species is ranked first in Virginia for significant negative trends among its guild, open-cup nesters.

Distributional patterns - The pattern of loss of breeding shrikes in Virginia, per BBS data, occurs first in the southeastern regions of Virginia and gradually moves north then west. Table 1 lists eight regions of Virginia, as defined by the VSO publication *Virginia Birds*, with cumulative numbers of Loggerhead Shrikes (n=261) reported on BBS routes (n=28) within each region and the year shrikes were last detected. When BBS commenced in 1966, Loggerhead Shrikes in Virginia were widespread geographically and reported in all regions except coastal and eastern Virginia. Per BBS reports, shrikes were lost progressively over time first in Southeast, followed by North, Central, South Central, and last in the Western region.

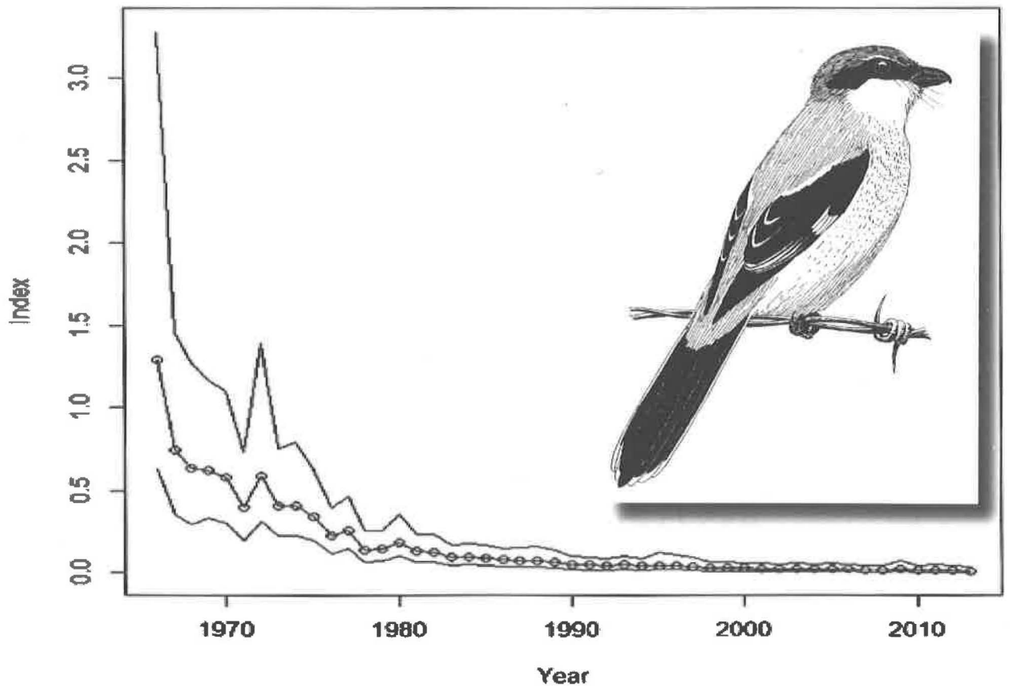

Fig. 1. Breeding Bird Survey annual indices of abundance of Loggerhead Shrikes in Virginia: 1966 – 2013. Solid lines indicate 95% confidence intervals.

Table 1. BBS survey for Loggerhead Shrikes in Virginia from 1966-2013 by region: numbers of shrikes reported, numbers of routes reporting shrikes, and the last year shrikes were reported.

Region	# Shrikes reported	# Routes reporting Shrikes	Last year Shrikes reported
Southeast	41	2	1979
North	3	3	1982
Central	71	7	1996
South Central	90	4	1998
Southwest	10	3	2011
West	46	9	2012
East	0	na	na
Coastal	0	na	na

Loggerhead Shrikes reported by the Christmas Bird Count - Fig. 2 depicts Loggerhead Shrikes counted by the CBC in Virginia per party hour by year from 1966-2014. The annual rate of decline in shrikes per the CBC is 6.9 % per year. The best fit trend line for the CBC data is an exponential curve with an R-squared value of 0.92 indicating a good fit. Based on an exponential decay model, the calculated half-life is 9.8 years.

Virginia Shrikes Detected by BBS and VABBA Compared with Shrike Sightings and Bandings of Nestlings - To demonstrate which areas of Virginia have documented shrikes by different survey methods, Table 2 collates all 95 Virginia counties grouped by regions, with presence or absence of shrikes detected by various means: BBS, Virginia Breeding Bird Atlas, VSO-reported shrike sightings and shrike nestlings banded with USGS bird bands.

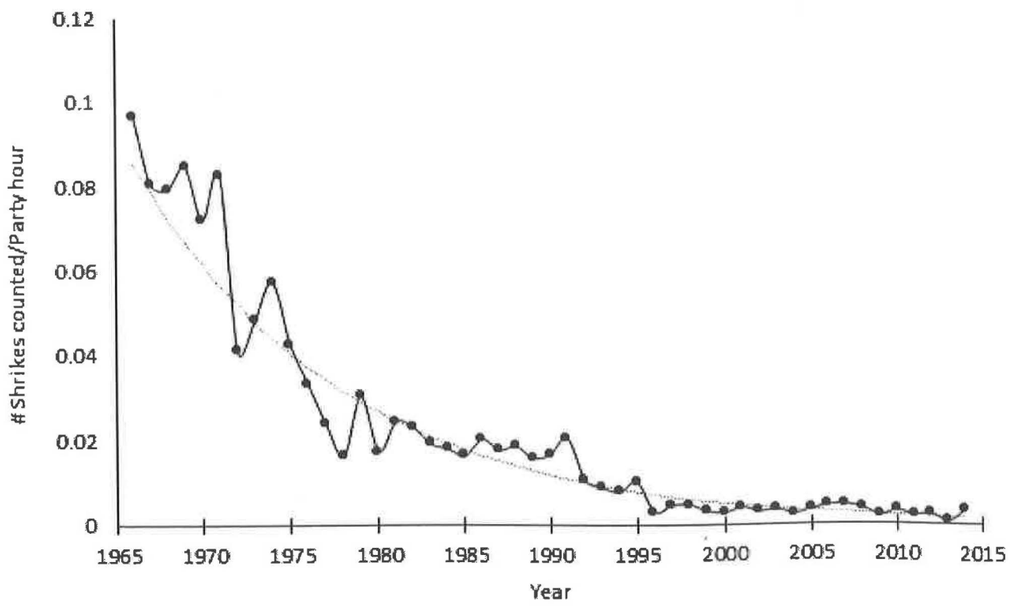

Fig 2. Loggerhead Shrikes counted per party hour in Virginia by Christmas Bird Count: 1966 - 2014. Dashed line represents best curve fit (exponential trend line with R^2=0.925).

Twenty-six counties are not sampled by BBS, comprising approximately one-third of the state's counties. CBC count circles also have an uneven geographic distribution; some counties have up to three CBC circles, but most counties have no CBC coverage (data not shown). For example, the 166th CBC conducted December 2015 through January 2016, surveyed 30 counties and six independent cities, leaving approximately two-thirds (n=65) of Virginia counties and two independent cities uncounted. It should be noted that annual participation on BBS routes varies and CBC circle locations can change, so survey effort and locations do fluctuate over time.

Table 2. Presence or absence of Loggerhead Shrikes in Virginia by county per Breeding Bird Survey, Virginia Breeding Bird Atlas, sightings reported by VSO, and USGS shrike nestling band records.

Virginia Counties	BBS Shrike detected	VABBA Shrike confirmed	VSO Shrike sighting	USGS banded nestling
West Region				
Alleghany	Yes			
Augusta	Yes	Yes	Yes	Yes
Bath		Yes	Yes	
Botetourt	Yes		Yes	
Clarke			Yes	Yes
Craig		Yes		
Frederick	Yes	Yes	Yes	
Giles				
Highland		Yes	Yes	Yes
Montgomery	Yes		Yes	Yes
Page	Yes			
Pulaski		Yes	Yes	
Roanoke		Yes	Yes	
Rockbridge	Yes			
Rockingham		Yes		Yes
Shenandoah	Yes	Yes	Yes	Yes
Warren		Yes		
Southwest Region				
Bland		Yes		
Buchanan				
Carroll			Yes	
Dickenson				
Floyd				
Grayson		Yes	Yes	
Lee				
Russell			Yes	
Scott				
Smyth	Yes	Yes	Yes	
Tazewell			Yes	
Washington	Yes	Yes		
Wise			Yes	
Wythe	Yes	Yes	Yes	

Table 2 continued

South Central Region				
Amelia	Yes		Yes	
Appomattox				
Brunswick	Yes			
Buckingham			Yes	
Charlotte	Yes	Yes		
Cumberland				
Dinwiddie	Yes			
Franklin		Yes	Yes	
Greensville		Yes	Yes	
Halifax				
Henry				
Lunenburg				
Mecklenburg		Yes	Yes	
Nottoway			Yes	
Patrick				
Pittsylvania				
Prince Edward				
Central Region				
Albemarle	Yes	Yes	Yes	
Amherst	Yes			
Bedford	Yes		Yes	
Campbell	Yes			
Caroline				
Fluvanna				
Goochland				
Greene				
Hanover				
Louisa	Yes		Yes	
Nelson	Yes	Yes		
Orange			Yes	
Powhatan				
Spotsylvania				
North Region				
Arlington				
Culpeper		Yes		
Fairfax				Yes
Fauquier	Yes		Yes	
Loudoun	Yes	Yes	Yes	Yes

Table 2 continued

North Region (cont'd)				
Madison	Yes	Yes		
Prince William				
Rappahannock		Yes		
Stafford				Yes
Southeast Region				
Charles City				
Chesterfield				
Henrico				
Isle of Wight			Yes	
James City				
New Kent				
Prince George		Yes		
Southampton	Yes	Yes		
Surry				
Sussex		Yes		
York				
East Region				
Essex				
Gloucester				
King & Queen				
King George				
King William				
Lancaster				
Mathews				
Middlesex				
Northumberland				
Richmond				
Westmoreland				
Coastal Region				
Accomack				
Northampton				

Loggerhead Shrikes reported by the Christmas Bird Count - Fig. 2 depicts Loggerhead Shrikes counted by the CBC in Virginia per party hour by year from 1966-2014. The annual rate of decline in shrikes per the CBC is 6.9 % per year. The best fit trend line for the CBC data is an exponential curve with an R-squared value of 0.92 indicating a good fit. Based on an exponential decay model, the calculated half-life is 9.8 yrs.

Although neither standard survey is designed as a comprehensive population census, these surveys excel at sampling areas to determine long-term trends and regional distribution. Although all regions of Virginia are sampled by BBS and CBC, there are 19 counties that are not included in either the BBS or CBC; thus, approximately 20% of Virginia counties are not sampled by either standardized survey method (data not shown).

The entire state was surveyed in the first VABBA, confirming 58 shrikes breeding in 28 Virginia counties from 1985-1989. There was concordance between BBS and VABBA for 12 counties, but VABBA confirmed shrikes breeding in another 16 counties that either had no BBS route (n=4) or counties in which BBS routes did not detect breeding Loggerhead Shrikes.

Between 2004 and 2014, there were 190 shrike sightings recorded in *Virginia Birds*. Shrike sightings were reported by VSO members year-round in 30 counties (and in the independent city Virginia Beach - not shown). These include nine counties where shrikes were not detected by either the BBS or VABBA.

The presence of breeding shrikes is conclusively documented by nestling shrike band records, which may or may not be represented in BBS and VABBA. We analyzed USGS band records of nestling shrikes (n=265) as definitive documentation of shrikes breeding in nine Virginia counties. The majority, 92% (n=243), of nestlings were banded in the Western region between 1985-1987 by two researchers from Virginia Tech (Luukkonen 1987 Blumton 1989). There are also shrike banding records from Clarke, Fairfax and Stafford counties where no shrikes were detected by BBS or VABBA and only Clarke county had a recorded shrike sighting.

DISCUSSION

Loggerhead Shrike populations in Virginia have been assessed by several different means. Variations in methodology, ability and training of observers, weather conditions, bird detectability in various habitats, and other variables influence the precision and accuracy of bird surveys (Sauer and Link 2011). Here we discuss the variabilities, strengths, and weaknesses of each type of bird survey.

Small sample sizes, low relative abundances on survey routes, imprecise trends, and missing data can compromise BBS results (USGS North American Breeding Bird Survey). However, over the long term, BBS data are credible, and the downward trend of Virginia shrikes is difficult to refute.

Loggerhead shrikes are attracted to linear habitat such as roadsides (Degeus 1990). The BBS is mostly likely to be sensitive to population changes of those species likely to be observed along roads (Bohall-Wood 1987), where the roadside habitat is representative of the larger area, and the factors affecting the bird population are present along the road (Sullivan et al. 2002). When shrike numbers were higher in the mid-1980s, BBS was deemed an appropriate survey (Luukkonen 1987). However, since Loggerhead Shrikes are currently at low densities with patchy distribution in Virginia, the credibility of BBS data decreases and results can be more difficult to interpret (Wiggins 2005).

Loggerhead Shrikes are one of the earliest bird species to nest in Virginia (Luukkonen 1987), which likely results in lower BBS detection rates. Based on our observations of shrikes in the Shenandoah Valley of Virginia (Morrow and Morrow 2015), fledglings' food begging vocalizations peak between 20 May and 10 June, prior to the average date of BBS surveys in Virginia on June 13th. Secondly, shrikes frequently begin a second clutch immediately after the first clutch fledges (Yosef 1996). Therefore, by the date of the average BBS count in Virginia, female shrikes may be incubating a second clutch of eggs and may be less detectable.

The CBC is suitable for estimating avian populations if users are aware of its methodology and limitations (Peterson 1995). Consistency in CBC

counts is seldom possible and yearly differences can significantly influence interpretation of the results (Bock and Lepthien 1975). The methodology of the CBC is less standardized than the BBS, and it is an inappropriate substitute for census work associated with local projects (Drennan 1981). The CBC is better suited for patterning common and well-dispersed species than for rare and/or highly social species (Bock and Root 1981).

Data from major bird surveys, BBS and CBC, both show precipitous decreases in shrike numbers in Virginia, raising the prospect of imminent extirpation. BBS detected one breeding shrike in Wythe County, Virginia, in 2016 (data not shown). We anticipate similar sporadic shrike detections for several years prior to the time when shrike detections become consistently zero. Similarly, we anticipate the second *Virginia Breeding Bird Atlas,* ongoing since 2016, will confirm breeding by a few remnant pairs of shrikes, but we predict fewer confirmed breeding shrikes in this second VABBA compared to the 58 confirmed by the first VABBA.

Although survey analysis is not reliable to accurately predict future populations (Stedman and Allen 2003), it suggests that shrikes may not exist in Virginia in the near future unless something is done to mitigate their decline. Shrike researcher Blumton (1989) declared almost three decades ago: "Shrike populations in Virginia have declined to a level that justifies this species being added to the state's Endangered Species List". However, the state has not listed shrikes as "endangered" despite clear evidence that Loggerhead Shrikes in Virginia are endangered per the regulatory definition: "Endangered Species means any species which is in danger of extinction throughout all or a significant portion of its range" (Virginia Law 2016). In our opinion, shrikes in Virginia are now "functionally extirpated". The Virginia shrike situation is analogous to Aplomado Falcons (*Falco femoralis septentrionalis*) in northern Mexico where falcons breed, but produce too few young to sustain a viable population (Macias-Duarte et al. 2016). We expect shrikes to advance directly from threatened to extirpated in Virginia.

Causes of Loggerhead Shrike population declines have proved difficult to pinpoint and are probably multifactorial and regional/local. Proposed factors include: habitat degradation and/or destruction, poor overwinter survival, exposure to pesticides/herbicides/toxins, low reproductive success, collisions with vehicles, interspecific competition, and disease (Yosef 1996). Severe winter weather during 1976-1979 may have contributed to shrike population losses in the eastern US and Canada in tandem with other factors (Sauer et. al 1995).

As habitat quality decreases, the area required to maintain a nesting pair increases (Kridelbaugh 1983). It has been hypothesized, and we concur, that most shrike populations are limited by the capacity of non-breeding habitat (Temple 1995). Similarly, Blumton (1989) found poor overwinter survival due to land use changes, predation, extended periods of cold and/or snow on the ground, and collisions with vehicles. It has also been suggested that increased shrike mortality may be a more important factor than loss of habitat in declining populations. In a 14-year period, 101 shrikes were killed by vehicles on a 6.4 km section of a highway in Texas (Flickinger 1995). There is no comparable study for shrike deaths on roads in Virginia.

Patterns of decline of Virginia's Loggerhead Shrikes fit Wilcove's pattern type III characterized by retraction from peripheral parts of its range and reduced densities in marginal and optimal habitat (Wilcove and Terborgh 1984). In Virginia, losses of shrikes began first in the southeastern regions and proceeded north then westward. Currently, Loggerhead Shrikes persist in the western portion of the state with occasional rare sightings in other regions. The directional gradient of shrike's range retraction from east to west is probably due to changing agricultural uses dictated by climate and geology. There is a causal link between changes in agricultural practices and declines in farmland bird populations (Murphy 2003). In the western region of Virginia many pastures and hayfields have been converted into monoculture row crops (pers. obs.). Row crops are not suitable habitat for shrikes and necessitate higher use of herbicides and pesticides which may be deleterious to shrikes (Yosef 1996). Use of insecticides, particularly neonicotinoids, are significantly correlated with recent declines in grassland bird populations (Hallmann et al. 2014).

As fields are enlarged and scattered trees within fields are removed, the distances shrikes must fly to escape cover when avian predators enter shrike territory is lengthened, thus increasing exposure to predation. In Virginia, the number one cause of shrike deaths in the Shenandoah Valley during winter was predation by raptors, accounting for 57% of 18 winter mortalities (Blumton 1989).

Loggerhead Shrikes from Virginia's Shenandoah Valley were tested for pesticides in the 1980s. Although detectable levels of organochlorides and organophosphates were present in eggs and tissues, the author concluded that pesticide toxicity was not a likely factor in shrike population declines in her study area (Blumton 1989). However, fencerow and roadside shrike habitat has been adversely effected by the widespread use of the herbicides. Glyphosate (brand name "RoundUp") is sprayed on a regular basis on genetically modified/conventional row crops and along roads and fence-rows to remove, reduce weeds, and "clean up" fencerows and other brushy areas, a practice that has eliminated important shrike nesting, hunting and escape habitat. Furthermore, the US EPA concluded that Paraquat (N,N′-dimethyl-4,4′-bipyridinium dichloride), a widely used non-selective herbicide, is moderately toxic to birds and can decrease reproduction, egg hatchability and cause endocrine disruption in birds (US Environmental Protection Agency 2009).

Disappearance of pastures, increasingly larger areas of cultivation, predominance of corn fields, gradual removal of shelterbelts, and return of marginal fields to forests all contributed to loss of shrikes in Quebec (LaPorte and Robert 1995). With the possible exception of reforestation, all these factors may be contributing to loss of shrikes in Virginia.

RECOMMENDATIONS

After analyzing the decline of Virginia's Loggerhead Shrike population, we conclude that the most appropriate regions to concentrate shrike conservation efforts are southwestern and western Virginia. These regions have relatively few row crops, probably because the terrain is too rocky for cultivation, and currently have Loggerhead Shrikes throughout the year.

Conservation recommendations:

- List the Loggerhead Shrike as a state endangered species. Even though it would add no further legal protections, an endangered listing would reflect its current status and demonstrate more urgency to protect this species.
- Document and protect every known recent and current shrike breeding territory.
- Lower speed limits on roads adjacent to active shrike territories.
- Immediately halt all roadside spraying of pesticides or herbicides and restrict aerial spraying within 20 km of known shrike territories, unless the chemicals are shown to be harmless to shrikes.
- Encourage/incentivize farmers and landowners to allow at least a 6-meter buffer to grow up along fencerows and roadsides.
- Encourage land usage to be pastures lightly grazed by cattle (not sheep or goats), hay fields and rough fields. Discourage removal of potential nesting structures (small trees, thorny trees, dense shrubs, brushpiles and blackberry thickets), hunting perches and habitat suitable for providing shrike prey items (arthropods, small rodents, reptiles, amphibians and birds).
- Institute rotational mowing or grazing, leaving sections unmowed for a year or two and coordinate timing of mowing with nesting grassland birds.
- Leave a set minimal stubble height in pastures and hayfields to assure adequate winter cover for future shrike prey.
- Financially encourage farmers who are currently using pesticides and herbicides on row crops to switch to organically grown hay fields and pastures.
- Initiate economic and tax incentives for shrike habitat conservation, restoration and management; for example, fields can be leased long-term by the state accompanied by tax incentives for landowners.
- Offer free or low-cost shrike-friendly trees and shrubs for landowners or conservation organizations to plant as hunting perches for shrikes near foraging areas.
- Plant and maintain various tree and shrubs that have been documented as preferred shrike nest sites. Protect nest structures with board/split rail fences (any type of fence that does not contribute to raptor strikes).
- Promote awareness through landowner educational seminars, brochures, website, etc.
- Initiate surveys that target areas where shrikes have been seen recently. Surveys should be conducted in a standardized manner at least once per year during breeding season (Apr-Jun) and once per year in winter months (Dec- Feb).
- Test feathers of wintering shrikes in Virginia to determine the birds' natal origins using stable isotopes (Hobson and Wasenaar 2001). Additionally, telemetry studies would be useful to determine movements and causes of mortality. If it is determined that shrikes stay here year-round, different conservation strategies can be formulated than if Virginia shrikes are migratory.
- Currently, the Virginia Game and Inland Fisheries Department (VDGIF) does not issue bird banding permits to qualified independent researchers to work with Loggerhead Shrikes. If VDGIF permitted more people to do research on shrikes, the species could benefit by furthering understanding of shrikes' specific requirements, breeding productivity, movements/migration, and causes of mortality.

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Loggerhead Shrike
from Birchside photo's
George West