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Kelsey Bedford
South Dakota State University

Nicole Burkard
South Dakota State University

Brandi Crider
South Dakota State University

Emma Barnett
South Dakota State University

N. H. Troelstrup Jr.
South Dakota State University, nels.troelstrup@sdstate.edu

EFFECTS OF CLIMATE CHANGE ON PHENOLOGY OF BLACKBIRDS AND ORIOLES (ICTERIDS) IN EASTERN SOUTH DAKOTA

Kelsey Bedford, Nicole Burkard, Brandi Crider, Emma Barnett, and Nels H. Troelstrup, Jr.*
Department of Natural Resource Management
South Dakota State University
Brookings, SD 57007
*Corresponding author email: nels.troelstrup@sdstate.edu

ABSTRACT

Birds are among the first responders to climate change, often having clearly observable phenological responses to less perceptible levels of climate shift. Declines in populations of a number of bird species have been witnessed both in the United States and abroad, with up to a 48% decline in grassland birds of the Central U.S. Understanding changes in bird abundance and distribution is essential because birds supply a wide variety of critical ecosystem services, including pollination and pest control. While the effects of climate change on many bird species' phenology have been studied intensely, research on the family Icteridae is limited. This study was conducted using spring bird presence and absence data and weather data from Oak Lake Field Station from 1995 to 2012. Linear regression analysis was applied against warmth sum days for the 30 days prior to each spring bird survey. Our analysis demonstrated significant increases in accumulated warmth sum days between 1999 and 2012 ($P = 0.01$). Icterid species richness also increased with increasing warmth sum days during the month leading up to surveys ($P = 0.02$). Trends in both habitat (open woodland, marsh, and grassland) and feeding guild (insectivores and omnivores) species richness were also observed with increasing warmth sum days. These findings suggest a shift towards earlier spring arrival of members of the family Icteridae in eastern South Dakota.

Keywords

Migration, Seasonal occurrence, Spring bird counts, Temporal variation, Warmth sum days, Icteridae

INTRODUCTION

Climate change and its effects on bird phenology have been studied over a wide range of temporal and spatial scales. Birds are among the first responders to climate change (Courter et al. 2013), often having clearly observable phenological responses to less perceptible levels of climate shift. Modifications

in the phenological schedules of organisms can have widespread effects on both an organism's ability to persist in its given ecosystem and a ripple effect on the ecosystems in which the organism exists (Haggerty and Mazer 2008). Significant declines in populations of a number of bird species have been witnessed both in the United States and abroad over the past few decades, with up to a 48% decline in grassland birds of the Central U.S. (Troelstrup et al. 2009). The Breeding Bird Survey has also reported declines in bird populations (Sauer et al. 2012). Understanding changes in bird abundance and distribution is essential because birds supply a wide variety of critical ecosystem services, including pollination, and pest control (Courter et al. 2013) The effects of climate change have been observed in the northward shift of the distribution of many insectivorous and granivorous birds across North America (Courter et al. 2013). Understanding the effects of climate change on bird phenology allows for greater insight into the effects of climate change on species persistence, abundance, and composition, and assists in identifying those bird species most at risk of extirpation (Hurlbert and Liang 2012).

Many species of blackbirds (Icteridae family) are considered pests to grain crops grown in the United States, with five to eight million dollars of damage caused annually (Linz et al. 2003). The economic impacts Icterids exert make them a family of interest in climate change effects on bird phenology. Blackbirds are also known to utilize a wide variety of habitats, with meadowlarks preferring grassland habitats, orioles occurring in forested areas, and grackles and allies occurring across a broad range of habitats (Jaramillo and Burke 1999). These differences in niche and habitat selection also mean that these species, collectively, might serve as indicators of broader trends in bird phenology due to climate change.

While the effects of climate change on many bird species' phenology has been studied intensely, research on the family Icteridae is limited. The objectives of this study were threefold. First, we sought to investigate if evidence of climate change could be seen at the Oak Lake Field Station in Brookings County, South Dakota. Next, relationships between Icterid species richness and climactic shifts were assessed. Finally, patterns in feeding and habitat guilds of members of the family Icteridae in response to climate change were explored. Consequently, the environmental and economic impacts of shifts in blackbird and oriole phenology may be better understood, and potential general implications for other avian species may be identified.

METHODS

***Site Description*—**The Oak Lake Field Station, located at 44˚30'30.36" latitude and 96˚31'52.98" longitude, is comprised of 231 hectares of mixed woodland, tall grass prairie, and developed land bordering Oak Lake in Brookings County, South Dakota (Troelstrup et al. 2009). Sited in the Prairie Pothole region at an elevation of 556m, Oak Lake Field Station experiences a mid-continental climate with a mean annual precipitation of 583 mm and a mean annual temperature of 5.9 ˚C. The Oak Lake Field Station is composed

of approximately 66% rangeland and pasture, 12% cropland, 13% forest, 8% wetlands, and 1% roads and developed areas. The route taken to assess the bird communities spans each of these habitats (Figure 1). In order to maintain a historically natural landscape, the Field Station uses prescribed burning to manage vegetation and promote native plant diversity. Grasslands within the Field Station have been burned 17 times between 1995 and 2011.

***Data Collection*—**Spring bird counts have been conducted at Oak Lake Field Station once per year since 1995. The count has been performed on a standardized 5.5 kilometer route (Figure 1) by 5-15 participants, and the observers have always included at least one professional ornithologist. Bird species observed during the count were recorded as present or absent. Weather records, including maximum and minimum temperatures and precipitation, are collected daily at Oak Lake Field Station. For this study, weather data from 1994-2012 and the spring bird counts of eight Icteridae species observed along the established route from 1995-2012 were utilized. Actual dates of the counts varied between April 22nd and May 21st.

***Analysis*—**Warmth sum days (WSDs) were calculated using daily temperatures of the 30 days prior to the annual spring bird count each year at Oak Lake Field Station. The WSDs were calculated as the sum of the mean of the maximum (Tmax) and minimum (Tmin) temperatures for each day (Perrins and McCleery 1989;Troelstrup et al. 2009):

$$\Sigma\left(\frac{Tmax+Tmin}{2}\right)$$

Annual species richness of Icterids was calculated using presence/absence of the eight Icteridae species recorded during the 1995-2012 Oak Lake spring bird counts. Species observed included the Red-winged Blackbird (*Agelaius phoeniceus*), Bobolink (*Dolichonyx oryzivorus*), Baltimore Oriole (*Icterus galbula*), Orchard Oriole (*Icterus spurius*), Brown-headed Cowbird (*Molothrus ater*), Common Grackle (*Quiscalus quiscula*), Western Meadowlark (*Stumella neglecta*), and Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*).

Changes in the number of WSDs from 1995-2012 were determined using linear regression of WSDs against date. Linear regression analysis was then applied to species richness and WSDs to determine a relationship between these two variables. Appropriate feeding and habitat guilds were determined for each species in our study using guilds established by the Cornell Lab of Ornithology (2011). Omnivorous species included the Red-winged Blackbird, Bobolink, Baltimore Oriole, Brown-headed Cowbird, Common Grackle, and Yellow-headed Blackbird. Insectivorous species included the Orchard Oriole and the Western Meadowlark. Marsh species included the Red-winged Blackbird and the Yellow-headed Blackbird. Open woodland species included the Baltimore Oriole, Orchard Oriole, and Common Grackle. Grassland species included the Brown-headed Cowbird, Bobolink, and Western Meadowlark. Changes in species richness among guilds as a function of WSDs were also assessed using linear regression.

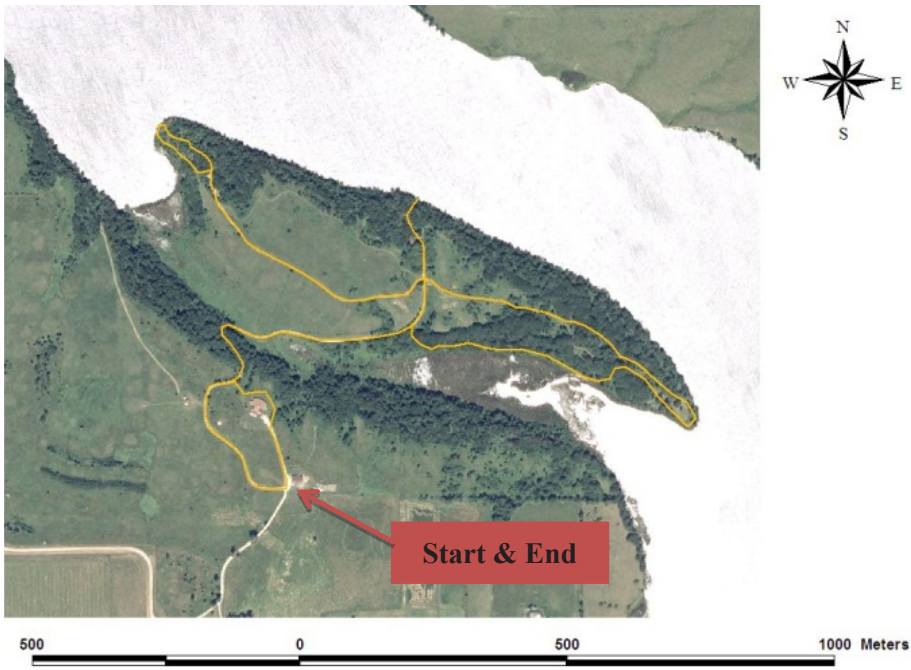

Figure 1. Annual spring bird count route (5.5 kilometers) at Oak Lake Field Station, Brookings County, South Dakota.

RESULTS

Icterid species richness increased approximately 167% between 1995 and 2012 (P = 0.01) (Figure 2) and number of WSDs increased approximately 609% between 1995 and 2012 (P = 0.01) (Figure 3). Icteridae species richness increased as WSDs increased in the month prior to sampling between 1995 and 2012 (P = 0.02) (Figure 4). Species richness increased from three in 1995 to eight in 2012 (Table 1). Of the Icterid feeding guilds, species richness of omnivores showed the strongest positive relationship with increasing WSDs between 1995 and 2012 (P = 0.02), with species richness of insectivores also demonstrating a positive relationship with increasing WSDs (P = 0.09) (Figure 5). However, when linear regression was applied to species richness of insectivores and Julian date, more variation was explained by Julian date (P = 0.02) than WSDs. Within the habitat guilds, species richness of grassland Icterids showed the greatest positive relationship with increasing WSDs (P = 0.01), while marsh (P = 0.93) and woodland (P = 0.16) guilds' diversities exhibited little to no relationship with increasing WSDs (Figure 6).

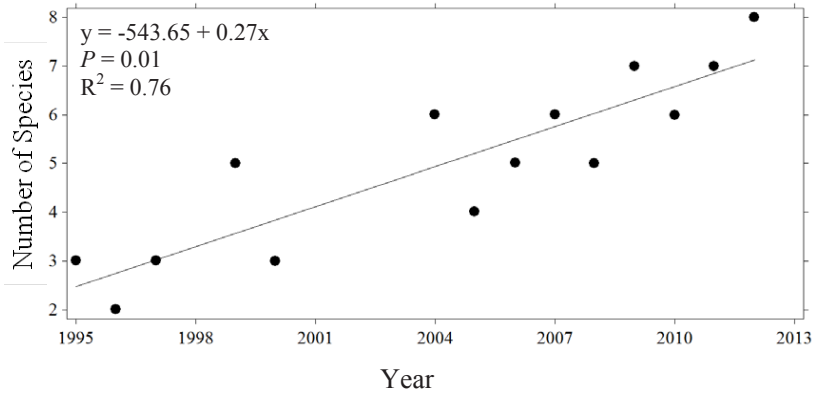

Figure 2. Increase of annual Icterid species richness from 1995-2012 at Oak Lake Field Station, Brookings County, South Dakota (P = 0.01).

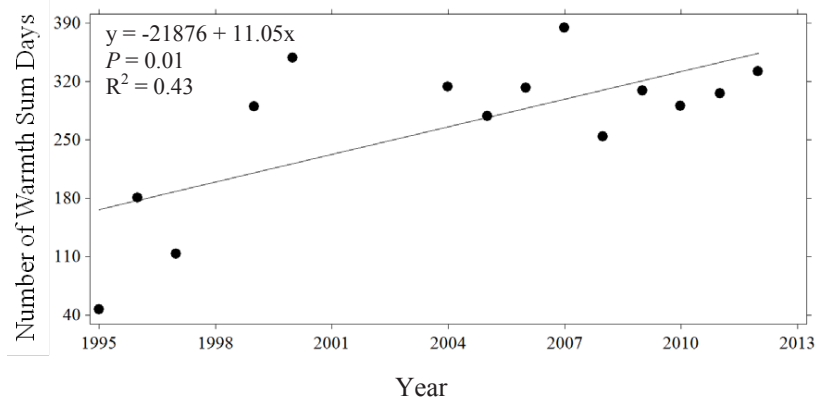

Figure 3. Increase of annual warmth sum days from 1995-2012 at Oak Lake Field Station, Brookings County, South Dakota (P = 0.01).

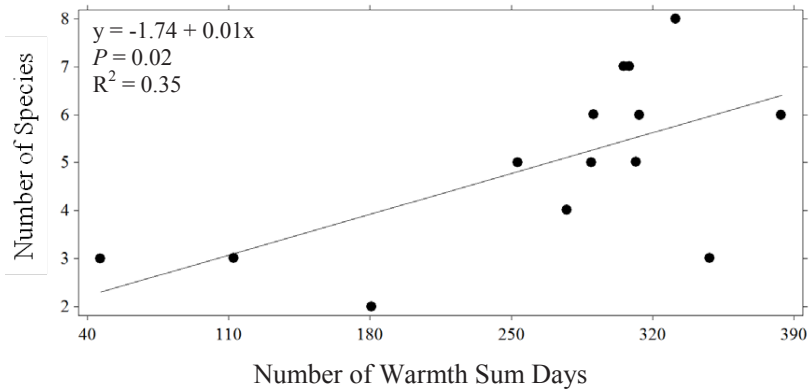

Figure 4. Relationship between Icterid species richness and number of warmth sum days at Oak Lake Field Station, Brookings County, South Dakota, from 1995-2012.

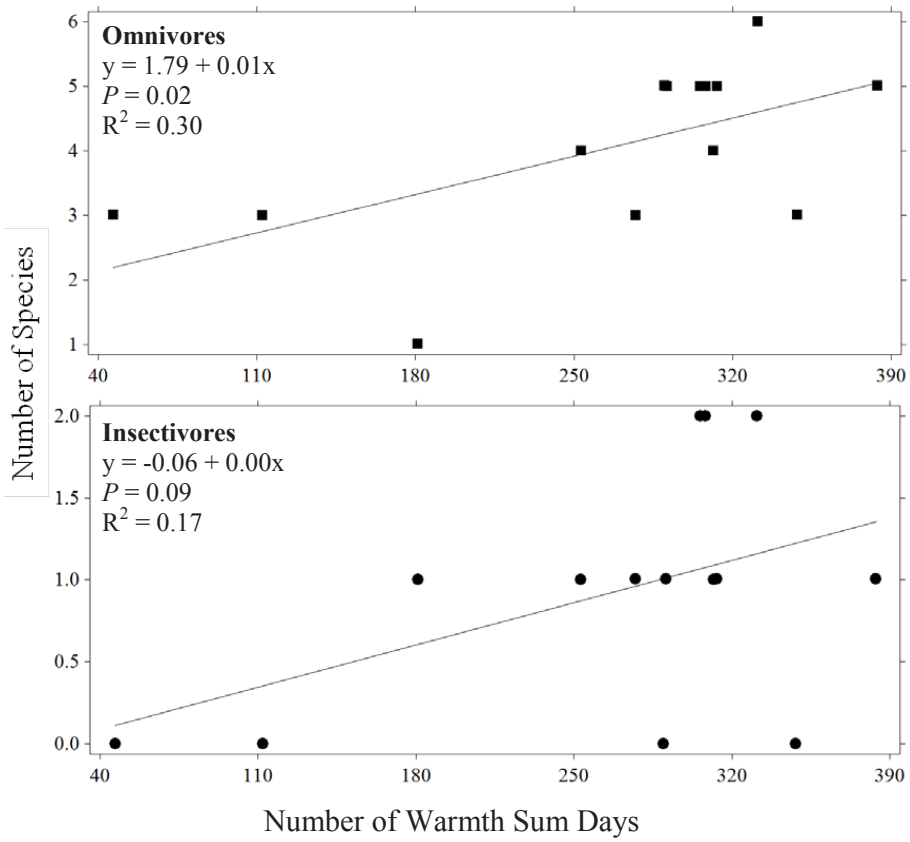

Figure 5. Relationship between Icterid feeding guilds and WSDs from 1995-2012 at Oak Lake Field Station, Brookings County, South Dakota.

DISCUSSION

The Midwest shows some of the greatest Icterid species richness in North America (Nott and Pimm 1997). This makes eastern South Dakota an ideal area in which to study Icterid species diversity. Between 1995 and 2012, eight species of the family Icteridae were observed during the spring bird counts at Oak Lake Field Station in Brookings County, South Dakota. Species observed included the Red-winged Blackbird (*Agelaius phoeniceus*), Bobolink (*Dolichonyx oryzivorus*), Baltimore Oriole (*Icterus galbula*), Orchard Oriole (*Icterus spurius*), Brown-headed Cowbird (*Molothrus ater*), Common Grackle (*Quiscalus quiscula*), Western Meadowlark (*Stumella neglecta*), and Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*).

***Climate Change*—**Increasing spring WSDs in the month prior to bird surveys at Oak Lake Field Station were observed between 1995 and 2012 (P = 0.01). Our findings complement Troelstrup et al. (2009) who reported an increase in WSDs between the 1990's and the 2000's at the station. These results are consis-

Table 1. Species richness and Icterid species observed for each spring bird count conducted at Oak Lake Field Station between 1995 and 2012 (RWB: Red-winged Blackbird; BO: Baltimore Oriole; OO: Orchard Oriole; WML: Western Meadowlark; BOB: Bobolink; CG: Common Grackle; YHB: Yellow-headed Blackbird).

Date	RWB	BO	OO	BHC	WML	BOB	CG	YHB	Species Richness
4/22/1995	X			X				X	3
5/11/1996	X				X				2
5/4/1997	X			X			X		3
5/15/1999	X	X		X		X	X		5
5/13/2000	X			X		X			3
5/15/2004	X			X	X	X	X	X	6
5/14/2005	X			X	X		X		4
5/13/2006	X			X	X	X	X		5
5/12/2007	X	X		X	X	X		X	6
5/17/2008		X		X	X	X	X		5
5/16/2009	X	X	X	X	X	X	X		7
5/15/2010	X	X		X	X	X	X		6
5/21/2011	X	X	X	X	X	X	X		7
5/12/2012	X	X	X	X	X	X	X	X	8

tent with larger trends in increasing spring temperatures seen across temperate regions of the Northern Hemisphere (Both and Visser 2001). In our study, WSDs accumulated over the month prior to the spring bird survey at Oak Lake Field Station between 1995 and 2012 serve as proxy for regional date of the arrival of spring. The bird count dates varied within a week (May 11 to May 17) over a 17 year study, with the exception of three outlier years (1995, 1997, and 2011). The seasonality of temperatures, rather than actual heat accumulations, is a central factor in species response to climate change (Bradshaw and Holzapfel 2006). An advance of spring season start dates by 5-6 days has been observed across much of North America, and has been shown to influence a wide variety of phenologies from bird nesting times to first leaf appearance in plants (Schwartz and Reiter 2000; Crick et al. 1997; Sorenson et al. 1998). Earlier spring arrival has also resulted in longer growing seasons in northern growing areas, increasing crop yields (Motha and Baier 2005). The advancement of spring warming seen in our study could have far-reaching implications for not only avian species, but also entire ecosystems, and the agriculturally based economy of eastern South Dakota.

***Species Richness and Climate Change*—**In our study, Icterid species richness increased significantly with increasing spring WSDs (P = 0.02). Previous studies have noted earlier spring arrivals of migrant bird species in conjunction with winter (Swanson and Palmer 2009) or earlier spring warming (Vegvari et al. 2010; Murphy-Klassen et al. 2005). The increase in Icterid species richness seen in our study may demonstrate a phenological shift towards earlier spring

migration. While Oak Lake Field Station endeavors to create a historically natural landscape, disturbances outside the study area may change the habitat and migration pathways birds traditionally utilize. Some species, including the Common Grackle, Red-winged Blackbird, and Brown-headed Cowbird, were observed almost yearly, regardless of WSDs in the previous month (Table 1). It is possible that these species simply migrate earlier than the other members of the family Icteridae in the study. Common Grackles and Red-winged Blackbirds typically make their migrations in April, and this may account for their yearly presence during the bird count (Linz et al. 2003). Other species, such as the Western Meadowlark, Yellow-headed Blackbird, Baltimore Oriole, Orchard Oriole, and Bobolink, were observed only in the mid to later 2000's. Moller et al. (2008) documented that bird species that did not advance their spring arrival dates showed population declines over time. The North American Breeding Bird Survey results support these findings (Sauer et al. 2012). While Common Grackle and Red-winged Blackbird populations in the prairie pothole region have increased or remained stable, Baltimore Oriole and Western Meadowlark populations have declined. The decline of these two species, however, has become less severe in the last decade (Sauer et al. 2012). The earlier spring arrival of Icterid species at Oak Lake Field Station could indicate a positive outlook for maintaining blackbird and oriole populations in eastern South Dakota. Earlier spring warming could also have potentially negative effects on Icterid populations. Crick (2004) noted that climate shifts can result in avian phenological disjunction, where essential phenology (such as nesting and brood rearing) becomes out of sync with the environment, resulting in declines in population size and shifts in community composition. Thus, earlier arrival of Icteridae species in eastern South Dakota might also result in population declines over time. While our data suggest an increase in species richness in conjunction with increasing WSDs, further studies will need to be conducted to establish the effects of climate change on the composition of bird communities in eastern South Dakota.

Shifts in Guild Structure—We divided the eight Icterid species observed into two feeding guilds, omnivores and insectivores (De Graaf et al. 1985). In our study, species richness of omnivores increased with increasing WSDs ($P = 0.02$), while the relationship between insectivore species richness and WSDs was less robust ($P = 0.09$). However, insectivore species richness was highly correlated with increasing Julian date ($P = 0.02$). This suggests that factors other than temperature (e.g. photoperiod, insect life cycle along migration route, and rainfall) have greater influence on spring arrival of Icterid insectivore species. Vegvari et al. (2010) noted that birds with more generalized diets showed greater advancement of spring arrival dates than those avian species with more specialized diets. Habitat guilds were also established among the eight species observed including marsh, open woodland, and grassland (Skutch 1996). Of the three habitat guilds, grassland Icterids showed the most notable positive relationship in species richness with increasing WSDs. Open woodland, and marsh bird species richness showed little or no relationship with increasing WSDs (Figure 6). While species richness of grassland Icterids may be increasing, it is possible that their ecological success is being impacted by a disjunction between the phenology of these species and their environment (Crick 2004).

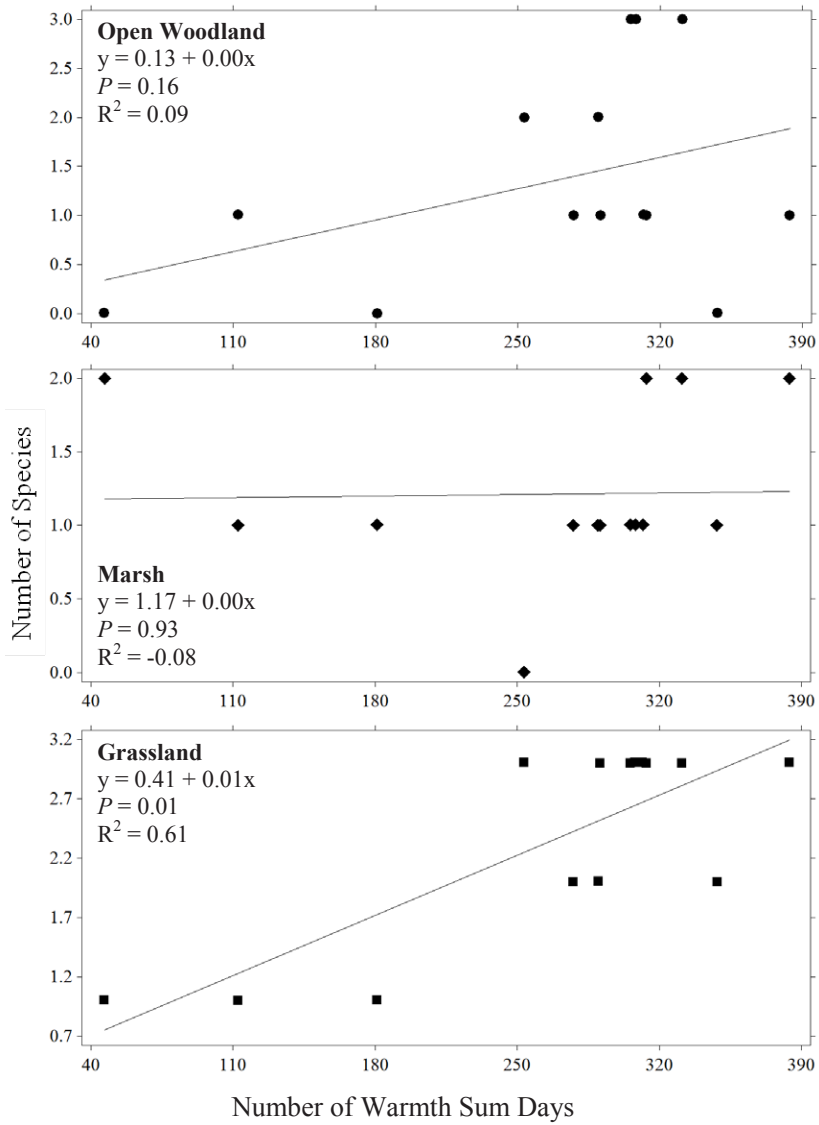

Figure 6. Relationship between Icterid habitat guilds and WSDs from 1995-2012 at Oak Lake Field Station, Brookings County, South Dakota.

Future Recommendations—The findings of this study can give scientists greater insight into how the world is changing. Future researchers can build upon our results in many ways. First, to solidify our findings, we recommend that this study be replicated with more species and in other areas of Eastern South Dakota. Second, other families or orders, such as Charadriiformes (shore birds) or Falconiformes (diurnal raptors), should be studied and compared. These studies could identify similarities between bird groups and determine specific limitations that cause these birds to be susceptible to climate change. Third, the

physiological mechanisms related to phenology and differences among species should be investigated. Finally, once differences in limitations among species are assessed, solutions can be found to help reduce the impacts of climate change. However, these are just treatments for the symptoms. If climate change is truly affecting bird species, humanity must address the real problem-climate change.

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LITERATURE CITED

Both, C., and M.E. Visser. 2001. Adjustment to climate change is constrained by arrival date in long-distance migrant bird. Nature 411:296-298.

Bradshaw, W.E, and C.M. Holzapfel. 2006. Evolutionary response to rapid climate change. Science 312:1477-1478.

Crick, H.Q.P. 2004. The impact of climate change on birds. Ibis 146:48-56.

Crick, H.Q.P, C. Dudley, D.E. Glue, and D.L. Thomson. 1997. UK birds are laying eggs earlier. Nature 388: 526

Cornell Lab of Ornithology. 2011. All about birds. Available at *www.allaboutbirds.org*. [Cited 19 March 2013.]

Courter, J. R., R. J. Johnson, W. C. Bridges, and K. G. Hubbard. 2013. Assessing migration of Ruby-throated Hummingbirds (Archilochus colubris) at broad spatial and temporal scales. Auk 130:107–117.

De Graaf, R., N.G. Tighman, and S.H. Anderson. 1985. Foraging guilds of North American birds. Environmental Management 9:493-536.

Haggerty, B. P., and S. J. Mazer. 2008. The Phenology Handbook; A guide to phenological monitoring for students, teachers, families, and nature enthusiasts. University of California, 21–27.

Hurlbert, A. H. and Z. Liang. 2012. Spatiotemporal variation in avian migration phenology: Citizen science reveals effects of climate change. PLoS ONE7, e31662.

Jaramillo, A., and P. Burke. 1999. New world blackbirds: the *Icterids*. Princeton University Press, Princeton, New Jersey.

Linz, G. M., G. A. Knutsen, and H. Homan. 2003. Baiting blackbirds (Icteridae) in stubble grain fields during spring migration in South Dakota. Crop Protection 22:261–264.

Moller A.P., D. Rubolini, and E. Lehikoinen. 2008. Populations of migratory bird species that did not show a phenological response to climate change are declining. Proceedings of the National Academy of Sciences 105:16195–16200.

Motha, R.P., and W. Baier. 2005. Impacts of present and future climate change and climate variability on agriculture in temperate regions: North America. Climatic Change 70:137-164.

Murphy-Klassen, H.M, T.J. Underwood, S.G. Sealy, and A.A. Czyrnyi. 2005. Long-term trends in spring arrival dates of migrant birds at Delta Marsh, Manitoba, in relation to climate change. Auk 122:1130-1148.

Nott, M.P. and S.L. Pimm. 1997 . The evaluation of biodiversity as a target for conservation. Chapman & Hall, New York, NY.

Perrins, C. M. and R. H. McCleery. 1989. Laying dates and clutch size in the great tit. The Wilson Bulletin 101:236–253.

Sauer, J. R., J. E. Hines, J. E. Fallon, K. L. Pardieck, D. J. Ziolkowski, Jr., and W. A. Link. 2012. The North American Breeding Bird Survey, Results and Analysis 1966 - 2011. Version 07.03.2013. USGS Patuxent Wildlife Research Center, Laurel, MD.

Schwartz, M.D. and B.E. Reiter. 2000. Changes in North American spring. International Journal of Climatology 20:929-932.

Skutch, A.F. 1996. Orioles, Blackbirds, & Their Kin. The University of Arizona, Tucson, AZ.

Sorenson, L.G., R. Goldberg, T.L. Root, and M.G. Anderson. 1998. Potential effects of global warming on waterfowl populations breeding in the Northern Great Plains. Climate Change 40:343-369.

Swanson, D.L. and J.S. Palmer. 2009. Spring migration phenology of birds in the northern prairie region is correlated with local climate change. Journal of Field Ornithology 80:351-363.

Troelstrup, N., J. D. Maag, and G. E. Larson. 2009. Spring bird counts conducted at Oak Lake Field Station Brookings County, South Dakota. Proceedings of the South Dakota Academy of Science 88:164.

Vegvari, Z., V. Bokony, Z. Barta, and G. Kovacs. 2010. Life history predicts advancement of avian spring migration in response to climate change. Global Change Biology 16:1-11.