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Shorebird (Charadriiformes) migration at selected sites throughout Kansas during 2002-2006

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Shorebirds were counted at selected sites throughout Kansas during 2002-2006. At least 75% of the shorebirds counted during spring and summer-fall were counted at either Cheyenne Bottoms Wildlife Area or Quivira National Wildlife Refuge. Thirty-nine species of shorebirds were reported and species composition varied among regions and seasons. Shorebird numbers peaked during the first two weeks of May in spring and mid-August through September during summer-fall, but varied among regions and species. Recommendations pertaining to habitat management and future surveys are provided based on the results.

Keywords: shorebirds, Cheyenne Bottoms, Quivira National Wildlife Refuge

INTRODUCTION

Although Kansas is an inland prairie state, it has two wetlands that attract some of the largest concentrations of shorebirds (Charadridae, Recurvirostridae, and Scolopacidae) in the Western Hemisphere. These wetlands, Cheyenne Bottoms (both the state and Nature Conservancy-owned properties) and Quivira National Wildlife Refuge (QNWR), have been recognized by the Western Hemisphere Shorebird Reserve Network (2006) as Hemispheric and Regional reserves, respectively. Because conditions for shorebirds at these and other Great Plains wetlands vary annually, I wanted to identify alternative sites for shorebirds migrating through Kansas.

Shorebird surveys were conducted at 26 other sites in Kansas during 1976-2002. However, surveys at these sites usually were conducted just once or irregularly, probably when shorebirds were present (International Shorebird Survey, unpubl. data, S. K. Skagen, unpubl. data). Regular surveys during one or a few migratory periods (e.g., spring, summer-fall) have been conducted at only a few sites in Kansas besides Cheyenne Bottoms Wildlife Area (CBWA), The Nature Conservancy's Cheyenne Bottoms Preserve, and QNWR (Davis 1964, Schreiber 1970, Young 1993, Mitchell 1996, Langley et al. 1998, Rice et al. 2001). The objectives of the Kansas shorebird surveys during 2002-2006 were to contemporaneously document shorebird use at a variety of locations throughout Kansas to identify important shorebird use areas in addition to those already surveyed regularly and hopefully stimulate regular surveys of other shorebird stopover sites in Kansas.

METHODS

Volunteers were recruited at the Kansas Ornithological Society (KOS) meeting in October 2001, through the KOS newsletter, on the KSBIRDS listserv, and with announcements in Audubon chapter newsletters. Volunteers were asked to select a site to conduct shorebird surveys. I suggested that sites should have the potential to attract shorebirds and be convenient enough to visit several times during the survey periods.

Methods for conducting shorebird surveys were similar to those for the International

Shorebird Survey (Manomet Center for Conservation Sciences 2007). However, volunteers were asked to count shorebirds at their sites twice monthly during spring (16 March-31 May) and summer-fall (1 July-31 October) during specific 2-week periods (e.g, 16-31 March, 1-15 April), rather than three times per month. Frequent surveys are needed to describe migration chronology and are necessary to detect shorebird use of ephemeral habitats. Although it would have been better to survey sites more frequently, perhaps as often as daily (Young 1993), such frequent surveys were not feasible for most volunteers. When *Calidris* sandpipers could not be identified to species due to distance, poor light, or if flushed before observers were able to identify them, they were recorded as "peeps." Long-billed (*Limnodromus scolopaceus*) and Short-billed (*L. griseus*) dowitchers were combined as "dowitchers".

DATA ANALYSIS

Number of surveys varied among sites within and among years for various reasons (e.g., illness, lack of time to complete surveys, poor road conditions, poor shorebird habitat). Thus, to calculate total number of shorebirds per site per season per year while minimizing bias due to differences in number of surveys, maximum counts were summed for each species per site per 2-week survey period (Skagen et al. 1999).

Proportion of total shorebirds occurring at each site was calculated by season and year. These percentages were then averaged over the five years of surveys. Because number of shorebirds varied widely among sites, differences in the proportion of the various species (i.e., species composition) and shorebird abundance among 2-week survey periods (i.e., migration chronology) were compared among three regions: north, central, and south. Sites were assigned to a region based on latitude (decimal degrees) such that in the north latitude ranged from 39.00 to 39.99, central 38.00 to 38.99, and south 37.00 to 37.99.

Species composition and migration chronology for each of the three regions were calculated by season and year. Species composition was calculated by dividing the number of individuals of each species by the total number of shorebirds excluding individuals that were not identified to group (e.g., peeps, yellowlegs). Migration chronology was calculated by dividing number of individuals of each species recorded during each 2-week period by the total number of individuals of each species during each season. Species composition and migration chronology were calculated for each season and year and then averaged by season over the five years of the survey.

Because peeps comprised significant portions of the shorebirds recorded at some sites, peeps were re-allocated among the *Calidris* species using the proportions of *Calidris* species identified. For example if Semipalmated Sandpipers (*Calidris pusilla*) comprised 10% of shorebirds, Semipalmated Sandpipers comprised 30% of all *Calidris* sandpipers identified to species, and peeps comprised 10% of the shorebirds identified, then Semipalmated Sandpipers would comprise 13% of shorebirds after re-allocation. All percentages pertaining to species (e.g., species composition, migration chronology) were calculated from the data as reported, and not re-allocated from peeps, unless specifically stated to have been re-allocated.

Table 1. Number of sites surveyed as part of the Kansas Shorebird Survey during 2002-2006. Percent is calculated based on the number of sites that volunteers offered to survey.

	Spring		Summer-fall	
Year	Number	%	Number	%
2002	39	80	33	71
2003	34	70	31	63
2004	31	58	29	55
2005	23	43	23	43
2006	25	47	23	43

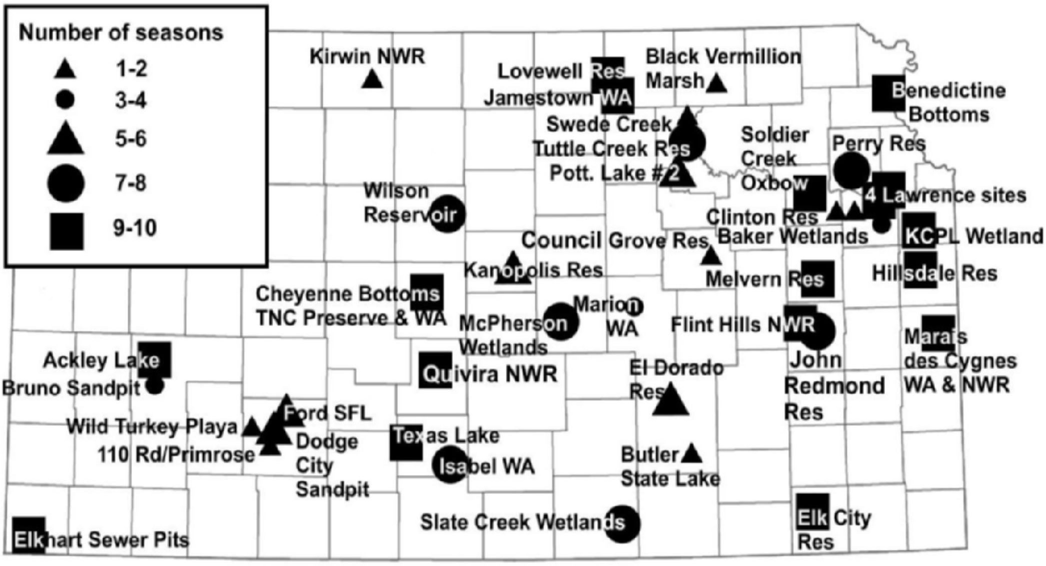

Number of seasons
1-2
3-4
5-6
7-8
9-10
Kirwin NWR
Lovewell Res
Jamestown WA
Black Vermillion Marsh
Benedictine Bottoms
Swede Creek
Tuttle Creek Res
Pott. Lake #2
Soldier Creek Oxbow
Perry Res
4 Lawrence sites
Clinton Res
Baker Wetlands
KCPL Wetland
Wilson Reservoir
Council Grove Res
Kanopolis Res
Melvern Res
Hillsdale Res
Cheyenne Bottoms TNC Preserve & WA
McPherson Wetlands
Marion WA
Flint Hills NWR
John Redmond Res
Marais des Cygnes WA & NWR
Ackley Lake
Bruno Sandpit
Quivira NWR
El Dorado Res
Wild Turkey Playa
110 Rd/Primrose
Ford SFL
Dodge City Sandpit
Texas Lake
Isabel WA
Butler State Lake
Slate Creek Wetlands
Elk City Res
Elkhart Sewer Pits

Figure 1. Sites where shorebird surveys have been conducted as part of the Kansas Shorebird Survey during 2002-2006. Symbols indicate the number of seasons in which at least one survey was conducted at each site.

RESULTS

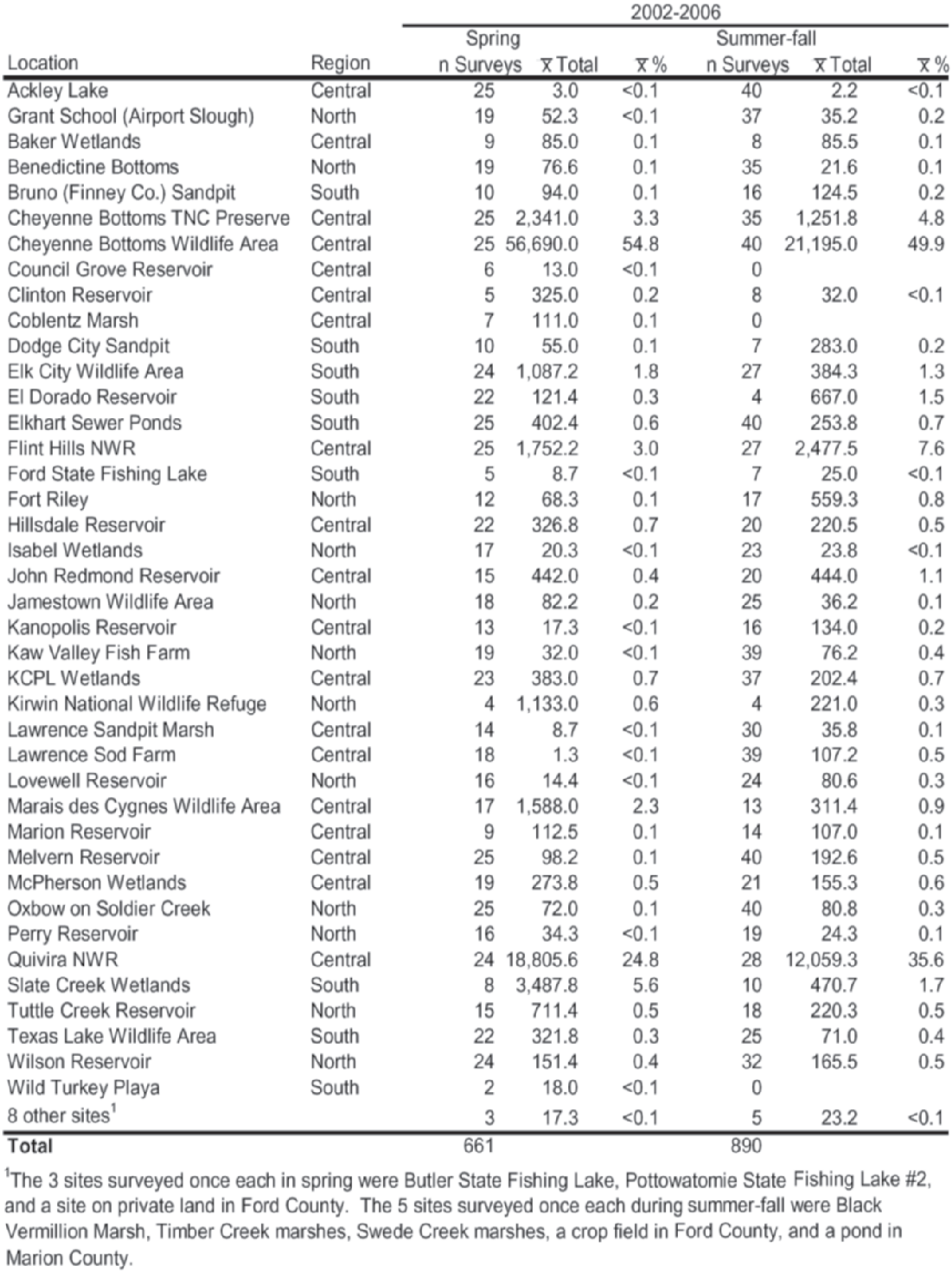
Over 80 people volunteered to survey 54 sites. Survey data were received for 23 to 39 sites per season (Table 1, Fig. 1). Percent of sites surveyed declined over the course of the 5-year survey. When a site was not surveyed in a year due to lack of habitat suitable for shorebirds, it was excluded from the data in Table 1.

During the five springs, 444,908 shorebirds were reported. Total number of shorebirds counted in spring ranged from 29,134 to 178,038 and averaged 88,982 (n = 5 years, SE = 25,378). Not surprisingly, CBWA (Mean = 54.8%, n = 5, SE = 9.4) and QNWR (Mean = 24.8%, n = 5, SE = 8.7) had the highest average proportions of the annual statewide total number of shorebirds during spring 2002-2006 (Table 2). After these traditional hotspots came Slate Creek wetlands (SCW; Mean = 5.6%, n = 4, SE = 2.6), The Nature Conservancy's Cheyenne Bottoms Preserve (Mean = 3.3%, n = 5, SE = 0.8), Flint Hills National Wildlife Refuge (FNWR; Mean = 3.0%, n = 5, SE = 1.4), and Marais des Cygnes Wildlife Area (Mean = 2.3%, n = 5, SE = 0.7).

During summer-fall 2002-2006, 189,193 shorebirds were reported. Statewide totals during summer-fall 2002-2006 ranged from 22,831 to 76,586 and averaged 37,839 (n = 5 years, SE = 9,837). Mean proportion of the annual statewide total number of shorebirds also was highest at CBWA (Mean = 49.9%, n = 5, SE = 10.2), followed by QNWR (Mean = 35.6%, n = 4, SE = 7.8), FNWR (Mean = 7.6%, n = 4, SE = 2.5), and SCW (Mean = 1.7%, n = 3, SE = 0.4) (Table 2).

During spring and summer-fall 2002-2006, 39 species of shorebirds were recorded (Table 3). Statewide, unidentified shorebirds comprised 22% of shorebirds recorded; however, the vast majority (87%) of these were from CBWA. Of those shorebirds identified to at least a taxonomic group (i.e., excluding the

Table 2. Number of surveys, mean total number of shorebirds, and mean percent of shorebirds by location during 2002-2006. Region was assigned based on latitude (decimal degrees) of the location. Locations with latitude between 39.00 and 39.99 were in the north, between 38.00 and 38.99 in the central, and 37.00 and 37.99 in the south.



		2002-2006					
		Spring			Summer-fall		
Location	Region	n Surveys	$\bar{x}$ Total	$\bar{x}$ %	n Surveys	$\bar{x}$ Total	$\bar{x}$ %
Ackley Lake	Central	25	3.0	<0.1	40	2.2	<0.1
Grant School (Airport Slough)	North	19	52.3	<0.1	37	35.2	0.2
Baker Wetlands	Central	9	85.0	0.1	8	85.5	0.1
Benedictine Bottoms	North	19	76.6	0.1	35	21.6	0.1
Bruno (Finney Co.) Sandpit	South	10	94.0	0.1	16	124.5	0.2
Cheyenne Bottoms TNC Preserve	Central	25	2,341.0	3.3	35	1,251.8	4.8
Cheyenne Bottoms Wildlife Area	Central	25	56,690.0	54.8	40	21,195.0	49.9
Council Grove Reservoir	Central	6	13.0	<0.1	0		
Clinton Reservoir	Central	5	325.0	0.2	8	32.0	<0.1
Coblentz Marsh	Central	7	111.0	0.1	0		
Dodge City Sandpit	South	10	55.0	0.1	7	283.0	0.2
Elk City Wildlife Area	South	24	1,087.2	1.8	27	384.3	1.3
El Dorado Reservoir	South	22	121.4	0.3	4	667.0	1.5
Elkhart Sewer Ponds	South	25	402.4	0.6	40	253.8	0.7
Flint Hills NWR	Central	25	1,752.2	3.0	27	2,477.5	7.6
Ford State Fishing Lake	South	5	8.7	<0.1	7	25.0	<0.1
Fort Riley	North	12	68.3	0.1	17	559.3	0.8
Hillsdale Reservoir	Central	22	326.8	0.7	20	220.5	0.5
Isabel Wetlands	North	17	20.3	<0.1	23	23.8	<0.1
John Redmond Reservoir	Central	15	442.0	0.4	20	444.0	1.1
Jamestown Wildlife Area	North	18	82.2	0.2	25	36.2	0.1
Kanopolis Reservoir	Central	13	17.3	<0.1	16	134.0	0.2
Kaw Valley Fish Farm	North	19	32.0	<0.1	39	76.2	0.4
KCPL Wetlands	Central	23	383.0	0.7	37	202.4	0.7
Kirwin National Wildlife Refuge	North	4	1,133.0	0.6	4	221.0	0.3
Lawrence Sandpit Marsh	Central	14	8.7	<0.1	30	35.8	0.1
Lawrence Sod Farm	Central	18	1.3	<0.1	39	107.2	0.5
Lovewell Reservoir	North	16	14.4	<0.1	24	80.6	0.3
Marais des Cygnes Wildlife Area	Central	17	1,588.0	2.3	13	311.4	0.9
Marion Reservoir	Central	9	112.5	0.1	14	107.0	0.1
Melvern Reservoir	Central	25	98.2	0.1	40	192.6	0.5
McPherson Wetlands	Central	19	273.8	0.5	21	155.3	0.6
Oxbow on Soldier Creek	North	25	72.0	0.1	40	80.8	0.3
Perry Reservoir	North	16	34.3	<0.1	19	24.3	0.1
Quivira NWR	Central	24	18,805.6	24.8	28	12,059.3	35.6
Slate Creek Wetlands	South	8	3,487.8	5.6	10	470.7	1.7
Tuttle Creek Reservoir	North	15	711.4	0.5	18	220.3	0.5
Texas Lake Wildlife Area	South	22	321.8	0.3	25	71.0	0.4
Wilson Reservoir	North	24	151.4	0.4	32	165.5	0.5
Wild Turkey Playa	South	2	18.0	<0.1	0		
8 other sites[1]		3	17.3	<0.1	5	23.2	<0.1
Total		661			890		

[1] The 3 sites surveyed once each in spring were Butler State Fishing Lake, Pottowatomie State Fishing Lake #2, and a site on private land in Ford County. The 5 sites surveyed once each during summer-fall were Black Vermillion Marsh, Timber Creek marshes, Swede Creek marshes, a crop field in Ford County, and a pond in Marion County.

Table 3. Mean number of shorebirds and mean percent of total shorebirds (excluding unidentified shorebirds) in the northern, central, and southern regions of Kansas during spring and summer-fall 2002-2006. Regions were delineated by latitude (decimal degrees) such that latitudes ranged from 39.00-39.99 in the north, 38.00-38.99 in the central, and 37.00-37.99 in the south.

	2002-2006 Mean											
	Spring						Summer-fall					
	North		Central		South		North		Central		South	
Species	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Black-bellied Plover	0.0	0.0	67.2	0.1	16.8	0.4	1.6	0.1	22.8	0.1	1.2	0.1
American Golden-plover	4.4	1.1	25.4	0.0	13.8	0.3	0.6	0.1	8.4	0.0	0.0	0.0
Snowy Plover	0.0	0.0	214.2	0.4	1.2	0.0	0.0	0.0	147.0	0.5	0.0	0.0
Semipalmated Plover	2.4	0.2	153.6	0.2	57.0	1.3	15.8	0.8	63.8	0.2	5.2	0.5
Piping Plover	0.0	0.0	38.6	0.1	0.4	0.0	0.0	0.0	7.8	0.0	0.2	0.0
Killdeer	205.6	12.9	870.4	1.0	311.2	5.2	491.2	37.4	2,333.2	4.5	280.8	20.0
Black-necked Stilt	0.2	0.0	271.2	0.5	5.2	0.1	0.0	0.0	399.6	1.6	0.6	0.0
American Avocet	3.2	0.2	1,029.0	1.3	27.2	1.4	21.2	5.3	2,644.2	9.5	33.8	2.7
Greater Yellowlegs	24.0	2.2	496.0	0.6	172.4	3.9	24.4	2.7	454.2	1.3	16.6	1.5
Lesser Yellowlegs	21.8	2.4	1,399.4	1.7	335.4	9.6	41.6	3.9	987.6	2.6	58.0	5.7
Unidentified yellowlegs	7.6	2.1	475.2	0.9	4.8	0.1	2.4	0.4	330.6	1.1	2.6	0.5
Solitary Sandpiper	2.4	0.3	13.6	0.0	2.0	0.0	11.2	1.7	88.6	0.3	12.6	0.9
Willet	3.2	0.2	41.8	0.1	6.6	0.2	6.2	1.5	26.6	0.1	0.8	0.1
Spotted Sandpipter	31.4	2.9	100.2	0.1	50.6	1.3	27.4	2.3	112.8	0.3	68.4	7.5
Upland Sandpiper	3.6	0.5	36.4	0.1	2.2	0.0	5.4	0.6	34.6	0.1	8.2	0.7
Whimbrel	0.0	0.0	2.6	0.0	0.6	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Long-billed Curlew	0.0	0.0	11.4	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0
Hudsonian Godwit	23.4	2.1	99.2	0.2	22.8	0.3	4.6	0.7	1.2	0.0	0.0	0.0
Marbled Godwit	0.2	0.1	12.4	0.0	0.0	0.0	0.4	0.0	5.8	0.0	0.4	0.0
Ruddy Turnstone	0.0	0.0	12.2	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0
Red Knot	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sanderling	1.4	0.2	56.2	0.1	1.4	0.1	5.0	0.5	32.2	0.1	0.8	0.1
Semipalmated Sandpiper	38.6	3.1	1,821.0	3.3	235.6	6.9	15.0	2.2	481.6	1.5	56.2	4.3
Western Sandpiper	3.4	0.2	61.0	0.1	20.4	1.5	1.2	0.1	89.0	0.3	7.0	0.9
Least Sandpiper	102.2	7.6	586.2	1.0	319.8	5.5	44.8	7.4	2,522.2	7.0	58.8	4.6
White-rumped Sandpiper	23.2	2.0	2,111.4	2.9	1,037.4	15.1	4.6	0.5	46.4	0.1	2.0	0.2
Baird's Sandpiper	250.6	20.6	1,881.6	2.1	230.0	4.3	29.8	4.1	436.0	1.5	28.6	3.9
Pectoral Sandpiper	31.0	4.5	1,226.2	2.5	301.4	6.1	18.4	2.8	1,119.0	4.2	26.8	1.8
Dunlin	1.2	0.2	75.6	0.2	7.8	0.2	0.0	0.0	2.2	0.0	0.0	0.0
Stilt Sandpiper	3.0	0.3	3,891.0	7.0	141.4	5.4	3.6	0.6	3,187.2	10.4	12.4	0.8
Buff-breasted Sandpiper	0.0	0.0	1.4	0.0	11.2	0.2	1.0	0.2	59.6	0.2	2.4	0.1
Ruff	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0
Unidentified peeps	629.0	30.4	20,578.4	26.8	940.6	14.6	268.8	17.5	5,782.6	18.5	302.6	20.2
Short-billed Dowitcher	1.8	0.2	0.4	0.0	0.8	0.0	1.4	0.4	6.8	0.0	0.4	0.0
Long-billed Dowitcher	8.4	0.7	170.4	0.4	144.0	3.8	7.0	1.8	177.0	0.8	58.2	8.1
Unidentified Dowitcher	35.0	1.3	10,007.8	22.3	19.8	0.6	14.8	2.5	8,735.8	28.5	1.8	0.2
Wilson's Snipe	10.8	0.7	109.8	0.2	118.0	1.9	4.0	0.8	371.6	1.5	59.4	6.4
American Woodcock	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0
Wilson's Phalarope	14.8	0.9	16,547.8	23.4	602.2	9.7	7.6	1.2	754.6	2.4	92.0	7.7
Red-necked Phalarope	0.2	0.0	2.4	0.0	0.2	0.0	0.0	0.0	132.6	0.6	5.8	0.4
Red Phalarope	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.2	0.0
Unidentified *Charadrius* plover	0.0	0.0	145.0	0.3	0.0	0.0	0.0	0.0	21.8	0.1	0.0	0.0
Unidentified *Pluvialis* plover	2.6	0.1	9.4	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0
Unidentified shorebirds	15.0		30,971.6		0.0		1.4		6,611.0		0.2	
Total shorebirds	**1,274.6**		**80,325.0**		**4,549.4**		**787.6**		**31,922.8**		**1,010.6**	

unidentified shorebirds), species composition varied among regions.

Peeps (Mean = 30.4% of all shorebirds, n = 5 years, SE = 12.8) and Baird's sandpipers (*Calidris bairdii*; Mean = 20.6%, SE = 8.8) were the most common species on average during spring 2002-2006 in the northern region (Table 3). After re-allocation of peeps, most common *Calidris* sandpipers were Baird's (Mean = 41.2%, SE = 17.5) and Least (*C. minutilla*; (Mean = 15.2, SE = 5.1) Sandpipers. Peeps (Mean = 26.8%, n = 5, SE = 7.6), Wilson's Phalaropes (*Phalaropus tricolor*; Mean = 23.4%, SE = 5.8), and dowitchers (Mean = 22.3%, SE = 6.6) were the most common shorebirds reported in the central region. After re-allocation of peeps, Stilt Sandpipers (*C. himantopus*; Mean = 13.9%, SE = 5.9) were the most common *Calidris* species in the central region. In the southern region, White-rumped Sandpipers (*C. fuscicollis*; Mean = 15.1%, SE = 8.3) and peeps (Mean = 14.6%, SE = 5.2) were the most common species reported. After re-allocation of peeps, proportions of White-rumped (Mean = 30.3%, SE = 16.5), Semipalmated (Mean = 13.9, SE = 4.2) and Pectoral (*C. melanotos*; Mean = 12.2%, SE = 4.6) Sandpipers increased substantially.

During summer-fall 2002-2006, Killdeer (*Charadrius vociferous*; Mean = 37.4%, n = 5 years, SE = 6.0) and peeps (Mean = 17.5%, SE = 9.3) were the predominant species on average in the northern region (Table 3). After re-allocation of peeps, proportion of Least (Mean = 14.8%, SE = 5.5) and Baird's Sandpipers (Mean = 8.1%, SE = 3.4) increased substantially. Dowitchers (Mean = 28.5%, SE = 4.9) and peeps (Mean = 18.5%, SE = 5.0) were most common in the central region. After re-allocation of peeps, proportions of Stilt (Mean = 20.7%, SE = 4.6) and Least (Mean = 14.1%, SE = 2.8) Sandpipers increased substantially. Peeps (Mean = 20.2%, SE = 8.2) and Killdeer (Mean = 20.0%, SE = 4.4) were the most commonly reported species in the southern region. After re-allocation of peeps, proportions of Least (Mean = 9.2%, SE = 3.5), Semipalmated (Mean = 8.6%, SE = 7.8), and Baird's (Mean = 7.8%, SE = 2.8) Sandpipers increased substantially.

Migration chronology was similar among regions during spring 2002-2006 (Fig. 2). Proportion of all shorebirds during spring was highest during the first two weeks of May. During summer-fall, migration chronology differed somewhat among the three regions (Fig. 2). Shorebirds peaked during the last two weeks of August in the north, during the last two weeks of September in the central region, and during the first two weeks of October in the south. However, 95% confidence intervals overlapped among all regions and nearly all 2-week periods during spring and summer-fall.

There was so much overlap among 95% confidence intervals for percentages of individual species occurring during the 2-week periods during spring and summer-fall that error bars showing 95% confidence intervals were not included for any of the species graphs (Figs. 3-10). During spring, Killdeer were the earliest to reach peak numbers, late March to early April, and migration chronology was similar throughout the state (Fig. 3). Among the plovers, Snowy Plovers (*C. alexandrinus*) were the next to peak, followed by Semipalmated (*C. semipalmatus*), Piping (*C. melodus*), and Black-bellied (*C. squatarola*) Plovers. Migration chronology of Snowy Plovers differed between the central and southern regions, but was not recorded in the northern region. Numbers of Snowy Plovers in the central region remained at relatively high levels through late May, whereas in the south their numbers declined after reaching a peak in early April.

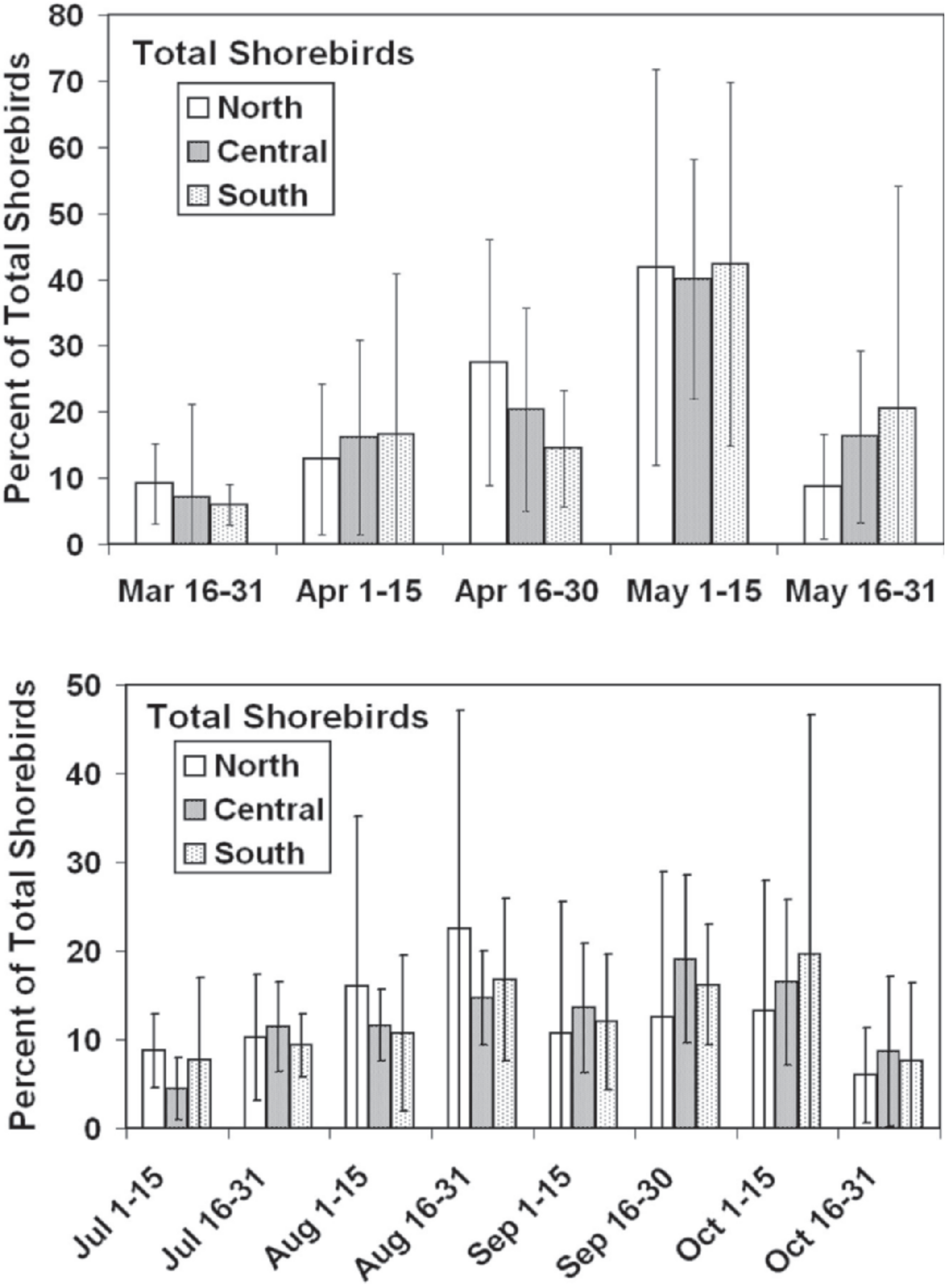


Figure 2. Average (5-year) migration chronology of total shorebirds in the northern, central, and southern regions of Kansas during spring and summer-fall 2002-2006. Error bars show 95% confidence intervals.

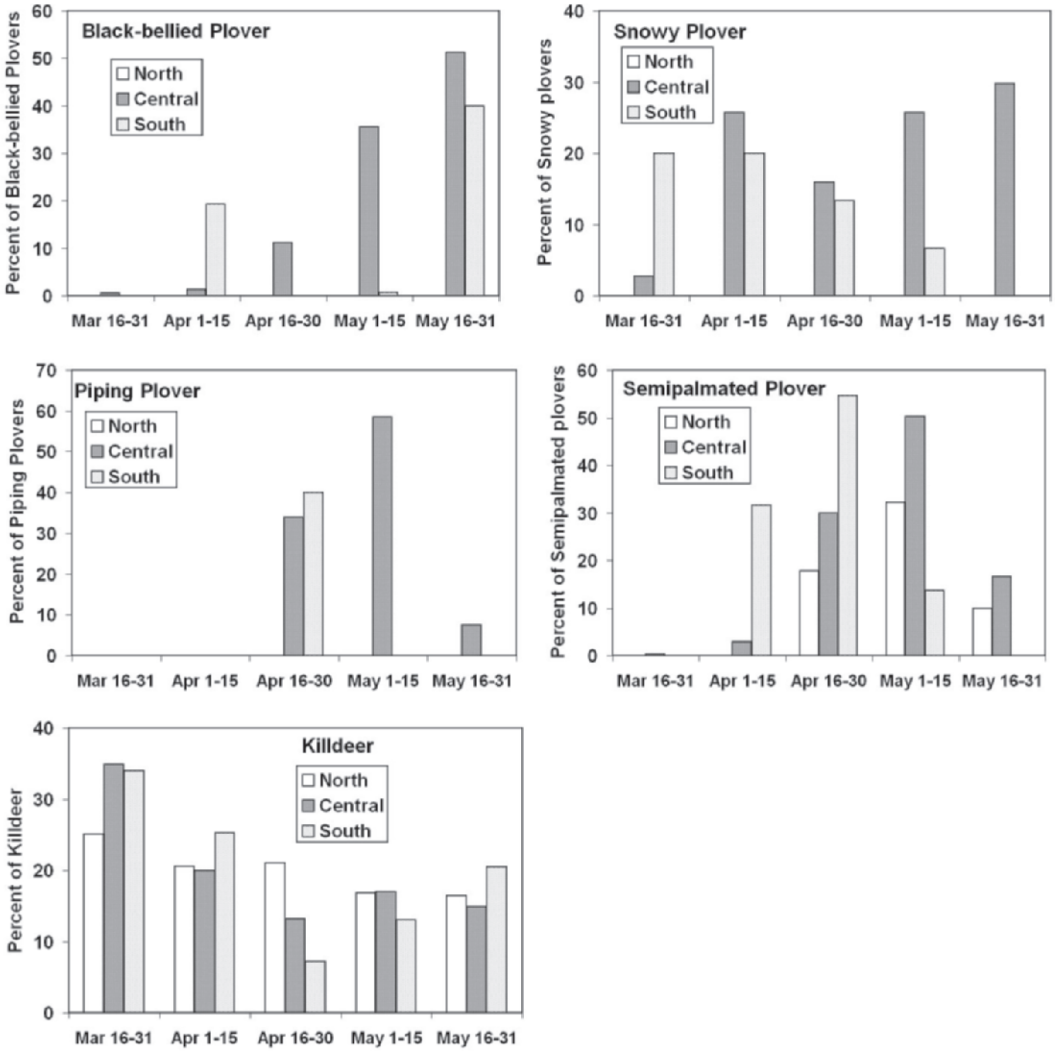


Figure 3. Average (5-year) migration chronology of five species of plovers in the northern, central, and southern regions of Kansas during spring 2002-2006.

Among the large water-column feeders (Black-necked Stilts [*Himantopus mexicanus*], American Avocets [*Recurvirostra americana*], Hudsonian [*Limosa haemastica*] and Marbled Godwits [*L. fedoa*], and Greater [*Tringa melanoleuca*] and Lesser Yellowlegs [*T. flavipes*]), Greater Yellowlegs were the first to reach peak numbers, doing so in early April in all regions (Fig. 4). American Avocets, the godwits, and Lesser Yellowlegs peaked in late April and early May. Black-necked Stilt abundances were highest in May in the central region, but patterns were irregular elsewhere.

Baird's Sandpiper abundances peaked in April in the central and southern regions, but about two weeks later in the northern region (Fig. 5). Western Sandpipers (*C. mauri*) were most abundant during April in the southern region, during the first two weeks of May in the central region, but very few were reported in

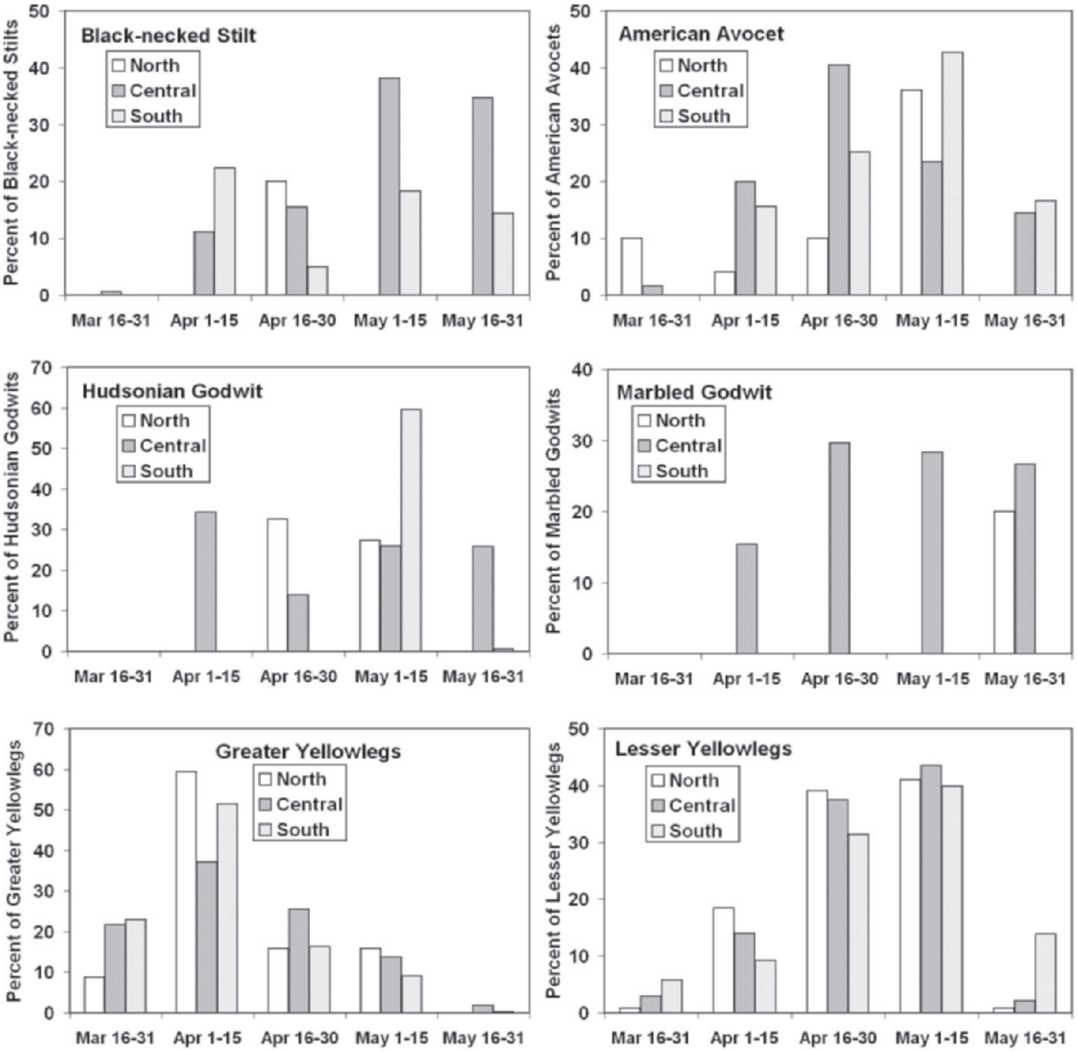


Figure 4. Average (5-year) migration chronology of Black-necked Stilts, American Avocets, Hudsonian and Marbled Godwits, and Greater and Lesser Yellowlegs in the northern, central, and southern regions of Kansas during spring 2002-2006.

the northern region. Semipalmated Sandpipers peaked in the northern and central regions during late April and early May, but did not peak in the southern region until about two weeks later. Least Sandpipers peaked during the first half of May in all three regions. Pectoral Sandpiper numbers were highest during the first half of May in the northern and central regions, but numbers were fairly constant throughout April and May in the southern region. White-rumped Sandpipers were the last to reach peak numbers, which occurred throughout May in the northern and southern regions and during the last half of May in the central region.

Dowitcher abundances were highest in late April and early May in all regions (Fig. 6). Next to peak were Wilson’s Phalaropes in the first two weeks of May, followed by Stilt Sandpipers.

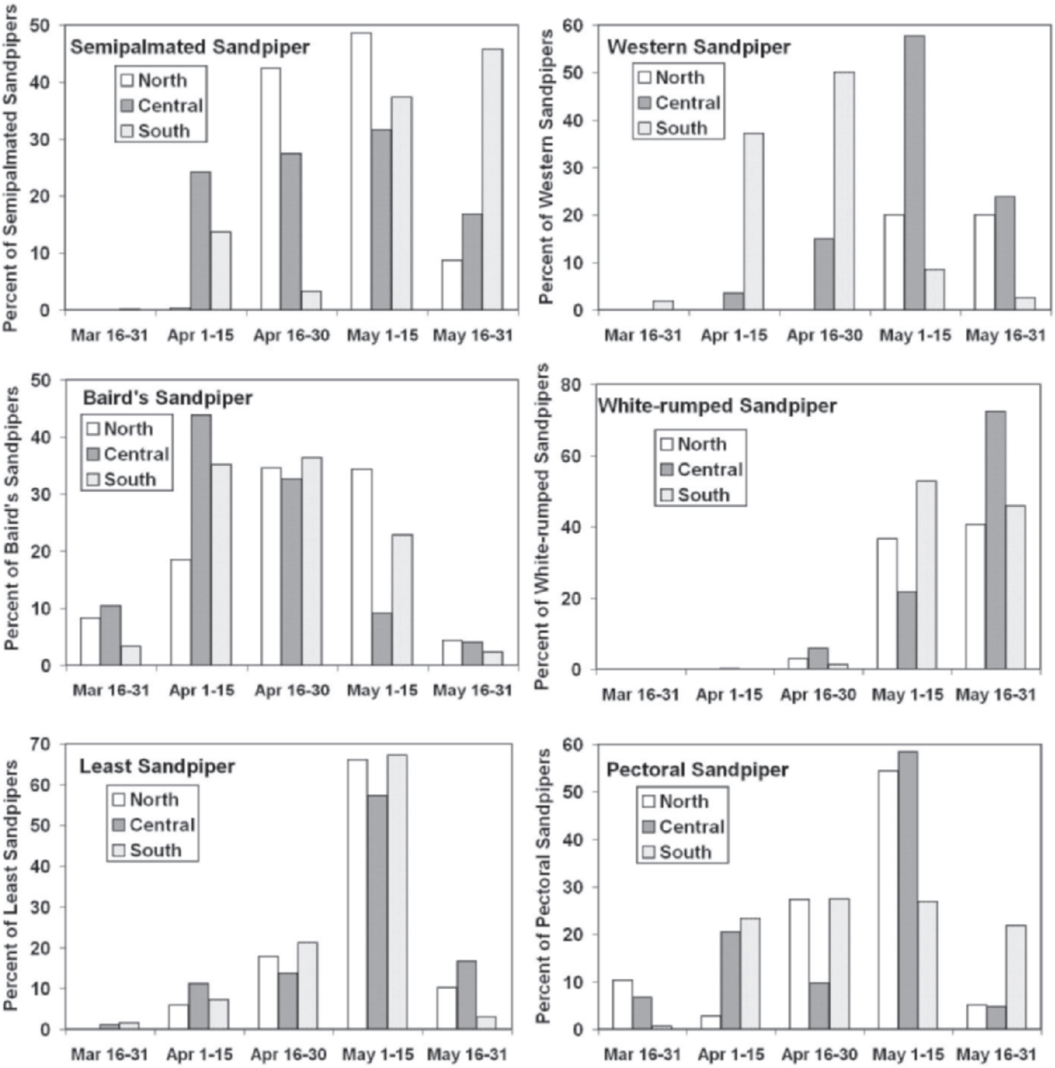


Figure 5. Average (5-year) migration chronology of six species of *Calidris* sandpipers in the northern, central, and southern regions of Kansas during spring 2002-2006.

Compared to spring, summer-fall peaks of total shorebird abundance were much less distinct, but a slight north-south shift in the timing of peaks was detected (Fig. 2). Among the plovers, numbers of Snowy Plovers, which only occurred in the central region, showed a consistent decline from the second half of July through October (Fig. 7). Numbers of Black-bellied and Semipalmated Plovers in the northern region peaked during the second half of August. Black-bellied Plovers in the central region peaked during the first half of October.

Migration chronology patterns were variable for the large, water-column feeders (Fig. 8). The most distinctive patterns were the steady decline of Black-necked Stilts after the first half of August and the sharp peak in Greater and Lesser Yellowlegs during the second half of August in the northern region.

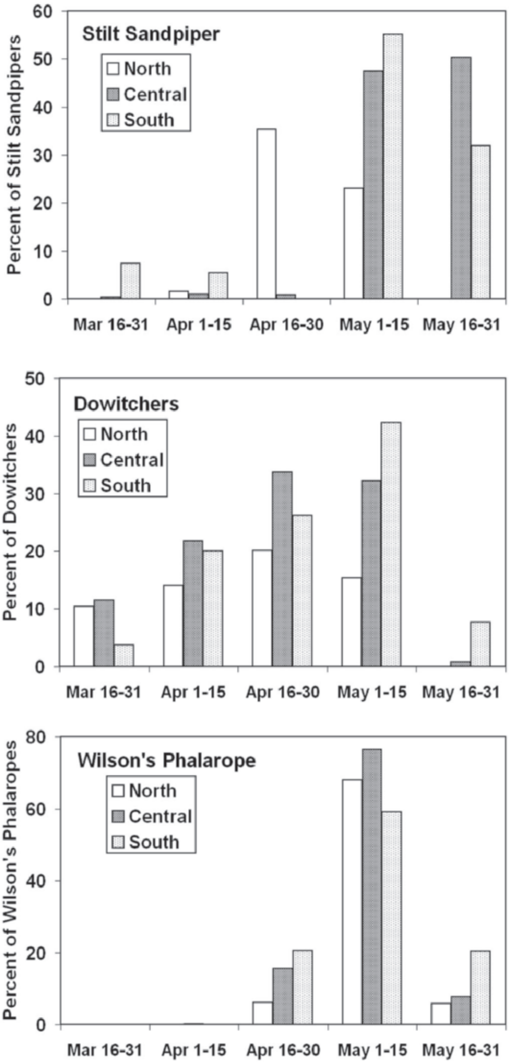


Figure 6. Average (5-year) migration chronology of Stilt Sandpipers, dowitchers (Long-billed and Short-billed combined), and Wilson's Phalaropes in the northern, central, and southern regions of Kansas during spring 2002-2006.

Migration of Semipalmated Sandpipers primarily occurred before 1 September throughout the state (Fig. 9). Western, Least, and Baird's Sandpiper migration was nearly complete by the end of September.

Pectoral Sandpiper abundance was highest during August in all regions (Fig. 10). Dowitchers reached peak numbers during the first half of October throughout the state.

Discussion

Declining participation rates and inconsistencies in numbers of surveys per site from 2002-2006 indicated that conducting 13 shorebird surveys per year is a major time commitment for many volunteers. Maintaining survey consistency over a number of years is more difficult for species such as shorebirds, which require a fairly narrow range of habitat conditions and at sites where habitat availability is extremely variable and often cannot be managed for shorebirds. These factors combined with volunteers' other commitments make long-term shorebird surveys conducted by volunteers a challenge.

It was not surprising that at least 75% of the shorebirds reported during this 5-year project were at QNWR and CBWA, Kansas' two Western Hemisphere Reserve Network sites. However, I expected more shorebirds to be reported at other managed wetlands and at some reservoirs because the 5-year survey period, which occurred during a period of relatively low statewide precipitation. For example, about 10,000 shorebirds were counted at Jamestown Wildlife Area on 26 April and 2 May 1996 (Rice et al. 2001), but less than 1,000 during this 5-year survey. Of course, amount and timing of precipitation in specific areas are the major factors determining habitat availability for shorebirds at specific sites. Shorebird habitat and use may also be more ephemeral at smaller sites that are not part of a wetland complex like CBWA and QNWR. Thus, more frequent surveys, as often as daily, may be necessary to record shorebird migration at peripheral sites (Young 1993).

Species composition and migration chronology within the three regions strongly

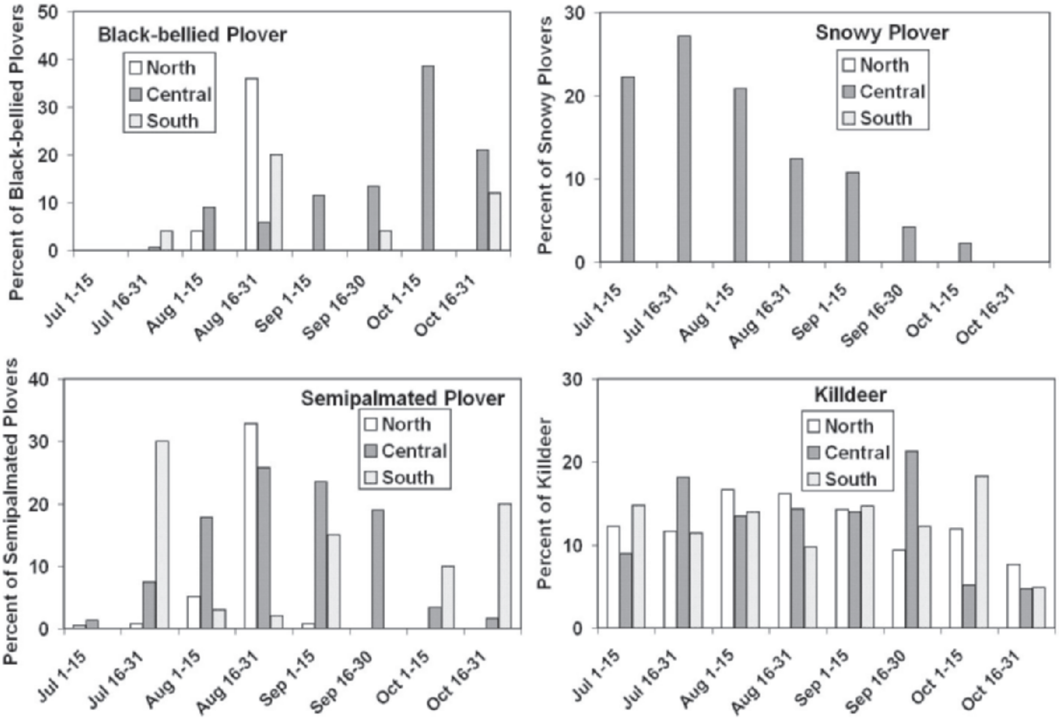


Figure 7. Average (5-year) migration chronology of four species of plovers in the northern, central, and southern regions of Kansas during summer-fall 2002-2006.

reflect where the most shorebirds were reported. Predominant sites within the northern region include Kirwin National Wildlife Refuge, Tuttle Creek Reservoir, and Fort Riley (summer-fall only). SCW and Elk City Reservoir were the major sites in the southern region in spring, but shorebirds were more evenly distributed in this region during summer-fall. The influence of CBWA and QNWR on the central region is much stronger than the influence of the major sites in the other two regions.

Past descriptions of species composition and migration chronology of shorebirds are available for only three (CBWA, QNWR, and SCW) of the predominant sites. Species composition in the central region during spring and summer-fall 2002-2006 differed from those for CBWA during 1976-2005 and QNWR during 1995-2001. The longer-term CBWA data set on average contained more peeps and fewer Wilson's Phalaropes and dowitchers during spring, and fewer dowitchers during summer-fall (KDWP 2006). At QNWR, more peeps and fewer dowitchers were reported during spring 1995-2001 and summer-fall 2001 (International Shorebird Survey unpubl. data). More Stilt and Baird's Sandpipers were recorded at SCW during the springs of 1988 and 1989 than during 2002-2006 (Young 1993). Possible explanations for differences between this and other data sets include annual variability in species composition and the central region being comprised of both CBWA and QNWR.

Migration chronology in the central region during 2002-2006 was similar to that for CBWA during spring and summer-fall 1976-2005, but was somewhat different compared to QNWR during spring 1995-2001. At

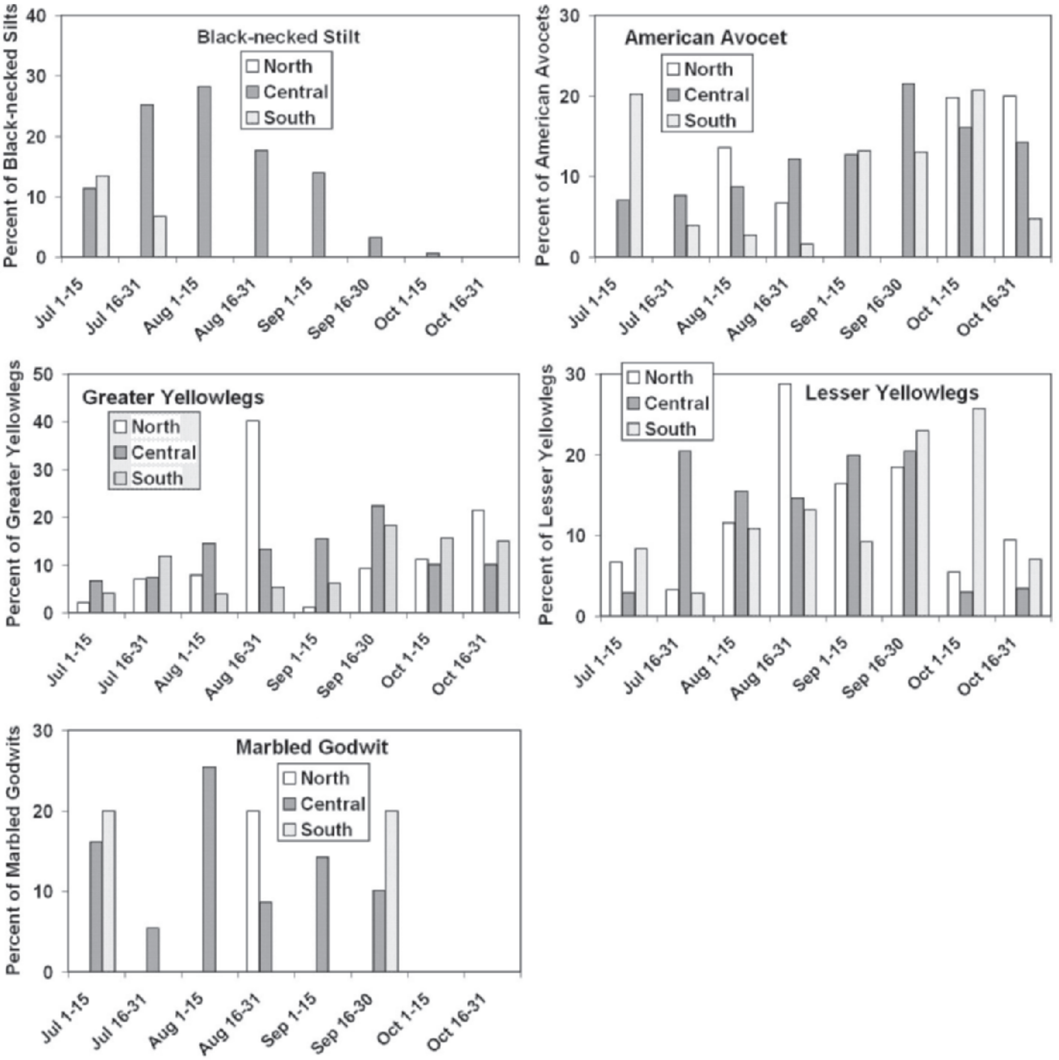


Figure 8. Average (5-year) migration chronology of Black-necked Stilts, American Avocets, Greater and Lesser Yellowlegs, and Marbled Godwits in the northern, central, and southern regions of Kansas during summer-fall 2002-2006.

QNWR, peak numbers of Baird's Sandpipers occurred earlier and Western Sandpipers, Least Sandpipers, and Lesser Yellowlegs later during 2002-2006 than during 1995-2001. Spring migration chronology for all shorebirds; Lesser Yellowlegs; and Semipalmated, Least, Baird's, White-rumped, Pectoral, and Stilt Sandpipers was similar at SCW during 2002-2006 and during 1988-89 (Young 1993). However, American Avocet and Wilson's Phalarope numbers peaked earlier during the springs of 1988 and 1989 than during 2002-2006.

Relative abundance of shorebirds by site and species composition and migration chronology by region were based on the sites that were surveyed and the habitat conditions at those sites during 2002-2006. Somewhat different results could have been obtained if a

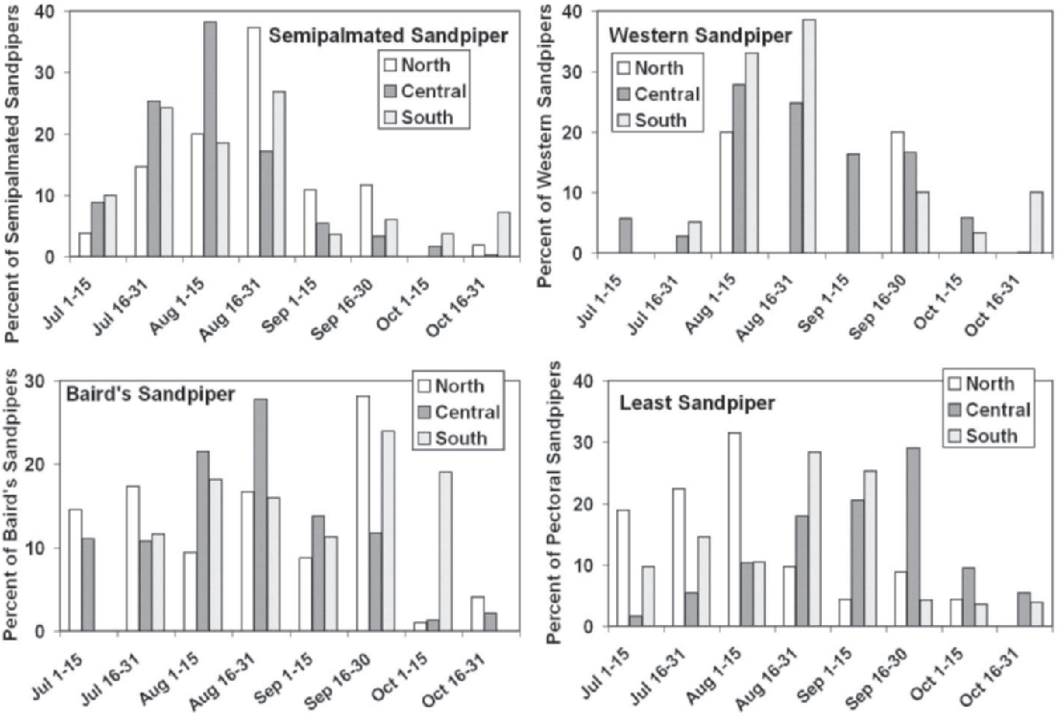


Figure 9. Average (5-year) migration chronology of Semipalmated, Western, Baird's, and Least Sandpipers in the northern, central, and southern regions of Kansas during summer-fall 2002-2006.

large group of playas in the western quarter of the state had been surveyed, other marshes had been surveyed (e.g., Neosho Wildlife Area), some sites had been surveyed more regularly (e.g., Kirwin NWR), and habitat conditions had been more favorable during 2002-2006.

There was much overlap in 95% confidence intervals among 2-week time periods for total shorebirds and especially for individual species during both spring and summer-fall. Some of this overlap was due to annual variation in migration chronology, but some was due to the relatively short duration of these surveys. When number of years of data from QNWR during spring were increased from 4-5 to 7-11, width of 95% confidence intervals decreased 18-60% (Fig. 11). When number of years of data from CBWA during spring were increased from five to 20-24, 95% confidence intervals decreased 78-97%. Thus, even in spring, when migration chronology is fairly consistent from year to year, at least ten years of surveys are needed to start to obtain statistically precise estimates of migration chronology.

RECOMMENDATIONS FOR MANAGEMENT AND FURTHER RESEARCH

These surveys further reinforced the importance of CBWA and QNWR to migrating shorebirds. However, five years is not long enough to discount the importance of other wetlands and some reservoirs, and the years 2002-2006 probably were not representative of past or future years.

Most common species recorded during 2002-2006 varied in size and feeding strategy from Killdeer, which feed on invertebrates on dry

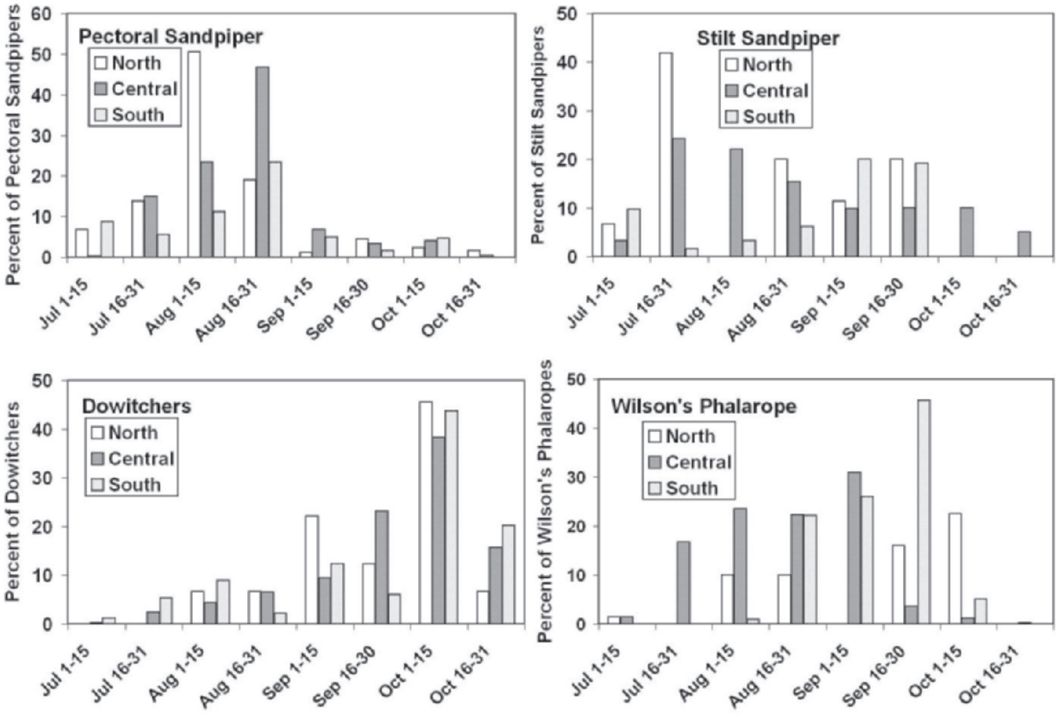


Figure 10. Average (5-year) migration chronology of Pectoral and Stilt Sandpipers, dowitchers, and Wilson's Phalaropes in the northern, central, and southern regions of Kansas during summer-fall 2002-2006.

and moist mud, to small peeps, such as Semipalmated and White-rumped Sandpipers, which probe for invertebrates in the mud, to dowitchers, which probe in the mud but can utilize deeper water, to Wilson's Phalaropes, which have relatively long legs for wading in deeper water, can forage while swimming, and feed on invertebrates on the surface of the water. Because these species represent the extremes of water depth and feeding niches, shorebird management in Kansas involves providing dry and moist mud and water less than 7.6 cm deep with adequate densities of invertebrates in and on the mud and in the water column.

These surveys also have shown that habitat for migrating shorebirds should be provided from at least mid-March through May and during July through October. If shorebird habitat cannot be provided continuously during these periods, shorebird habitat should at least be provided during mid-April through mid-May, when over 70% of the spring shorebirds were counted, and mid-August through September, when nearly 60% of the summer-fall shorebirds were counted. More detailed habitat management recommendations are provided in site reports for 20 of the sites surveyed during 2002-2006. Area reports were prepared for these sites because surveys were done at these sites more consistently than other sites and they have at least some management potential.

Continuation of shorebird surveys in the future depends on their objectives. If the objective is to monitor shorebird numbers and migration chronology at specific sites, then surveys should continue at those sites. If the

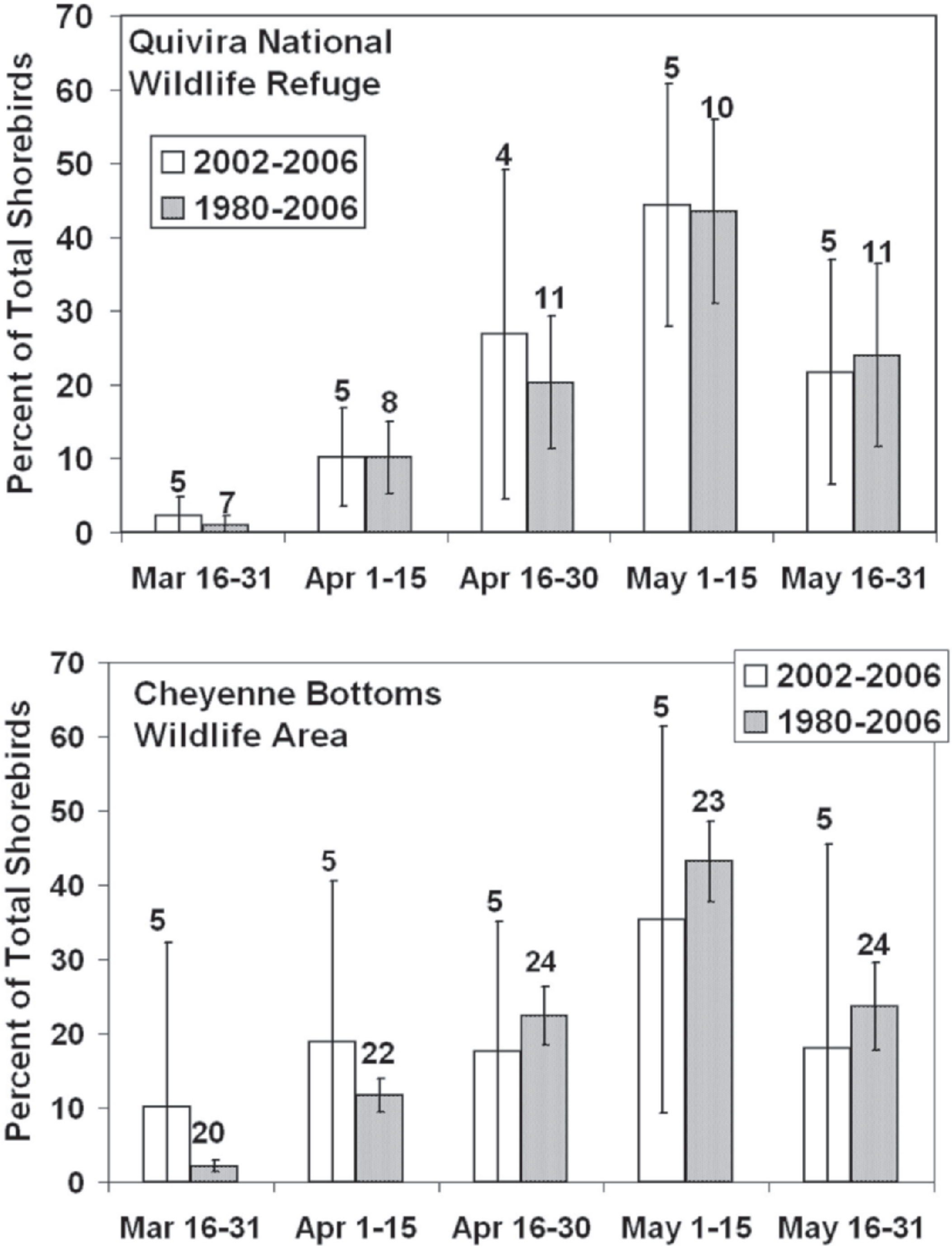


Figure 11. Effect of number of years of surveys on 95% confidence intervals for mean percent of total shorebirds occurring during 2-week periods at Quivira National Wildlife Refuge and Cheyenne Bottoms Wildlife Area. Error bars show 95% confidence intervals. Numbers above error bars are numbers of years of spring surveys.

objective is to monitor shorebird numbers and migration chronology in the state of Kansas, this can be accomplished by surveying less than ten sites. Based on these surveys, 80-85% of Kansas' shorebirds can be monitored by surveying CBWA and QNWR only. To monitor 90-95% of Kansas' shorebirds would require surveying four additional sites (The Nature Conservancy's Cheyenne Bottoms Preserve, Slate Creek wetlands, Flint Hills National Wildlife Refuge, and Marais des Cygnes Wildlife Area). The latter strategy is the preferred option; however, it is hoped that surveys will continue at other sites.

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