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BUFF-BREASTED SANDPIPER DENSITY AND NUMBERS DURING MIGRATORY STOPOVER IN THE RAINWATER BASIN, NEBRASKA

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BUFF-BREASTED SANDPIPER DENSITY AND NUMBERS DURING MIGRATORY STOPOVER IN THE RAINWATER BASIN, NEBRASKA

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Abstract. The Buff-breasted Sandpiper (*Tryngites subruficollis*) is a shorebird of conservation concern whose migration patterns and population size are poorly known. We conducted surveys in the Eastern Rainwater Basin, Nebraska, in 2004 and 2005 using distance sampling. This survey produced density estimates of 0.09 birds per ha in 2004 and 0.04 birds per ha in 2005. Because the study area was explicitly defined by soil characteristics, we were able to extrapolate from density estimates to produce predictions of overall numbers in the study area. We produced minimum estimates of the numbers of Buff-breasted Sandpipers stopping over in the region—43 300 in 2004 and 22 924 in 2005. When we restricted our predictions to only the area adjacent to roads, numbers of birds ranged from 13 488 to 41 513, depending on the area used. These predictions indicate two important findings—that 1) the current estimate of the world population of Buff-breasted Sandpipers of 15 000 to 20 000 individuals is too low, and 2) the Eastern Rainwater Basin appears to be a primary spring stopover site for the species in the North American Great Plains.

Key words: Buff-breasted Sandpiper, migration, shorebirds, stopover, Tryngites subruficollis.

Densidad y Número de *Tryngites subruficollis* Durante las Paradas Migratorias en la Cuenca de Rainwater, Nebraska

Resumen. Tryngites subruficollis es un ave playera con estatus de conservación preocupante, de la cual se conoce poco sobre sus patrones migratorios y tamaños poblacionales. Realizamos muestreos en el este de la Cuenca de Rainwater en Nebraska en los años 2004 y 2005 utilizando el método de muestreo que considera las distancias. Este muestreo produjo estimaciones de densidad de 0.09 individuos por ha en 2004 y de 0.04 individuos por ha en 2005. Debido a que el área de estudio fue definida explícitamente por las características del suelo, fuimos capaces de extrapolar las estimaciones de densidad para predecir los números totales en el área de estudio. Produjimos estimaciones mínimas del número de individuos de *T. subruficollis* que realizan paradas migratorias en la región—43 300 en 2004 y 22 924 en 2005. Al restringir las predicciones sólo a las áreas adyacentes a los caminos, el número de aves varió entro 13 488 y 41 513, dependiendo del área utilizada. Estas predicciones señalan dos hallazgos importantes—que 1) la estimación actual de la población mundial de *T. subruficollis* de 15 000 a 20 000 individuos es muy baja y que 2) el este de la Cuenca de Rainwater parece ser uno de los puntos de parada migratoria más importantes para esta especie en la región de las grandes planicies de Norte América.

INTRODUCTION

Migration and migratory stopover sites are increasingly recognized as crucial components of migratory shorebirds' annual cycle and long-term survival (Morrison et al. 2004, Skagen 2006, Thomas et al. 2006). The Buff-breasted Sandpiper (*Tryngites subruficollis*) is a long-distance migrant shorebird of high conservation concern (Brown et al. 2001). While populations are believed to have numbered in the hundreds of thousands prior to the 20th century (Lanctot et al. 2002), the world population has recently been estimated at 15 000–20 000 individuals (Morrison et al. 2001). The United States Shorebird Conservation Plan recently elevated the conservation status of Buff-breasted Sandpipers from of "high concern" to "highly imperiled" (Brown et al. 2001, USSCP 2004).

Buff-breasted Sandpiper migration is poorly understood, and this lack of information prevents the evaluation of potential risks to the population and the initiation of effective conservation efforts. In spring, Buff-breasted Sandpipers migrate from primary wintering areas in southern Brazil, southern Uruguay, and northern Argentina (Lanctot et al. 2002) northward through South America to the Gulf Coast of Texas and Louisiana (Lanctot and Laredo 1994). In North America, migration to Arctic breeding areas in central Canada and Alaska is through the Great Plains (Lanctot and Laredo 1994). Southward migration follows a similar route, but more individuals are observed throughout the interior and along both coasts of North America, suggesting broader or alternative migration routes (Lanctot and Laredo 1994). While this general

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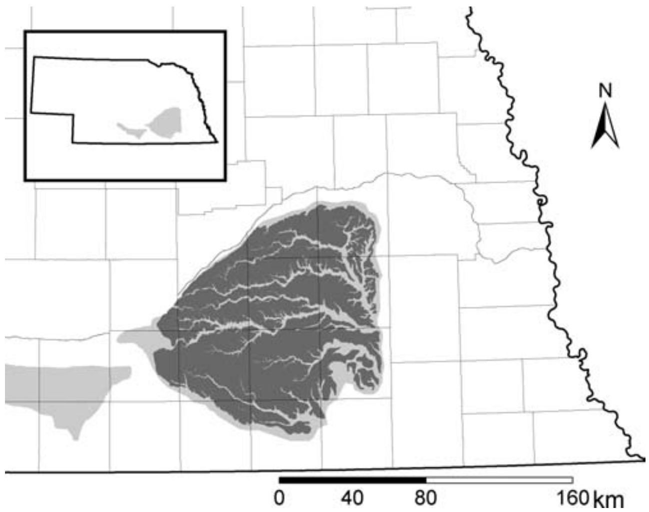

FIGURE 1. The eastern and western portions of the Rainwater Basin, Nebraska, (light gray). The survey area in the Eastern Rainwater Basin as defined by Soil Survey Geographic data is shown in dark gray.

migration pattern is known, specific information about important stopover areas is lacking.

Observations from North America do indicate that certain areas may be used regularly as stopover sites by Buff-breasted Sandpipers. For instance, several hundred individuals were observed during spring migration at Norman, Oklahoma, 1961–1962 (Oring 1964, Oring and Davis 1966). Other areas in the Great Plains are used infrequently or by small numbers. For example, four years of shorebird surveys from Quivira National Wildlife Refuge, Kansas detected only one bird (Skagen and Knopf 1994), and no birds were detected during two years of surveys in the Playa Lakes Region of the Texas Panhandle (Davis and Smith 1998).

Buff-breasted Sandpipers have been observed in relatively large numbers and with some regularity in the Rainwater Basin region of Nebraska, first by Morris (1978, 1995), and more recently by Jorgensen (1997, 2004). The Rainwater Basin encompasses approximately 10 000 km^2 in south-central Nebraska (Kuzila 1994; Fig. 1). The Rainwater Basin is a relatively flat to gently rolling loess plain. Historically, the region was a tall- and mid-grass prairie, which contained a network of more than 11 000 playa wetlands (R. Reker, Rainwater Basin Joint Venture, pers. comm.). The modern Rainwater Basin is greatly altered and dominated by agriculture. Over 90% of all wetlands have been destroyed by draining and conversion to agriculture (Schildman and Hurt 1984); those that remain are degraded due to reduced hydrological function (LaGrange 2005). Over 90% of all land area in the region is devoted to agriculture, with over 80% planted in row crops (primarily corn and soybeans; USDA 2002).

Because the Rainwater Basin is known to be an important stopover area for waterbirds (LaGrange 2005), and given the consistent observations of Buff-breasted Sandpipers in the area, we identified this region as a potentially important stopover site. While Jorgensen (2004) observed hundreds of Buff-breasted Sandpipers each spring from 1997 to 2003, no systematic survey of the species had been conducted. One reason for this is that the birds primarily occupy agricultural fields in the Rainwater Basin (Jorgensen 2004), which makes locating and counting them difficult.

We estimated Buff-breasted Sandpiper density in 2004–2005 using distance sampling. Combining density data with data on the area occupied; we produced an estimate of the total number of birds present during migration to determine the possible importance of this region as a stopover site.

METHODS

We surveyed Buff-breasted Sandpipers in the Rainwater Basin during May 2004 and 2005. The Rainwater Basin consists of two regions of south central Nebraska separated by approximately 20 km (LaGrange 2005). Based on previous work (Jorgensen 2004), we knew that the species was restricted to the Eastern Rainwater Basin during spring migration. The extent of this landscape is well defined based on the unique loess uplands soil type (Kuzila and Lewis 1993, Kuzila 1994). We developed a geographic information system using Soil Survey Geographic data (Natural Resource Conservation Service 2005) to define the study area. This provided us with an explicitly and independently defined study area (Fig. 1) of loess uplands, dissected by the drainages of streams (considered distinct from the Rainwater Basin habitat).

We used distance sampling (Buckland et al. 2001) at point transects (Reynolds et al. 1980) to survey Buff-breasted Sandpipers within the study area. We surveyed birds from points because 1) Buff-breasted Sandpipers are cryptically colored and are easier to detect when an observer is standing still (Lanctot et al. 2002), 2) the region's landscape often allows views over 1 km, and 3) habitat and landscape variables can be easily measured from a single point. We used the existing grid system of county roads, based on the U.S. Public Land Survey System, that are laid out in 1.61 km increments in both an east-west and north-south direction. We conducted surveys from county roads. Prior to the start of fieldwork, point transects were systematically located at 4.82 km intervals. Points were not located off public roads because over 90% of land is privately owned by hundreds of individuals and entities (USDA 2002), and gaining access would have been difficult or impossible. We surveyed 179 and 221 points in 2004 and 2005, respectively, and each point was visited 4–5 times during May. Point locations were recorded with a handheld GPS.

We spent five minutes at each survey point and recorded all shorebirds. Distance of birds from the observation point was determined using a Leica LRF rangefinder (Leica Camera AG, Solms, Germany). In 2004, we conducted surveys in the mornings beginning a half hour before sunrise until 11:00, and during late afternoon, commencing at 16:00 and continuing until sunset. In 2005, surveys were conducted continuously during daylight hours. Surveys were not conducted during extreme rainfall or when winds were >40 km hr^{-1}. All surveys were conducted by JGJ, eliminating potential problems of observer bias.

Independent detections of individuals or groups were treated as "clusters" (Buckland et al. 2001). Groups of birds are considered clusters when the detection of one individual is dependent on the known location of another individual. In other words, the detection is a function of the observer being cued to additional birds by locating the first individual. When a cluster was encountered, we recorded the distance from the point transect to the center of the cluster and the number of birds in it.

DATA ANALYSIS

Within each year, we pooled data from surveys during the time period when Buff-breasted Sandpipers were detected in the region and excluded data from surveys on days prior to the first detection and after the last detection. Because densities may be markedly different between the two years, we analyzed each year separately. We used program Distance 4.1 (Thomas et al. 2004) and followed methods from Plumb et al. (2005) and Wunder et al. (2003) to estimate density. Program Distance estimates density by fitting observer detection as a function of distance to a set of models. The six candidate models suggested by Buckland et al. (2001, p. 42–50) were used to select the best model of distance and detection with which to estimate density. The largest 10% of distances were truncated to limit error due to outliers (Buckland et al. 2001). To select the best model from the candidates, we used the model with the lowest Akaike's Information Criterion (AIC) value that also had nonsignificant P-values from Cramér-von-Mises, Kolmogorov-Smirnov, and χ^2 goodness-of-fit tests, indicating that there was close agreement between the predicted and empirical relationship between distance and detection (i.e., the mathematical model accurately reflected the data from which it was generated). We did not calculate or use Akaike's weights to select among equivalent models because density estimates were similar among them. We used bootstrapping to refine the coefficient of variation (Buckland et al. 2001, p. 82–84, p.161–164) and t-tests to determine whether density and effective radii (i.e., the distance that the probabilities of detection and nondetection are equal) were significantly different between years.

Because density estimates covered a defined area, we were able to use a straightforward extrapolation model to produce predictions of overall number of birds present during the stopover period. We used density estimates from selected models from each year. We calculated the area studied using ArcGIS 8.3 (Environmental Systems Research Institute, Inc., Redlands, California) and the X-tools Pro extension for ArcGIS (Data East, LLC, Moscow, Russia).

Distance sampling assumes that animals are distributed randomly relative to the survey sampling design. If surveys are conducted from roads, trails, or field perimeters, and an organism avoids or is attracted to roads, then this assumption may be violated, and estimates will be biased. Distance sampling along roads may provide reliable estimates of density only in the vicinity of roads (Buckland et al. 2001, 2004, Dreitz et al. 2006). Therefore, we also produced more conservative estimates of the number of birds present based on smaller subsections of the study area surrounding roads. The areas of these subsections were calculated in ArcGIS by placing buffers of different distances around county roads and eliminating areas in the center of sections. For one set of estimates, we used distances of 350 m and 500 m on each side of the road to create buffers. We also used the effective radius calculated in Program Distance from each year. These calculations of study area assume that Buff-breasted Sandpipers do not occupy the habitat away from roads.

RESULTS

We recorded 145 Buff-breasted Sandpiper cluster detections, totaling 660 birds, in 2004. All detections occurred during the period 5–23 May, and 96 (65%) were recorded 11–14 May, indicating the migration peak. We recorded 103 cluster detections, totaling 602 birds, in 2005. All detections were during the period 4–21 May, and 69 (58%) were recorded 10–14 May, indicating the migration peak. In addition to point counts, we also recorded the number and location of birds observed when driving from point to point or at any other time (i.e., "at-large sightings"). We recorded an additional 1512 and 2855 at-large sightings during 2004 and 2005, respectively. At-large sightings were recorded during 3–25 May in 2004, and all at-large sighting were recorded during 4–21 May in 2005.

Each year's data best-fit single, but different, detection probability model (Table 1). In 2004, a hazard-rate key function with simple polynomial series expansion had the lowest AIC value. The other five candidate models had ΔAIC values >1.0. In 2005, the uniform key function with simple polynomial series expansion had the lowest AIC value. The other five candidate models had ΔAIC values <1.0. Average densities were not significantly different ($t_{219} = 1.7$, $P = 0.11$) between years. Mean density and its lower confidence limit from selected models for 2004 were respectively 0.09 ± 0.03 birds per ha and 0.05 birds per ha. Mean density and its lower confidence limit for 2005 were respectively 0.04 ± 0.01 birds per ha and 0.03 birds per ha.

Converting densities of birds to the number of birds in the region produced a range of predictions depending on the area sampled (Table 2). Extrapolations using the mean density from program Distance produced predicted numbers of sandpipers as high as 78 960 (Fig. 2).

TABLE 1. Models of Buff-breasted Sandpiper density in the Rainwater Basin, Nebraska, in 2004 and 2005. Models are ordered by Akaike's information criterion (AIC). Log ($\mathcal{L}$) is the log-likelihood, K is the number of parameters, and ΔAIC is the difference in AIC from the top model.

Year	Model + series expansion[a]	Log ($\mathcal{L}$)	K	ΔAIC[b]	Density birds/ha	Density LCL[c]	CV[d]
2004	Hazard rate + simple polynomial	−711.42	4	0.00	0.09	0.05	0.32
	Hazard rate + cosine	−713.00	3	1.16	0.09	0.05	0.34
	Uniform + cosine	−712.96	4	3.09	0.10	0.06	0.30
	Uniform + simple polynomial	−715.76	3	6.69	0.09	0.05	0.30
	Half normal + cosine	−716.43	3	8.02	0.09	0.04	0.38
	Half normal + hermite polynomial	−723.85	1	18.88	0.09	0.05	0.30
2005	Uniform + simple polynomial	−554.60	2	0.00	0.04	0.03	0.22
	Hazard rate + cosine	−555.63	1	0.05	0.05	0.03	0.24
	Half normal + hermite polynomial	−555.63	1	0.05	0.05	0.03	0.24
	Half normal + cosine	−555.63	1	0.05	0.05	0.03	0.24
	Hazard rate + simple polynomial	−554.91	2	0.61	0.05	0.03	0.27
	Uniform + cosine	−556.02	1	0.84	0.04	0.03	0.21

[a]Model and series expansion recommended by Buckland et al. (2001).
[b]The AIC values of the top models in this analysis were 1430.83 in 2004 and 1113.20 in 2005.
[c]Lower 95% confidence limit.
[d]Coefficient of variation.

Using the lower 95% confidence limit of our density estimate, the predicted numbers of Buff-breasted Sandpipers stopping over in the entire 849 028 ha Eastern Rainwater Basin during spring migration were 43 300 in 2004 and 22 924 in 2005 (Fig. 2). When we restricted our prediction to the area within a 500 m buffer of the road grid, we predicted 41 513 birds in 2004 and 21 977 birds in 2005 across a 813 977 ha area. A smaller 350 m buffer around roads (643 009 ha) gave estimates of 32 793 in 2004 and 17 361 in 2005 (Fig. 2). Area estimates using effective radii were 292 101 ha in 2004 and 499 544 ha in 2005, giving minimum predicted numbers of Buff-breasted Sandpipers stopping over in the Eastern Rainwater Basin during spring migration of 14 897 in 2004 and 13 488 in 2005.

DISCUSSION

Our estimates of the number of Buff-breasted Sandpipers present in the Eastern Rainwater Basin during spring migration are equal to or greater than the current estimate of the world's population of 15 000–20 000 individuals (Morrison et al. 2001). These results, along with earlier observations, indicate that the Eastern Rainwater Basin is a major Buff-breasted Sandpiper stopover site in the North American Great Plains during spring. This is in contrast with the relative rarity of the species in much of the Great Plains. High counts reported by Skagen et al. (1999) from the entire midcontinent were from 29 to 700 (mean = 139). Buff-breasted Sandpipers

TABLE 2. Buff-breasted Sandpiper density and associated parameter estimates (± SE) for 2004 and 2005. Estimates were calculated using the top model of density in each year using Akaike's information criterion.

Parameter	2004	2005
Density (birds per ha)	0.09 ± 0.03	0.04 ± 0.01
Mean cluster size (number of birds)	3.7 ± 0.3	4.7 ± 0.6
Detection probability	0.16 ± 0.02	0.31 ± 0.03
Effective radii (m)	146 ± 10	279 ± 11
Maximum detection distance (m)	800 m	900 m
Maximum detection distance after truncation (m)	365 m	500 m

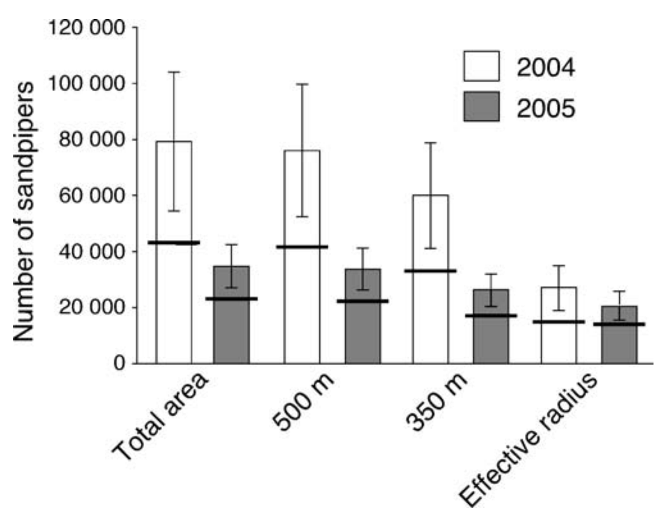

FIGURE 2. Mean estimates (± SE) and lower 95% confidence levels of the number of Buff-breasted Sandpipers in the Eastern Rainwater Basin during spring migration in 2004 and 2005 using four area estimates. Estimates of the numbers of sandpipers are based on the total area of the entire defined study area (849 028 ha; Fig. 1), the area in 500 m and 350 m buffers around roads (813 977 ha and 643 009 ha, respectively), and the area using the effective radius calculated by program Distance for 2004 (292 101 ha) and 2005 (499 544 ha).

are considered "rare or just unobserved" in Kansas (Thompson and Ely 1989), and rare in South Dakota (Tallman et al. 2002) and Iowa (Kent and Dinsmore 1996). In Nebraska, the only area where the species is regularly observed in spring is the Eastern Rainwater Basin (Sharpe et al. 2001).

Distance sampling provides the ability to produce reliable density estimates when the assumptions of the technique are met (Buckland et al. 2001, Norvell et al. 2003), as was the case in this study (Buckland et al. 2001, 2004). The precision of estimates may, however, be affected by a number of variables, both known and unknown. For instance, Plumb et al. (2005) produced a minimum estimate of Mountain Plovers (*Charadrius montanus*) because of a limited, albeit acceptable, sample size and because the estimate hinged on the accuracy of the estimated home range. Similarly, the estimates that we have produced also depend on an acceptable, albeit limited, sample size to calculate density (Buckland et al. 2001).

Road-based surveys of bird populations are often criticized because of the potential biases associated with limiting the habitat sampled to the area adjacent to roads. While logistics dictated our choice of a road-based sampling scheme, we believe that the degree of bias in population estimates from road-based sampling in this system is likely less than in many other systems. Most of the Eastern Rainwater Basin is a relatively homogenous landscape, with row crop fields stretching from roadside to roadside across the 1.62-km^2 sections defined by the road grid. This homogenous landscape allowed us to both sample the same general habitat that exists away from road. During the sampling period fields were relatively bare. Crops were not present or were just emerging after recently being planted. This allowed us to detect birds hundreds of meters from the roadside near the center of sections most isolated from roads. Therefore, we consider our estimates derived from the area of the entire region to be a reasonable approximation of the total number of Buff-breasted Sandpipers stopping over in the Eastern Rainwater Basin.

However, some bias is likely introduced into this overall estimate from birds being attracted to or repelled by roads. Because we do not know the size of the error this bias may introduce, we consider estimates of Buff-breasted Sandpiper numbers that are more restricted, based only on the area of the region adjacent to the roads we sampled, to be most reliable. This more conservative approach continues to support our conclusions that the current assessment of Buff-breasted Sandpiper numbers are underestimates and that the Eastern Rainwater Basin is a major stopover site for this species. Our approach to addressing possible bias associated with road-based surveys is consistent with our goal of determining the minimum number of birds in the region. A similar approach may not be applicable to other studies whose goals may not be met by producing a minimum estimate of bird numbers or where the habitat near roads is markedly different than that away from roads. If it is necessary to sample from roads, collecting additional data to estimate the magnitude of bias may be preferable to our approach of limiting the area considered.

The difference in effective radii estimates between years may have occurred for several reasons. More surveys were conducted in midday in 2005 than in 2004, and differences in lighting or bird behavior as a consequence of time of day may have influenced detection. There were fewer overall detections in 2005, but there were more detections of large clusters at distances farther from the points. Larger clusters are more likely to be detected than smaller ones, particularly at greater distances. Secondly, a higher number of "congregation fields" were encountered in 2004, with relatively few in 2005. In 2004, 76 cluster detections out of 145 were recorded at the five points with the highest number of detections. In contrast, only 29 cluster detections out of 103 were found at the five points with the highest number of detections in 2005. Buff-breasted Sandpipers often loosely congregate in selected fields in the Eastern Rainwater Basin, thereby leaving other similar-appearing nearby fields unoccupied (Jorgensen 2004). Buff-breasted Sandpipers often occupy these fields for a few days, appear to set up territories, and actively display. Birds also appear to become accustomed to the field perimeter and occupy areas closer to roads than what is typically observed. Encountering more of these congregation fields one year and few the next is a likely explanation for differences in estimated parameters. Several such fields were encountered away from point transects (i.e., at-large) in 2005 and explains the higher number of at-large sightings observed in that year.

In the Great Plains, shorebird conservation has focused largely on the importance of wetlands (Skagen and Knopf 1993, Skagen 2006). Our results indicate that upland habitats—in this case, agricultural fields—are used by large numbers of one species of high conservation concern—the Buff-breasted Sandpiper. Therefore, future conservation efforts will need to consider how large-scale land use changes or changes in farming practices may affect the Buff-breasted Sandpiper as well as other shorebird species using agricultural habitat during stopover. Stopover sites used by shorebirds during migration are increasingly recognized as vital components of shorebird's annual cycle (Schekkerman et al. 2003, Elner and Seaman 2003), and our study highlights the importance of such habitats in addition to wetlands.

There are obvious ramifications of suggesting that the population size of a species of conservation concern may be greater than previously suggested. Because of the implications of overestimating the population size, we advocate the use of the estimates of Buff-breasted Sandpiper numbers derived from the lower confidence limit of sandpiper densities, rather than the numbers based on mean density, until further information confirms or contradicts the density estimates presented here. Our minimum predictions still indicate that the current population estimate may be too low. However, our predicted numbers still indicate that the global population size of

Buff-breasted Sandpipers is comparable to other species of conservation concern. Most importantly, our results do not provide information about whether the population size is increasing or decreasing. The species experienced significant declines in the late 1800s and early 1900s due to market hunting (Lanctot and Laredo 1994, Lanctot et al. 2002). Evidence indicates that numbers have declined in recent decades and continue to decline (Lanctot et al. 2002). In the Eastern Rainwater Basin, the species is not nearly as numerous as a few decades ago (L. Morris, longtime local resident, pers. comm.). Thus, while the actual world population is likely greater than the 15 000–20 000 estimate (Morrison et al. 2001), a declining population size raises concerns about the species' vulnerability during stopover in the Eastern Rainwater Basin, and ultimately, the species' long-term persistence.

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