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HUNTING SUCCESS FOR MID-CONTINENT SANDHILL CRANES IN THE CENTRAL FLYWAY: COMPARING CURRENT AND HISTORIC RESULTS

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Abstract: Sport hunting for the Mid-continent population of sandhill cranes (*Grus canadensis*) in the United States resumed in New Mexico in 1961 after a 45-year moratorium. Interest in crane hunting continued to increase and by 1975, 8 states were participating in sandhill crane hunting. Currently, hunting seasons have been established in all Central Flyway states except Nebraska. Efforts to collect information on the annual harvest of sandhill cranes began in 1975 when hunters were required to obtain federal sandhill crane hunting permits. The permits included a hunting diary whereby hunters were asked to record information about their daily hunting activity. Some of these hunters were later mailed a questionnaire asking for the information reported on the diary. To assess whether success rates had changed since an earlier assessment in 1983-1984 (Miller 1987), we acquired 4,408 harvest questionnaires from the 1997-2001 hunting seasons. From the 12,582 days hunters spent afield, we found that on average hunters were unsuccessful at harvesting a crane on only 28% of the days hunted. Further, the proportion of days on which hunters harvested 2 or 3 cranes increased by 4.7% and 7.8%, respectively. These results corroborate other information suggesting that hunters' efficiency at harvesting cranes has increased. We estimated that the seasonal harvest of cranes would be reduced by 12% to 45% if bag limits were reduced by 1-2 birds per day in the U.S. The increase in hunting success may be attributed to many factors, including improved techniques and equipment by which sandhill cranes are harvested and increased knowledge of crane biology and behaviors by hunters. The ability to measure the effect of changing bag limits can be a useful tool for managers to adjust harvests in response to changing abundances of cranes.

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Key words: Central Flyway, *Grus canadensis*, harvest, hunting, sandhill crane, success.

Prior to the enactment of the Migratory Bird Treaty of 1916 between the U.S. and Canada, sandhill cranes (*Grus canadensis*) were traditionally hunted for food and recreation. As a result of over-harvesting and habitat destruction that severely reduced their numbers, both governments agreed that protection was needed for all members of the Gruidae family that migrated between the 2 countries. Therefore, the U.S. and Canada closed the season on the hunting of sandhill cranes. This closure remained in effect for 45 years until 1961 when the U.S. opened a season on sandhill cranes in New Mexico, initially in response to complaints of crop depredations. Interest in crane hunting continued to increase and by 1975 the U.S. Fish and Wildlife Service (Service) had authorized 8 states in the Central Flyway to establish sandhill crane hunting seasons. A cooperatively developed plan (Central Flyway Council, Pacific Flyway Council, and Mississippi Flyway Council 2006) guides the management of the Mid-continent population (MCP), including sport harvest. To formulate appropriate harvest-management recommendations, managers must understand the ability of hunters to harvest cranes, and whether that ability is spatially and temporally variable.

To monitor the U.S. annual harvest of the MCP, a permit system was implemented in 1975. The permits included a hunting diary whereby hunters were asked to record information

about their daily hunting activity. Some of these hunters were later mailed a questionnaire asking for the information reported on the diary. Miller (1987) analyzed harvest data from the 1975-1983 seasons and reported on the success of individual hunters. Results from the study found that crane hunters were unsuccessful at harvesting a crane on 44% of the days during the 1983-1984 season. Successful hunters reported bagging 1, 2, or 3 cranes on 28%, 15%, and 13% of the days hunted, respectively. In a subsequent analysis, Sharp and Vogel (1992) reported that crane harvests in the Central Flyway increased from 1975 to 1990, and that hunters' seasonal bags also increased until about 1988. Seasonal bags were relatively stable from 1987 to 2001 (Sharp et al. 2002) but appear to have declined in recent years (Sharp et al. 2006). Recent analyses of harvest data suggest a long-term increase in the Central Flyway harvest of cranes, although fluctuations in the annual number of birds harvested appear to have increased since 1990 (Sharp et al. 2006). During 1975-2004, the rate of change in harvest (+2.1% per year; $P < 0.01$) has been greater than the increase in the number of active crane hunters in the Central Flyway (+0.8% per year; $P = 0.02$), and the average number of days afield reported by those hunters has decreased slightly (-0.3% per year; $P = 0.09$) (Fig. 1). Further, although the number of cranes has increased during that time frame, the number of active hunters also has increased (Sharp et al. 2006), resulting in a fairly constant ratio of birds per hunter

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over time (J. Dubovsky, unpublished data). Thus, increased harvest does not appear to be a simple function of the number of hunters afield and hunter effort, nor as a result of a greater ratio of birds to active hunters in more recent years.

To more intensively assess hunter success and whether success had changed over time, we summarized data from harvest questionnaires collected from hunters in the Central Flyway during the 1997-2001 seasons and compared the results to those of Miller (1987). Results from our analyses may be useful if in the future changes in bag limits would be considered to effect reductions or liberalizations in harvest consistent with changes in crane abundance.

METHODS

Since 1975, all persons hunting cranes in the Central Flyway states have been required either to possess a federal sandhill crane hunting permit (issued by the Service free-of-charge, and in unlimited quantities), or more recently, to register as a crane hunter under the Harvest Information Program (HIP). These hunters comprise the universe from which a sample is drawn each year and to whom questionnaires are mailed asking them to supply information regarding their hunts. Details of the survey design and sampling methodology are provided in Office of Migratory Bird Management (1976) and Martin (2004).

We acquired 4,408 completed harvest-questionnaire cards from the Waterfowl Harvest Surveys Section of the Service for the 1997-2001 hunting seasons from those states having a crane season in the Central Flyway (Fig. 2). We coded each hunter's daily entries, including the location (county and state), date, and number of cranes harvested into a digital database. During the years of Miller's (1987) study, only the states of Montana, Wyoming, Colorado, New Mexico, North and South Dakota, Oklahoma, and Texas had hunting seasons for MCP cranes. During 1975-1990, only minor changes were made in crane hunting regulations within the Central Flyway (Sharp and Vogel 1992). Similarly, regulations in the aforementioned states have remained comparable to those in place during Miller's (1987) study (D. Sharp, personal communication). However, neither a crane hunting season in Kansas nor an eastern crane hunting zone in North Dakota (as currently defined; the eastern zone extant in 1983 actually was the easternmost portion of the current western zone [Sharp and Cornely 1997]) existed at the time of Miller's (1987) study. Therefore, we excluded data from North Dakota's eastern zone and from Kansas when making comparisons to Miller's (1987) results, but we did analyze Kansas data separately from the other Central Flyway states.

We analyzed data from 1997-2001 in the same manner as Miller (1987). We summarized (PROC FREQ, SAS Institute 1989) the frequency of days in which successful hunters (i.e.,

hunters who harvest ≥ 1 crane during the season) reported harvesting 0, 1, 2, 3, or more than 3 birds per day. As with previous studies (Miller 1987, Sharp and Vogel 1992), responses were accepted as presented, and we made no adjustments for memory, exaggeration, or other possible biases. Using the resulting percentages, we estimated the percent change in crane harvest expected if the bag limit were reduced by 1 or 2 birds per day across the entire flyway and within each state. Because areas in the Central Flyway had maximum bag limits of 2 birds per day (i.e. 1 zone in Texas and the state of Kansas), we summarized data for these areas separately from those where 3 birds per day could be harvested. Doing so allowed us to predict effects of 1- and 2-bird bag-limit reductions for combinations of 3- and 2-bird zones.

We compared our estimates to those presented by Miller (1987). Although the latter paper discussed harvest results from the 1975-1976 through 1983-1984 hunting seasons, it provided information on daily success only for the 1983-84 season. Thus, we could compare our results from 5 seasons to those from only 1 season.

RESULTS

Flyway-wide Analyses

During the 1997-2001 hunting seasons, 272,055 (\bar{x} = 54,411) permits were issued (i.e. hunters received Service-issued permits or were HIP-registered) to hunt sandhill cranes in the Central Flyway (Sharp et al. 2006). Martin (1998-2002) contacted 17-22% of permit holders annually by questionnaire and asked them to report on their daily hunting activity and success. An estimated 37,855 (14%) of the permittees were active sandhill crane hunters (i.e., hunted cranes on ≥ 1 day of the crane season), ranging from 6,629 in 1999 to 8,173 in 1998 and averaging just over 7,500 hunters each year. Of 12,582

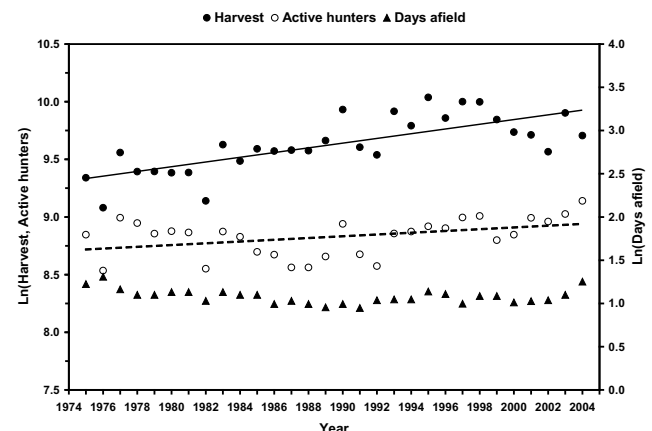


Fig. 1. Rates of change for harvest and hunter statistics in the Central Flyway, 1975-2004.

Table 1. Summary of responses by successful hunters sampled by the Mid-continent sandhill crane harvest survey during hunting seasons 1997–1998 through 2001–2002, with comparison to data from 1983–1984.

State	Days on which bag was reported as:					Total cranes killed
	0	1	2	3	> 3	
Colorado	38	25	13	3	1	64
Montana	30	46	20	4	0	98
North Dakota ^a	991	931	673	576	28	4,222
New Mexico	125	127	52	23	1	307
Oklahoma	130	177	139	152	0	911
South Dakota	152	189	105	86	1	662
Texas	695	778	551	801	36	4,510
Wyoming	3	8	4	1	0	19
Total	2,164	2,281	1,557	1,646	67	10,793
(%)	(28.0)	(29.6)	(20.2)	(21.3)	(0.9)	
(%) All States, 1983–84 ^b	(43.4)	(27.6)	(15.5)	(13.3)	(0.2)	
Kansas ^c	516	489	698	2	3	1,911
(%)	(30.2)	(28.6)	(40.9)	(0.1)	(0.2)	

^aData for eastern zone deleted because it did not exist when Miller's (1987) study was done.

^bFrom Miller (1987)

^cKansas initiated its sandhill crane season in 1993, so comparisons were not made with results from the earlier time frame analyzed by Miller (1987)

days afield, we found that hunters (all state data except Kansas pooled) were unsuccessful at harvesting a crane on 28% of days hunted, representing a 16% increase in success rates compared to the 1983–84 season (Table 1). Successful hunters reported harvesting 1, 2, or 3 cranes per day on 30%, 20%, and 21% of days hunted, respectively. The percentage of days in which hunters harvested 1 bird increased slightly compared to 1983–1984 (30% versus 28%), whereas the percentage of days in which 2 birds and 3 birds were harvested increased to a greater extent (20% versus 16% and 21% versus 13%, respectively). Over the 5 seasons, the greatest proportion of harvested cranes came from North Dakota (4,222) and Texas (4,510), which comprised over 80% of sandhill cranes harvested.

Using proportions from 1997–2001, we estimated that the seasonal harvest of cranes would be reduced by 12% to 45% depending on the combination of bag limit reductions for 3- and 2-birds per day areas (Table 2). That is, if the bag limit in 3-birds per day areas were reduced to 2-birds per day, but the bag limit in 2-birds per day areas were unchanged, the estimated reduction in harvest was 12.6%. However, if bag limits were reduced by 2 birds in 3-bird areas and by 1 bird in 2-birds areas (i.e., a bag limit of 1 bird per day in all states and areas), the estimated reduction in harvest was 45%.

Because Kansas initiated its sandhill crane season in 1993, we did not use its data to compare results to the earlier time frame analyzed by Miller (1987). However, analyses of harvest data from Kansas indicated that the proportion of days in which successful hunters were unable to bag a crane was similar to the pooled value for other states in the Central

Table 2. Estimated reductions in crane harvests for combinations of bag-limit reductions in 3- and 2-birds per day areas based on the 1997–2001 Mid-continent hunting seasons.

		Current 3-birds per day areas reduced to:	
		2 birds per day	1 bird per day
Current	2 birds per day	-12.6%	-36.8%
2-birds per day areas changed to:	1 bird per day	-20.8%	-45.0%

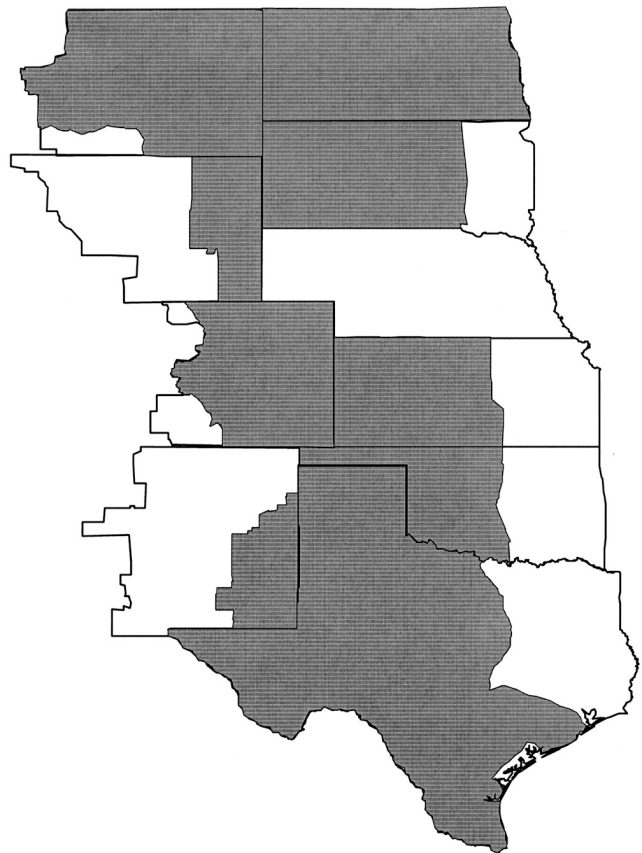


Fig. 2. Areas open to hunting of Mid-continent sandhill cranes in Central Flyway states, 2005 (from Sharp et al. 2006).

Flyway (30% versus 28%), as was the proportion of days in which they harvested 1 bird (29% versus 30%; Table 1). The proportion of days in which hunters harvested 2 birds (the maximum allowed) was essentially the same as the sum of proportions where 2 or 3 birds were harvested in other Central Flyway states (41%).

State-specific Analyses

The proportion of days in which successful hunters failed

to bag a crane varied by state, with hunters in Colorado having the largest proportion (47%) and Wyoming the smallest (19%) (Table 3). However, Wyoming had the lowest number of active hunters in the Central Flyway (Sharp et al. 2006). Generally, hunters in most states were unsuccessful on about 30% of the days they hunted. Also, within each state the proportion of days in which 1 bird was harvested typically was higher than the proportion of days in which 2 birds were harvested, which in turn was larger than the proportion for 3 birds. However, hunters in Texas reported a very high proportion (28%) of days in which the daily limit of cranes (3) was harvested compared to the other states, and this proportion was higher than for any other category in Texas. The states with the larger proportions of days in which hunters harvest multiple cranes also are likely to have the largest decreases in harvests if bag limits are reduced. Our results suggest that the largest reductions in state-specific harvests would occur in Texas, Oklahoma, and North Dakota (Fig. 3).

As with other states, initial seasons in Kansas were more restrictive than Federal frameworks allowed (Sharp et al. 2006). Opening dates were delayed until the first Saturday in November, partly to afford additional protection to endangered whooping cranes (*Grus americana*) (D. Sharp, personal communication), and the bag limit was 2 sandhill cranes per day compared to the 3 cranes per day allowed in the Federal frameworks. Shooting hours for cranes also were reduced from those allowed in the Federal frameworks, and began either at sunrise or one-half hour after sunrise and ended in the early

afternoon (14:00 hr) rather than sunset. Nevertheless, harvest data collected in Kansas indicated a high level of harvest, with the total number of cranes killed (1,911 during the 1997-2001 hunting seasons) higher than all states except North Dakota (4,222) and Texas (4,510). Therefore, if Kansas reduced the bag limit from 2 to 1 bird per day, a 37% reduction in harvest might be achieved within the state.

DISCUSSION

During the 45 years when seasons were closed to crane hunting, the MCP continued to increase, and eventually take (harvest) was allowed by permit in the U.S. in 1961. In 1974 and 1975, important population and harvest surveys were initiated in the Central Flyway to assist in managing the population and provide trends for total crane abundance upon which annual hunting regulations could be developed. Annual indices to abundance have been relatively stable since the early 1980s, but recent analyses of long-term trends (1982-2004) indicate that the harvest of the MCP (U.S. and Canadian harvests combined) has been increasing at a higher rate (+2.6% per year, $P < 0.01$) than population growth (+0.7% per year, $P = 0.20$) (Sharp et al. 2006). An objective of the management for this population (Central Flyway Council, Pacific Flyway Council, and Mississippi Flyway Council 2006) is to maintain a stable abundance of between 349,000 and 472,000 cranes using a 3-year running average. The spring survey of MCP abundance in 2005 revealed a photo-corrected index of 491,200 cranes, resulting in a 2003-2005 average of 422,133 cranes (Sharp et al. 2006). However, if the disparity in trajectories between abundance and harvest continues, at some point crane hunting frameworks (i.e. season lengths and/or bag limits) may need to be altered to effect changes in harvest levels.

Recent status assessments (e.g. Sharp et al. 2006) have documented long-term increases in success rates of hunters, and these increases are strongly correlated ($r = 0.80$, $P < 0.01$) to increases in Central Flyway harvests of cranes. Sharp and Vogel (1992) reported that seasonal bags increased from about 1.4 cranes to about 2.4 cranes during 1982-1986, and remained relatively stable at that level until 1990. Subsequent analyses indicated that success increased from 1975 until 1987 and was relatively unchanged from 1987 through 2001 (Sharp et al. 2002). Concurrently, harvests increased ($P < 0.01$) from about 10,100 birds during the 1970s and early 1980s to about 17,400 during 1997-2001. Sharp and Vogel (1992) attributed the higher success to increased hunter knowledge of crane ecology and behavior, improvements in hunting equipment (e.g. decoys, calls), and a shift from pass shooting and hunting on roosts to decoy hunting in fields. However, a detailed analysis of success has not been conducted since the early 1980s. Such knowledge is necessary to develop empirically based recommendations for changes in season structures, should changes in harvest

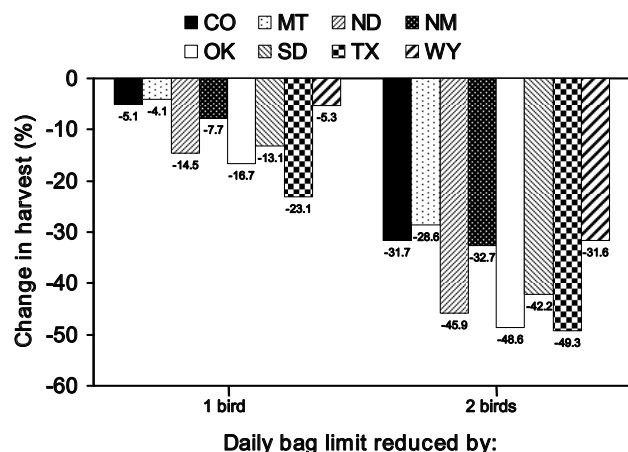


Fig. 3. Predicted change in harvests if bag limits were reduced in Central Flyway states, based on analyses of hunter responses to crane harvest-survey questionnaires, 1997-2001. For Texas, the depicted 1-bird reduction corresponds to reducing the bag from 3 to 2 in the 3-bird daily bag zone and from 2 to 1 in the 2-bird daily bag zone. The 2-bird reduction corresponds to reducing the bag from 3 to 1 in the 3-bird zone and from 2 to 1 in the 2-bird zone.

pressure be necessary to maintain crane abundance at levels specified in the management plan.

Assuming that Miller's (1987) data for 1 hunting season is representative of seasons during the early to mid-1980s, our results indicate that the increased success of crane hunters is due to a reduction in the number of days in which hunters fail to bag a crane, and an increase in the number of days in which hunters bag 2 or 3 cranes. The proportion of days in which hunters bagged 1 crane remained quite similar between the early 1980s and the late 1990s. We predict that reducing the bag limit by 1 bird per day would result in a decrease in flyway-wide harvest of about 13%, and reducing the bag limit by 2 birds per day would decrease harvest by 45%; both values are slightly larger than those reported by Miller (1987), due to the increased success of harvesting 2 or 3 birds in a day

during the late 1990s. The largest decreases in harvest would occur in Texas, North Dakota, and Oklahoma, because these states had higher proportions of hunters harvesting 2 or 3 birds in a day relative to the other states. Kansas also could have a large influence in reducing the overall flyway harvest because the proportion of days in which hunters harvested 2 birds (the maximum allowed) was higher than any other state (41%) and total harvest of cranes was the third highest (1,911) after Texas and North Dakota.

Changing bag limits, season lengths, and framework dates are the primary tools managers use to alter harvest pressure. We did not attempt to assess effects of changes in framework dates or season lengths in this paper, because harvest varies temporally among states due to migration chronology of cranes (Araya and Dubovsky 2008). State-specific analyses (Araya

Table 3. State-specific summary of responses by successful hunters sampled by the Mid-continent sandhill crane harvest survey during hunting seasons 1997–1998 through 2001–2002.

State	Season or Total	Days on which bag was reported as:					Total cranes killed
		0	1	2	3	> 3	
Colorado	1997	24	9	3	1	1	22
	1998	0	1	2	1	0	8
	1999	7	5	0	0	0	5
	2000	0	0	0	0	0	0
	2001	7	10	8	1	0	29
	Total	38	25	13	3	1	64
	(%)	(47.5)	(31.2)	(16.3)	(3.7)	(1.3)	
Kansas	1997	119	118	169	2	2	475
	1998	156	122	176	0	1	481
	1999	88	91	158	0	0	407
	2000	46	71	69	0	0	209
	2001	107	87	126	0	0	339
	Total	516	489	698	2	3	1,911
	(%)	(30.2)	(28.6)	(40.9)	(0.1)	(0.2)	
Montana	1997	4	12	6	1	0	27
	1998	4	9	1	1	0	14
	1999	9	11	3	0	0	17
	2000	2	7	2	0	0	11
	2001	11	7	8	2	0	29
	Total	30	46	20	4	0	98
	(%)	(30.0)	(46.0)	(20.0)	(4.0)	(0.0)	
North Dakota	1997	158	167	159	121	6	914
	1998	293	250	153	145	7	1,058
	1999	166	174	126	118	7	827
	2000	146	158	113	103	4	713
	2001	228	182	122	89	4	710
	Total	991	931	673	576	28	4,222
	(%)	(31.0)	(29.1)	(21.0)	(18.0)	(0.9)	

Table 3. Continued

New Mexico	1997	16	39	4	0	1	54
	1998	27	14	6	10	0	56
	1999	33	25	11	4	0	59
	2000	40	27	15	7	0	78
	2001	9	22	16	2	0	60
	Total	125	127	52	23	1	307
	(%)	(38.1)	(38.7)	(15.9)	(7.0)	(0.3)	
Oklahoma	1997	30	33	23	22	0	145
	1998	27	26	23	33	0	171
	1999	47	52	41	41	0	257
	2000	7	28	26	23	0	149
	2001	19	38	26	33	0	189
	Total	130	177	139	152	0	911
	(%)	(21.7)	(29.6)	(23.2)	(25.4)	(0.0)	
South Dakota	1997	23	20	13	6	0	64
	1998	44	52	21	19	1	156
	1999	28	29	12	9	0	80
	2000	37	50	28	20	0	166
	2001	20	38	31	32	0	196
	Total	152	189	105	86	1	662
	(%)	(28.5)	(35.5)	(19.7)	(16.1)	(0.2)	
Texas	1997	174	179	132	228	9	1,213
	1998	203	214	141	169	8	1,050
	1999	136	153	107	180	10	953
	2000	88	124	94	135	5	741
	2001	94	108	77	89	4	553
	Total	695	778	551	801	36	4,510
	(%)	(24.3)	(27.2)	(19.2)	(28.0)	(1.3)	
Wyoming	1997	1	3	0	0	0	3
	1998	0	0	0	0	0	0
	1999	0	1	0	0	0	1
	2000	0	2	2	1	0	9
	2001	2	2	2	0	0	6
	Total	3	8	4	1	0	19
	(%)	(18.7)	(50.0)	(25.0)	(6.3)	(0.0)	

and Dubovsky 2008) will provide additional tools to assist managers in formulating sport hunting regulations consistent with desired crane-abundance objectives.

We did not have data to analyze harvests in Canada similarly to our approach in this manuscript. However, harvests of cranes in Canada (i.e., Manitoba and Saskatchewan) have increased from about 24% of the combined U.S. and Canadian sandhill crane harvest during the early 1980s to 36% during the early 2000s (data in Sharp et al. 2006). Because of this increase, we encourage the analysis of Canadian harvest data to produce additional tools that harvest managers may use to predict changes in harvest relative to changes in hunting regulations.

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Mexican and American hunting party, Lagune de Babicora, Chihuahua, Mexico, November 1970. Photo by Roderick C. Drewien.