7-23-2006

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Published in PRAIRIE INVADERS: PROCEEDINGS OF THE 20TH NORTH AMERICAN PRAIRIE CONFERENCE, UNIVERSITY OF NEBRASKA AT KEARNEY, July 23–26, 2006, edited by Joseph T. Springer and Elaine C. Springer. Kearney, Nebraska : University of Nebraska at Kearney, 2006. Pages 297-306.

WHITE-TAILED DEER SPOTLIGHT SURVEY TRENDS ON QUIVIRA NATIONAL WILDLIFE REFUGE, 1989-2005

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Abstract: Legal harvest of deer has never been allowed on Quivira National Wildlife Refuge (QNWR) in south central Kansas; however, it is permitted on lands adjacent to the refuge. We assessed whether the rifle season for white-tailed deer (*Odocoileus virginianus*) caused increased use of QNWR between 1989 and 2005. Deer spotlight surveys were conducted pre-rifle, rifle, and post-rifle seasons from 1989-2005. Total count, buck count, buck:doe ratio, fawns per doe, and percentage of does with twins were computed for each survey conducted. The average of the last 4 years (2002-2005) of the pre-rifle season surveys was 4.5 times greater than the 4-year average of pre-rifle surveys conducted between 1989-1992 . Buck counts also increased markedly between these 2 periods. Considerable fluctuations in buck:doe ratios and number of fawns per doe were observed between years. Fluctuation in the percentage of does with twins (versus does with single fawns) was also noted. Twining declined from highs of 43-47% between 1989-1993 to 10-27% between 2001-2005. Contrary to our expectation, counts within-year for the rifle- and post-rifle season were not greater than pre-rifle season counts. We recommend that the surveys be continued to provide an index for possible conservation planning and management on the refuge.

Proceedings of the North American Prairie Conference 20:297-306

Key words: buck:doe ratio, fawns per doe, Quivira National Wildlife Refuge, spotlight surveys, white-tailed deer

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Overabundance of white-tailed deer (*Odocoileus virginianus*) in some areas has resulted in ecological and economic impacts that cause wildlife managers to consider a shift from protection and enhancement of deer populations to management efforts that seek to reduce local herds (Peck and Stahl 1997). More recently, chronic wasting disease (CWD) presence in many cervid populations across the country, poses an additional management challenge because it is contagious and epidemics are self-sustaining (Miller et al. 2000, Williams et al. 2002) . The first documented case of CWD in a free-ranging deer in Kansas was documented earlier this year (personal communication, Lloyd Fox, Kansas Department of Wildlife and Parks). Therefore, increased harvest

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of deer, especially does, or even fertility controls may be necessary to stem the undesired effects deer have on vegetation, other animal species dependent on those plant communities negatively impacted, the spread of CWD, and human safety associated with deer-vehicle collisions (Tilghman 1989, McNulty et al. 1997, Stromayer and Warren 1997, Curtis et al. 2002).

Deer represent wildlife viewing opportunities year-round that often are of interest to the non-hunting public. These viewing opportunities are common in our national, state, and metro parks, wildlife refuges, and suburbs, particularly where hunting has not been allowed and locally high deer populations have developed in areas where hunting is not allowed (Frost et al., 1997, Peck and Stahl 1997). Herd reduction may be needed when local deer population increase. But, this often becomes a challenging mix of science and politics (Shafer-Nolan 1997).

Management plans for deer on wildlife refuges must address needs of a variety of stakeholders including farmers, ranchers, hunters, hunting land lessors, and non-consumptive wildlife users. Two fundamental questions must be answered again and again in developing deer management plans: "how many deer are in the population of interest?" (Drake et al. 2005) and "how many would be optimal (or practical) to maintain?"

The Quivira National Wildlife Refuge (QNWR), established in 1955, has provided important habitat for a variety of wildlife species. For migratory birds such as Canada geese (*Branta canadensis*), ducks, shorebirds, sandhill cranes (*Grus canadensis*), and the endangered whooping crane (*G. americana*), QWNR serves as an important fall and spring stopover. A variety of other avian species breed in the marshes, grasslands, farmlands, and low sandhills.

Hunting of bobwhite quail (*Colinus virginianus*), ring-necked pheasant (*Phasianus colchicus*), mourning doves (*Zenaida macroura*), common snipe (*Gallinago gallinago*), rails, squirrels, and cottontail rabbits (*Sylvilagus floridanus*) is permitted on 3,237 ha (8,000 acres) of the refuge's 8,958 ha (22,135 acres). Legal harvest of white-tailed deer and wild turkey (*Meleagris gallopavo*) has never been allowed on the QWNR, but does occur on private lands adjacent to the refuge.

We examined deer count data collected during pre-, rifle, and post-rifle seasons by QNWR personnel from 1989-2005. Our objective was to examine trends in key demographic parameters.

STUDY AREA

The nearly 9,000-ha (22,000-acre) refuge, located in south central Kansas in Stafford, Reno, and Rice counties, represented a transition zone between tallgrass and mixed-grass prairie. The blend of plant communities and the presence of the Big and Little Salt Marshes attracted a wide-variety of wildlife. Rattlesnake Creek runs nearly the entire north-south distance of the refuge and provided a variety of woody riparian and edge habitats. A system of canals and water control structures resulted in 34 water units ranging in size from 3.4 to 502 ha (10 to 1,200 acres). The topography throughout the refuge was mostly flat.

The QNWR is primarily managed to provide food, water, and resting habitat for migratory waterfowl. Annual burning, cattle grazing, and manipulation of water levels are common practices. The refuge is surrounded by cropland, consisting mainly of wheat, corn, milo, soybeans, and alfalfa. Off the refuge, woodland and shrubland habitats are generally restricted to drainages, fencerows, and pastures. The woodland and shrubland habitats are maintained to enhance deer hunting opportunities.

Precipitation amounts have been monitored since 1931 at Hudson, Kansas, which is approximately 15 km (9 mi) west of QNWR. Annual precipitation averaged 60.9 cm from 1931-1988. From 1989-2005, the yearly average was 70.8 cm (minimum 38.3 cm; maximum 98.6 cm), with 1991 and 1994 being exceptionally dry years. From 1989-2005 over 78% of the annual precipitation in the area was received during the growing season (April - October).

METHODS

Field Protocol

We established 2 survey routes [north - 40.0 km (24.8 mi) and south - 41.0 km (25.2 mi)] that consisted of refuge roads and trails. Portions of

each route were on the QNWR boundary and included observations on some adjacent tracts of private property. Typically, surveys were started within 0.5 h after sunset and took 2-3 h to complete. Driving a pickup truck 10 - 35 km/h (2 - 20 mi/h), 2 crew members inside the cab scanned the terrain on both sides of the vehicle using 750,000 – 1 million candle power (cp) spotlights. From 1989 through 1997, only 750,000-cp spotlights were used; 750,000 cp spotlights along with 1 and 1.5 million-cp spotlights were used from 1998 through 2005. In flat terrain under clear conditions, the light beams illuminated objects up to 300 m; there was no apparent difference in field of view among spotlight models. We recorded deer observed as either doe, doe with fawn, doe with twins, doe with triplets, fawn, buck, or unknown. Determination of age (adult or juvenile) and sex was usually restricted to observations within 250 m of the vehicle. For the 2005 survey, we recorded additional data including GPS coordinates of the observation, deer cluster size, and habitat type.

Execution of the surveys by type (i.e., pre-, rifle, and post-rifle) was dictated by yearly funding, availability of personnel, and weather conditions. Although no deer hunting was permitted on the QNWR, survey dates were conducted relative to the deer rifle season set by the Kansas Department of Wildlife and Parks for this region of the state. For nearly all years, north and south routes were completed on the same night within each of the 3 survey periods (i.e., pre-rifle, rifle, and post-rifle seasons). Hunting for waterfowl, pheasants, and other small game was allowed on the refuge during the same time that deer were hunted off the refuge. The deer may have responded as though they were being hunted on the refuge even though they were not.

When surveys are conducted over many years several factors are likely to influence the accuracy and precision of counts. Among these factors are experience-level of observers, weather conditions, vegetation density and height (especially in grasslands and marshes), and succession or encroachment of woody vegetation. The effect of changes in vegetation structure particularly affects observations of fawns. Despite the influence of these various factors over time and the possible sampling bias because our survey routes were a form of convenience sampling, we contend that our data reflected long-term trends of deer demographics on the QNWR.

Data Analysis

Total count, buck count, buck:doe ratio, fawns per doe, and percentage of does with twins (based on total does with twins divided by total does with single fawns and twins multiplied by 100) were computed for each survey. Year-to-year trend lines for total count (i.e., all ages and sexes), total count by north and south routes, buck counts, buck:doe ratios, fawns per doe, and percentage of does with twins were generated and visually inspected (Sigma Plot, Systat Software, Inc., 2004a). Our visual inspection was further augmented by a quantitative analysis based on a locally-weighted scatterplot smoothing technique, which generates a best-fit trend line through the data points (Cleveland 1985, James et al. 1996). A smoothing parameter of $f = 0.5$ to 0.7 was selected because preliminary trials with this data set indicated these values provided adequate smoothing without distorting the underlying pattern in the data . We conducted a simple linear regression analysis to evaluate the statistical significance of trends (Zar 1999; SAS, SAS Institute 2000). To examine possible patterns between environmental conditions and fawn productivity, Spearman rank correlation coefficients (r_s) were calculated for precipitation amounts versus fawns per doe and twinning percentages (Zar 1999; SigmaStat, Systat Software Inc., 2004b).

RESULTS AND DISCUSSION

Total Counts

From 1989-1993, the pre-rifle season survey ranged from 71 to 150 (Fig. 1a, Table 1). No surveys were conducted in 1994 and 1995. From 1996 through 2003, the counts increased substantially. The deer count increased by 4.5 times when averaged over the first 4 years (1989-1992) and compared to the last 4 years (2002-2005) (Table 1). The general upward linear trend was statistically significant ($r^2 = 0.74$, $\beta = 18.45$, $P < 0.0001$) indicating a substantial increase in the QNWR deer herd on and closely adjacent to the refuge, regardless of the bias from observer turnover, changes in weather conditions,

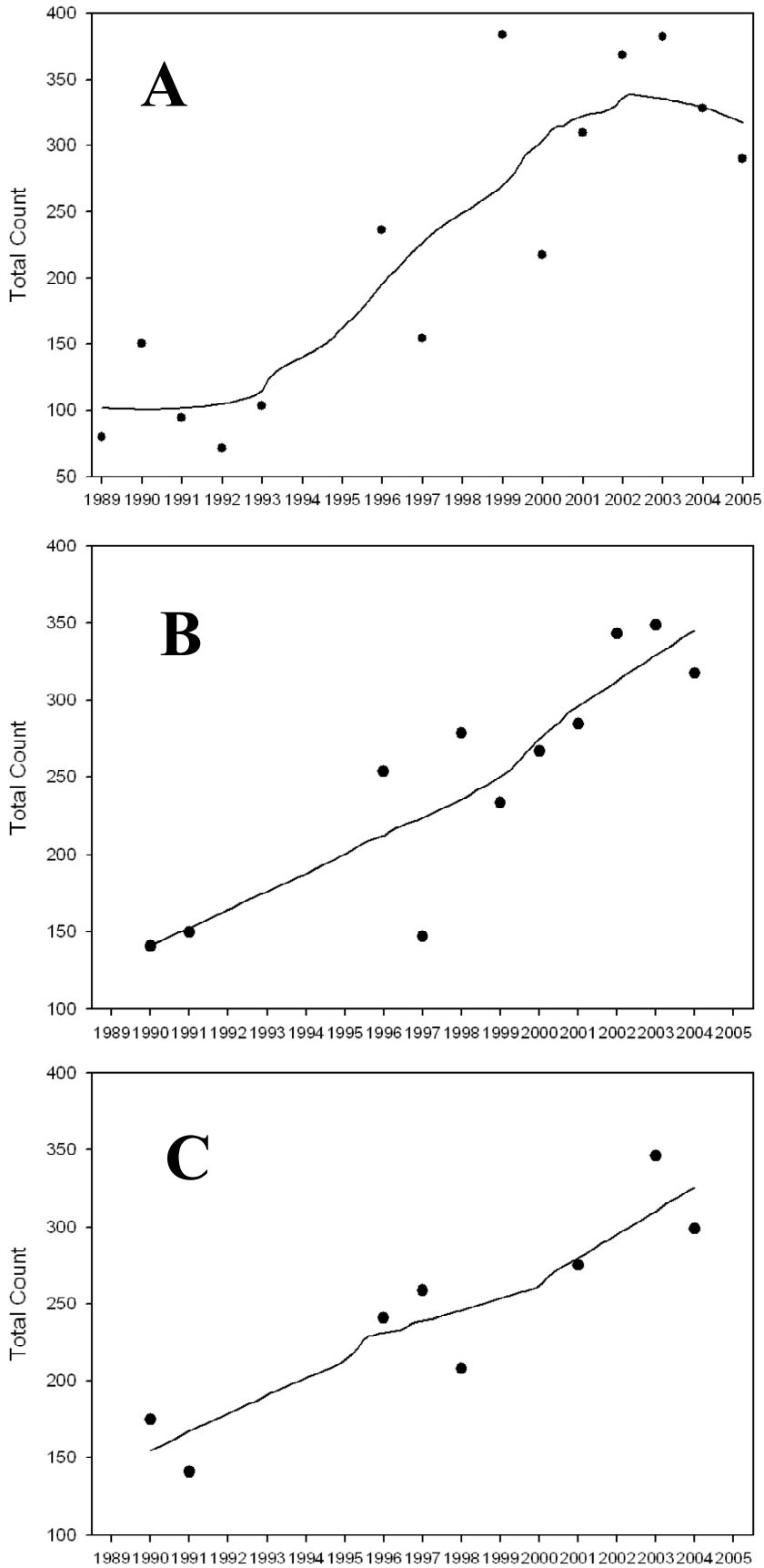

Fig. 1. Total counts of white-tailed deer during pre-rifle season (a), rifle season (b), and post-rifle season (c) surveys, Quivira National Wildlife Refuge, 1989-2005. No pre-rifle season surveys (a) were conducted in 1994-1995, and 1998. No rifle-season surveys (b) were conducted in 1989, 1992-1995, and 2005. No post-rifle season surveys (c) were conducted in 1989, 1992-1995, 1999-2000, 2002, and 2005.

Table 1. Total counts of deer during spotlight surveys on Quivira National Wildlife Refuge, 1989-2005.

Year	Month-Day (s) [a]	Season		
		Pre-rifle	Rifle	Post-rifle
1989 [b]	Nov 22 (7), NS, NS	79	-	-
1990	Nov 15 (13), Dec 6 (8), Jan 17 (38)	150	141	175
1991	Nov 19 (15), Dec 12 (7), Dec 18 (3)	94	150	141
1992	Nov 23 (9), NS, NS	71	-	-
1993	Nov 22 (8), NS, NS	103	-	-
1994	NS, NS, NS	-	-	-
1995	NS, NS, NS	-	-	-
1996	Nov 22 (11), Dec 12 (9), Dec 21 (6)	236	254	241
1997	Dec 2 (1), Dec 10 (7), Dec 16 (2)	154	147	259
1998	NS, Dec 1 (2), Dec 12 (1)	-	279	208
1999	Nov 30 (1), Dec 17 (4), NS	383	234	-
2000	Nov 16 (13), Dec 3 (5), NS	217	267	-
2001	Nov 19 (9), Dec 3 (6), Dec 10 (1)	309	285	275
2002	Nov 22 (12), Dec 9 (6), NS	368	343	-
2003	Nov25 (8), Dec 16 [c] (13), Dec 17 (3)	382	349	346
2004	Nov 22 (8), Dec 7 (7), Dec 13-14 (1-2)	328	317	299
2005	Nov 22 (7), NS, NS	290	-	-

[a] Sequence of dates is: Pre-rifle, Rifle, Post-rifle season. NS=no survey; numbers in parentheses represent days before start of the rifle season the pre-rifle survey was conducted, day number of the rifle season the survey was conducted, and days after the rifle season the survey was conducted, respectively.

[b] North route was 3.2 km shorter than subsequent years.

[c] Delayed rifle season count due to bad weather and shortage of personnel.

vegetation height and density, and spotlight brightness), and possible double counting of some deer moving between compartments during the survey.

Rifle season and post-rifle season total counts reflected pre-rifle season trends (Figs. 1b and 1c, Table 1). The lack of any trend, observed in the first few years of the pre-rifle surveys and in the last few years, was not present in the rifle and post-rifle surveys. However, this was likely an artifact because fewer rifle or post-rifle seasons were conducted over those same time periods. The lower deer count in the 2005 pre-rifle season survey coupled with the relatively low number of deer counted in 2004 (reflected in all 3 surveys in 2004) strongly influenced trend shapes. Counts during all periods in 2006 will help determine if numbers of deer have reached a plateau or if numbers are continuing to increase.

When rifle and post-rifle season total counts were compared to pre-rifle season counts, the trends were mixed (Table 1). From 1990-2000 (although not all surveys were conducted both years), rifle and post-rifle season counts usually exceeded pre-rifle season counts. In some instances, the rifle and post-rifle season counts increased by ≥ 1.5 times more deer (e.g., 1991 and 1997). Considering that hunting was not allowed on the refuge but on private property surrounding it, an influx of deer was not unexpected. By contrast, rifle and post-rifle season counts from 2001-2004 were lower than pre-rifle season counts by 11-35 deer. Possible explanations for these reductions in counts include a) weather conditions (i.e., snow) that reduced visibility of deer during rifle and post-rifle season surveys (effectively no change likely in the QNWR deer population), b) deer retreating from approaching survey vehicles because of off-refuge hunting pressure (effectively no change likely in the QNWR deer population), c) deer attracted off the refuge to recently harvested grain fields or bait piles (effectively a reduction in QNWR population), d) deer illegally harvested from the refuge after the pre-rifle season surveys

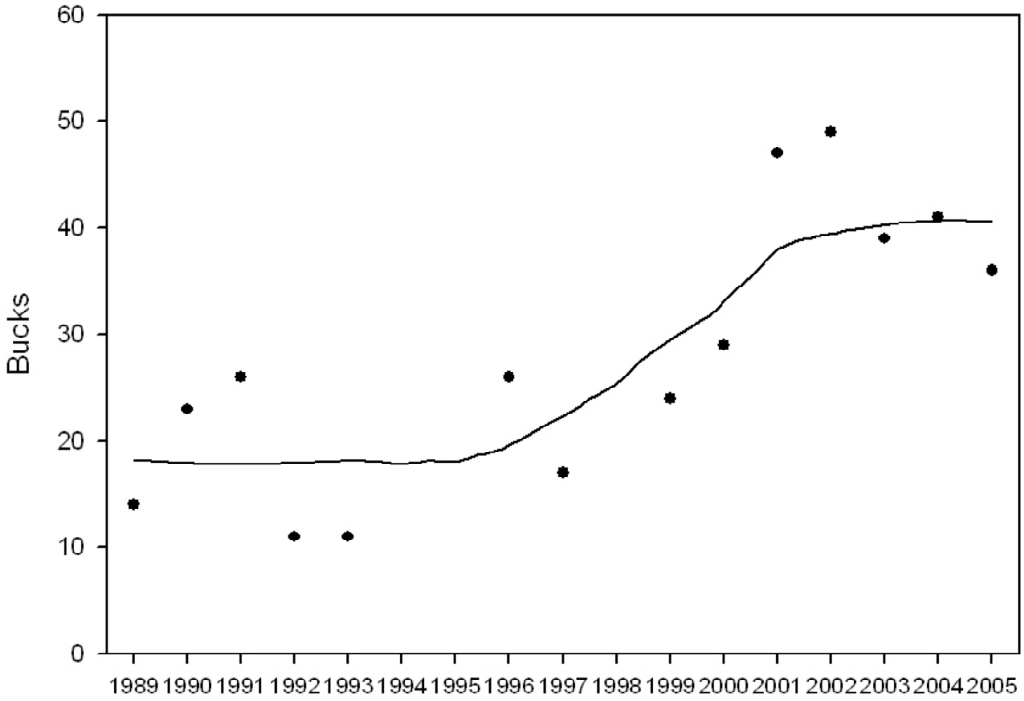

Fig. 2. Buck counts during pre-rifle season surveys, Quivira National Wildlife Refuge, 1989-2005. No surveys were conducted in 1994-1995, and 1998.

were conducted, or e) deer with home ranges that included parts of the refuge and private lands that were counted during pre-hunt surveys, but were legally harvested during the rifle season. Since 2000, there has been a large increase in the number of leases for hunting deer on private property adjoining QNWR. Often, lessees try to attract deer to their lands by using bait piles or remnants of standing crops, and this may have served to attract numerous deer from the refuge during rifle and post-rifle seasons.

Buck Counts

Pre-rifle season counts of bucks from 2001-2004 were approximately doubled those recorded the previous 12 years (Fig. 2). The timing of this increase lagged, by a few years, that observed for total counts (Fig. 1a versus Fig. 2 trends). This general upward linear trend was statistically significant (r^2 = 0.61, β = 1.81, $P < 0.0009$).

When rifle and post-rifle season buck counts were compared to pre-rifle season counts, trends were mixed (Fig. 3), much like those observed for total counts (Table 1). Perhaps the most salient trend was the reduction in number of bucks during the last 4 survey years (2001-2004) for rifle and post-rifle season counts. The reductions for most of the surveys among years represented approximately half of the total decreases observed for total counts (Fig. 1). This pattern existed despite bucks representing only 10-15% of the total counts during those years. It was not possible to determine whether some bucks moved off the refuge during or after the rifle season (and were subsequently harvested) or avoided detection during the rifle and post-rifle season spotlight surveys. This reduction in buck count in the rifle and post-rifle seasons from 2001-2004 was an indication that QNWR was not harboring bucks once the rifle seasons started. It was likely that some bucks that were counted during the pre-rifle season surveys were shot during the rifle season on private lands next to QNWR. Many of the bucks counted on QNWR in the pre-rifle season surveys (especially in recent years) probably left the refuge to visit bait piles and became vulnerable to harvest.

Buck:Doe Ratios

Buck:doe ratios ranged from 0.10 – 0.43 (10 bucks per 100 does – 43 bucks per 100 does) with considerable year-to-year fluctuation (Fig. 4); there

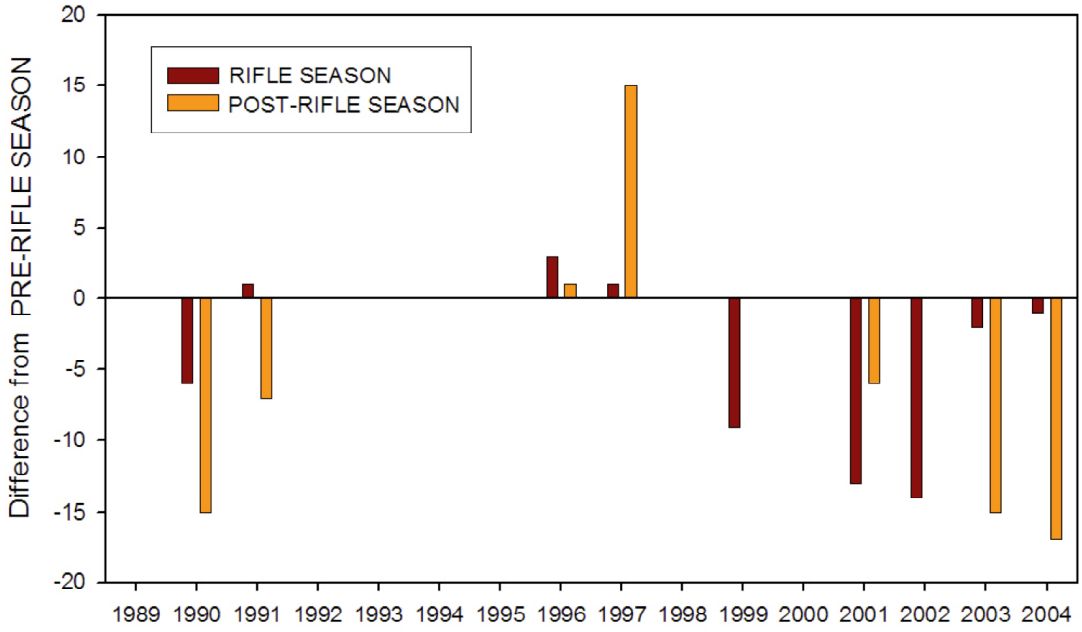

Fig. 3. Differences in pre-rifle season buck counts versus rifle and post-rifle season surveys, Quivira National Wildlife Refuge, 1989-2004. Bars above the zero line indicate rifle or post-rifle season counts were greater than the pre-season count, bars below the zero line indicate rifle or post-rifle season counts were less than the pre-season count.

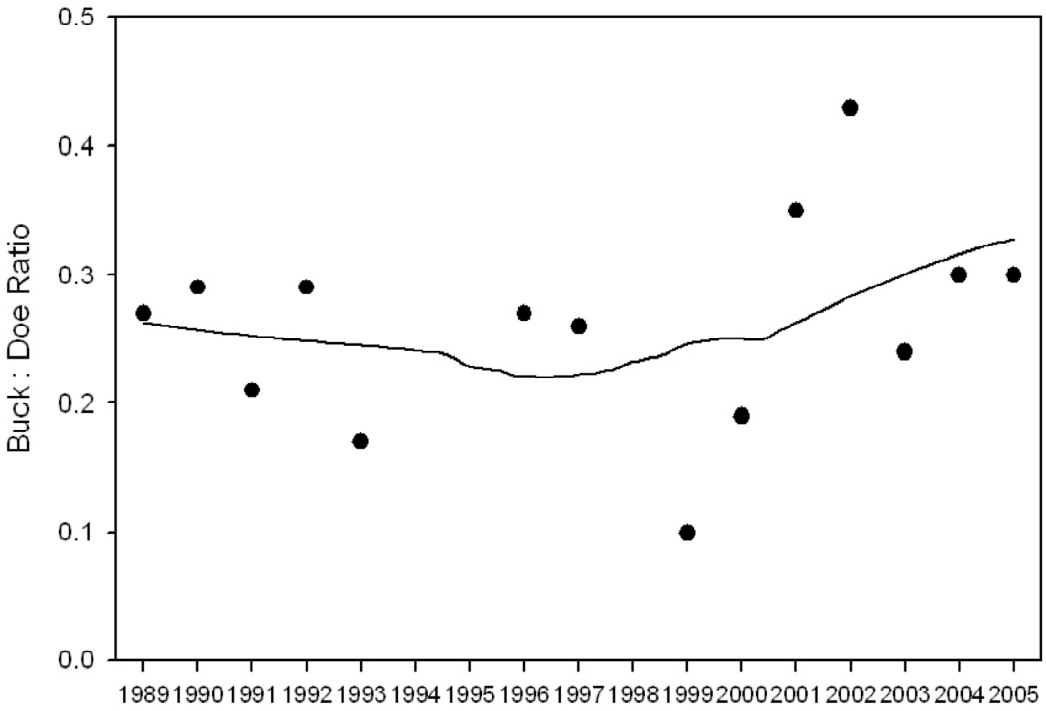

Fig. 4. Buck:doe ratios during pre-rifle season surveys, Quivira National Wildlife Refuge, 1989-2005. No surveys were conducted in 1994-1995, and 1998.

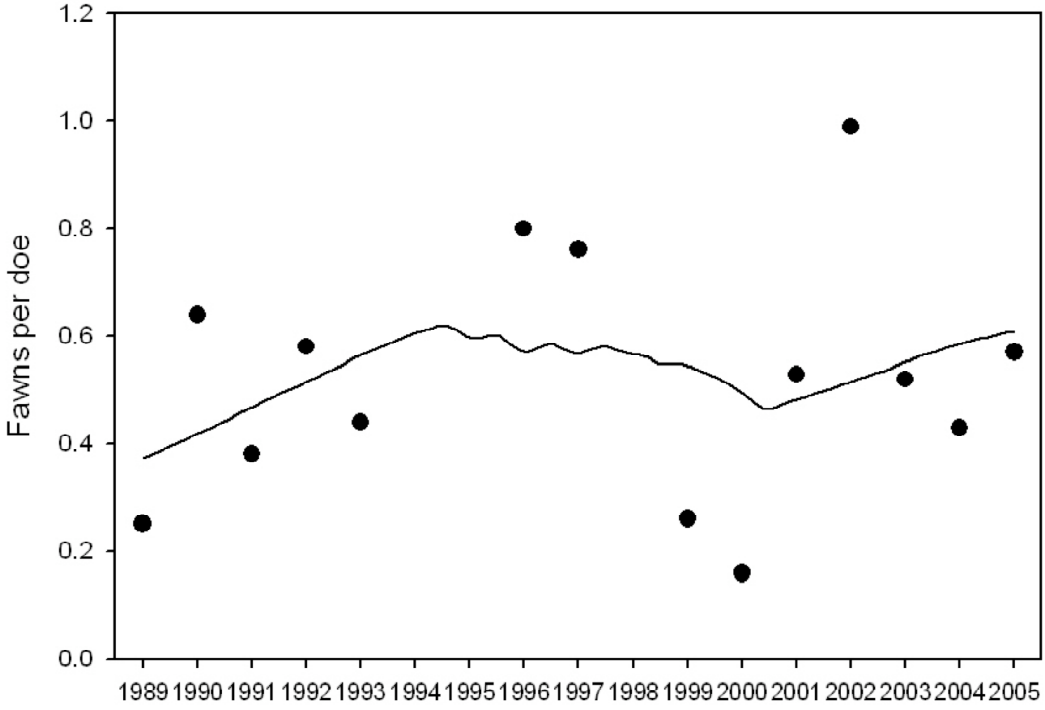

Fig. 5. Fawns per doe ratio observed during pre-rifle season surveys, Quivira National Wildlife Refuge, 1989-2005. No surveys were conducted in 1994-1995, and 1998.

was no statistically significantly linear trend for the survey period ($r^2 = 0.02$, $\beta = 0.01$, $P = 0.6092$). In 1999, the buck:doe ratio reached an all-time low, then over the next 3 years progressed to an all-time high of 43 bucks per 100 does before reverting back to approximately pre-1999 levels. The 2001-2002 period matched the highest buck counts (Fig. 3).

Fawns per Doe Ratios and Twining Rates

Fawns per doe fluctuated considerably from year-to-year (Fig. 5). The lowest ratio (0.16) was observed in 2000 and the highest (0.99) only 2 years later in 2002. The average ratio of 0.52 fawns per doe, the loess-trend line and lack of a statistically significant linear trend ($r^2 = 0.02$, $\beta = 0.01$, $P = 0.60$) suggest no major long-term increase or decrease in annual productivity.

The percentage of does with twins versus single fawns averaged 28% with a low of 8.3% in 1999 and a high of 46.7% in 1993 (Fig. 6). Like fawns per doe, considerable year-to-year fluctuation was observed. Several times, the twining rate increased by 1.5 times or more the year after low (<30%) twining rates (e.g., 45.3% in 1991 after being 25.8% in 1990; 46.7% in 1993 after being 15.8% in 1992; 34.0% in 2005 after being 10% in 2004). The general trend for twining percentage declined from the mid-1990s through 2004 (Fig. 6). An examination of precipitation patterns (e.g., annual precipitation, growing season precipitation, prior year annual precipitation, and prior year growing season precipitation) versus twining percentages or fawns per doe revealed no significant correlations (all $r_s < 0.2$).

MANAGEMENT IMPLICATIONS

Annual spotlight surveys on QNWR indicated that numbers of deer have increased markedly since the mid-1990s. Counts conducted before, during, and after the rifle hunting season all reflected an increase in total numbers of deer. These counts did not indicate an increase in deer on the refuge during and after the rifle hunting season, as we had hypothesized. Because deer hunting is not permitted on the refuge, we had expected to see increases in deer as they moved to the refuge avoiding hunters on adjacent private lands.

The percentage of does with twin fawns has declined since the mid-1990s. In other populations, this has been linked to physical condition of

Fig. 6. Percentage of does with twins (versus single fawns) during rifle season surveys, Quivira National Wildlife Refuge, 1989-2005. No surveys were conducted in 1994-1995, and 1998.

does (Verme 1965). Poor nutrition adversely affects reproduction and typically results in fewer does producing fawns. The nutritional condition of deer on and around QNWR should be monitored to determine if their diet is adequate. The fact that deer numbers have increased substantially while percentage of does with twin fawns has declined, and a browse line is evident in some wooded areas, may indicate that the herd's condition is declining.

The annual spotlight surveys are useful in understanding the development of the deer herd on QNWR. The surveys will be of greater value in future years for assessing the effects of changes in hunting pressure on private lands adjacent to QNWR and managing threats from CWD and other diseases transmissible to wildlife, livestock, poultry, and humans. The value of deer surveys (regardless of methods) could be enhanced with a telemetry study of deer movements to determine if and when deer on QNWR move onto private lands. A deer movement study could provide information about deer behavior that would aid in understanding the potential for disease transmission. For example, deer from QNWR may concentrate at bait piles off the refuge, where they contact deer from other areas. A telemetry study could also document if deer from QNWR move onto private lands, come into contact with livestock and other deer, and then return to the refuge.

ACKNOWLEDGMENTS

R. D. Hubbard assisted with data collection in 2005 and provided many helpful insights during data analysis. C. D. Smith provided advice on statistical analysis. Funding for the surveys was provided by the QNWR.

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