National Quail Symposium Proceedings

Volume 2 Article 4

1982

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EVALUATION OF BOBWHITE QUAIL SURVEYS IN KANSAS

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Abstract: Statistical analysis of selected Kansas bobwhite (*Colinus virginianus*) population and harvest surveys is presented. Survey techniques evaluated include roadside counts by rural mail carriers (RMCS), April roadside counts, whistling cock counts, random summer brood counts (RSBC), interviews of hunters contacted during the hunting season, wing collection envelopes distributed to hunters, and a mail questionnaire harvest survey of hunters. Significant differences ($P < 0.05$) between years and between survey regions existed for the April RMCS, April roadside count (coveys/observer), June whistle count, RSBC (young/adult and young/adult hen), and July RMCS. Correlation tests indicated significant ($P < 0.1$ to 0.001) correlation coefficient (r) values between many of the population surveys, and between many of the population surveys and harvest parameters. The October RMCS is the best single predictor of harvest parameters. When the October RMCS (quail/100 miles) is used in association with adults/observer (RSBC) and total quail/observer (RSBC), higher R^2 values are obtained as determined by stepwise multiple regression with harvest parameters.

Numerous bobwhite population monitoring techniques have been used in states containing significant numbers of this game bird. The most common techniques include the use of flush count census (Bennett and Hendrickson 1938), standardized roadside counts (Stiles and Hendrickson 1946, Fisher et al. 1947), whistling cock counts (Bennett 1951), random observations (Stanford 1972), and rural mail carrier counts (Dey 1971). In order to be of use for detecting population change and/or predicting harvest rates, any technique used must 1) be of sufficient sensitivity to detect significant annual change in bobwhite numbers; 2) cover a large enough geographic area in order to represent statewide and/or regional population levels; 3) not require such extensive manpower commitments that it would be rendered financially unfeasible; and 4) display a significant relationship to independent harvest estimates.

This paper discusses selected techniques used to monitor Kansas bobwhite populations and harvest, and the statistical relationships that exist between the various methods. The inventories considered here fall into 5 general categories: 1) those which measure pre-breeding bird densities; 2) those taken during the breeding and brood rearing period; 3) those which measure the pre-hunting season population; 4) those which measure bobwhite hunter performance; and 5) those which measure changes in age and sex ratios through collection of biological materials.

For survey purposes, Kansas is divided into 6 physiographic regions: West, Northcentral, Southcentral, Flint Hills, Northeast, and Southeast. The major bobwhite range is in the Flint Hills, Northeast, and Southeast regions with slightly lower densities in the Northcentral and Southcentral regions. The West Region has generally scattered low density bobwhite populations.

We gratefully acknowledge the assistance of the Wildlife Biologists and Game Protectors of the Kansas Fish and Game Commission and Kansas' rural mail carriers for their efforts in collecting field data for this study. Appreciation is also extended to Dr. A. Dayton, Kansas State University Department of Statistics, for his guidance in data analysis.

METHODS

Pre-breeding Inventories

April rural mail carriers survey (RMCS)

Starting in 1963, rural mail carriers recorded all quail seen during their normal deliveries for a four-day period during the last full calendar week of April. In 1970, the count period was extended to a five-day period. On a postcard supplied by the Fish and Game Commission, each carrier records the post office from which his route originates, counties traveled, and the number of miles traveled each day. Carriers are asked not to record observations on days of heavy fog or rain. An average of 550 carriers participate in the count and drive approximately 250,000 miles during the survey. A population index (quail/100 miles) is derived from data reported.

April roadside counts

Initiated in 1966, the April roadside count was designed to collect survey data from a 70 mile route for four days during the second full calendar week of April. The survey was intended to be similar to the rural mail carriers survey so that comparisons between the two could be made. However, after the first year it was evident that covey breakup and breeding activity affected the birds observability and thus survey results. It was decided to discontinue the route system and run the survey for the entire month of April and record random quail observations made while carrying out other work assignments. Fish and Game law enforcement officers and biologists in the eastern two-thirds of the state were asked to record, by weekly intervals, quail seen as coveys if more than three birds were seen, and the number of birds in each covey. The number of trios, pairs, and singles were also recorded. Indices used in this analysis were coveys seen/observer and total quail/observer. This survey was conducted for three years, 1967-1969.

Breeding and Brood Inventories

July RMCS

The July RMCS was initiated in 1962 and is conducted similarly to the April RMCS with the exception that carriers are asked to differentiate between young and adult quail seen. The indices derived from this survey include adults seen/100 miles, young seen/100 miles, total quail seen/100 miles, and young/adult. This survey has been conducted from 1962 to present.

Whistling cock counts

From 1963-1965, whistling cock counts were conducted during the second week of July. Thirty routes, each 14 miles long with 15 stops, were run in selected counties throughout the state.

In 1966, the July whistle count survey was replaced by two survey periods, June 1-10 and August 10-20. Twenty-five routes were run in the eastern two-thirds of Kansas. The routes were nine miles long with 10 listening stops (one per mile) for each route. The counts, conducted by Fish and Game law enforcement officers and biologists, started at sunrise on mornings with winds $<$ 12 mph and no threat of rain. Listening stops lasted three minutes, and the number of different males heard calling "bobwhite" was recorded. Observers were instructed not to whistle in order to stimulate calling.

The index derived from the whistling cock counts was males heard calling/stop. The June and August counts were conducted from 1966 to 1971.

Random summer brood counts (RSBC)

From 1963 to present, random brood counts have been conducted by Fish and Game personnel. In 1963 and 1964, the counts were made during a five-week period; July 15-August 18 and July 20-August 23, respectively. In 1965, the count was changed to cover a six-week period beginning in mid-July; in 1971 only five weeks of data were collected due to an error in the instructions.

Personnel were instructed to record all sightings of adult (separating cocks and hens) and young quail while conducting routine work assignments. With the aid of aging photographs, young were aged to the nearest week. Other information recorded was date, time of day to nearest hour, and county or Wildlife Management Area where the observations were made. Data sheets were sent in on a weekly basis.

Indices calculated from the brood count data are broods seen/observer, young seen/observer, males seen/observer, females seen/observer adults seen/observer, total quail seen/observer, young/brood, young/adult female, young/adult, and adult males/100 adult females. Hatch date information is not presented in this report.

Pre-Hunting Season Survey

October RMCS

The October RMCS survey has been conducted annually since 1966. Rural mail carriers record the number of bobwhites observed during a five-day period. The index derived from this survey is total quail observed/100 miles of route.

Hunter Surveys

Random bag-checks

The quail hunter bag-check was initiated in 1961 and continued through 1972. Fish and Game law enforcement officers and biologists located in the eastern two-thirds of Kansas were instructed to contact quail hunters in the field during the season in order to gather hunter performance and quail harvest data.

Information recorded in 1961 and 1962 for each hunter checked included county in which check was made, date, total number of birds bagged (by age), number of cripples lost, total number of hours hunted (separated by A.M. and P.M.), whether or not a dog was used, and whether or not the hunter had completed his hunt for that day. From 1963-1972, the following information was collected for each party contacted: county in which check was made, date, number of hunters in party, total number of birds bagged (by sex), number of cripples lost, number of coveys flushed, total number of hours hunted (separated by A.M. and P.M.), whether or not a dog was used, and whether or not the party had completed its hunt for that day.

Indices used for this analysis were coveys flushed/party hour, birds bagged/gun hour, bag/hunter, gun hours/hunter, cripples lost/100 birds bagged, and males/100 females.

Statewide harvest mail survey

The statewide harvest mail survey has been conducted from 1957 to present. A harvest estimate is obtained by sending mail questionnaires to a five percent sample of the previous year's hunting license buyers. These persons are contacted prior to the hunting seasons, and are sent forms for maintaining a record of their hunting activity (birds bagged on each hunt). At the close of the hunting seasons, they are contacted by mail and asked to report their total hunting activity including county hunted most, number of days spent quail hunting and total birds bagged. Of the license buyers contacted, generally over 40 percent return useable information representing about two percent of the current year's hunting license buyers. Indices and harvest figures used for this analysis include average bag/day per hunter, season bag/hunter, and estimated statewide harvest.

Wing collections

In an attempt to obtain age data for quail harvested, approximately 3,000 pre-addressed postage-paid wing envelopes were distributed to quail hunters by Fish and Game law enforcement officers during the quail season from 1962-1970. Instructions for removing one wing from each bird bagged during a hunt and for mailing the wings were printed on the envelope. The hunter was also asked to record on the envelope the county where birds were taken, date taken, and name and address of hunter. In addition to wing envelopes sent in by hunters, law enforcement officers and biologists were provided envelopes for collecting wings from those birds checked during opening weekend hunter bag-check interviews. These wings were kept separate according to sex. Wings were aged by the small game staff. Stage of primary feather molt for both young and adult wings were recorded to the nearest one-half feather increment and later classified by weeks of age.

Indices calculated and used in this analysis include young/adult, young/adult female, males/100 females, adult males/100 adult females, young males/100 young females, and percentage young.

Analysis

In 1973, one-way and two-way analysis of variance tests were performed on statewide and regional data at the Kansas State University (KSU) Statistical laboratory. More recently, simple correlation, regression, and stepwise regression analysis using the Statistical Analysis System (SAS) computer package were performed at the KSU Statistical Laboratory.

RESULTS

Pertinent data from the April roadside counts; June, July, and August whistle counts; April, July, and October RMCS; RSBC; mail harvest survey; random bag check, and wing collection are summarized in Tables 1-6.

In a previous analysis of Kansas bobwhite surveys (Sexson 1973), two-way analysis of variance tests were performed on all population surveys. Significant differences existed ($P < 0.05$) between survey years and survey regions. However, August whistle count indices were not significantly different among years, the RSBC index young/brood (years 1963-1972 only) did not vary significantly ($P > 0.05$) among years, and the wing collection indices young/adult and percentage young did not vary significantly among regions ($P > 0.05$).

Table 1. Bobwhite population indices from the April roadside count and June, July and August whistle counts in Kansas, 1963-71.

Year	Quail/Observer April Road Ct.	Coveys/Observer April Road Ct.	Males/Stop June W.C.	Males/Stop July W.C.	Males/Stop Aug. W.C.
1963	---	---	---	2.8	---
1964	---	---	---	5.1	---
1965	---	---	---	4.0	---
1966	---	---	4.9	---	2.1
1967	85	5.9	5.3	---	3.0
1968	65	5.0	4.5	---	2.2
1969	55	3.8	4.6	---	2.9
1970	---	---	4.4	---	1.5
1971	---	---	3.3	---	2.4
$\bar{X}$	68.3	4.90	4.50	3.97	2.35

Table 2. Bobwhite population indices from rural mail carrier counts in Kansas, 1962-80.

Year	Quail/100mi. April	Quail/100mi. July	Young/100mi. July	Adults/100mi. July	Young/Adult July	Quail/100mi. October
1962	----	4.80	1.73	2.78	0.62	----
1963	2.81	6.49	2.63	3.52	0.75	----
1964	2.28	5.80	1.75	3.88	0.45	----
1965	1.93	6.29	1.88	4.20	0.45	----
1966	3.05	7.35	2.71	4.50	0.60	6.52
1967	3.14	7.70	1.50	5.89	0.25	4.52
1968	1.92	7.62	2.44	4.87	0.50	5.93
1969	1.46	8.68	2.46	6.02	0.41	4.28
1970	1.54	5.54	1.65	3.73	0.44	4.85
1971	1.57	4.72	1.47	3.07	0.48	3.47
1972	1.56	6.95	2.61	4.08	0.64	3.34
1973	1.41	5.52	1.65	3.60	0.46	3.02
1974	1.38	3.54	1.29	2.18	0.59	1.95
1975	0.95	2.76	0.74	1.90	0.39	2.51
1976	1.05	2.92	0.90	1.89	0.48	2.48
1977	1.19	3.73	1.29	2.24	0.57	2.02
1978	0.98	4.18	1.17	2.83	0.41	3.19
1979	0.61	1.89	0.52	1.19	0.44	1.34
1980	0.50	1.70	0.62	0.99	0.63	1.67
$\overline{X}$	1.63	5.17	1.63	3.34	0.50	3.40

Table 3. Bobwhite population indices from random brood counts in Kansas, 1963-80.

Year	Broods/ Observer	Total Quail/ Observer	Young/ Observer	Adults/ Observer	Males/ Observer	Females/ Observer	Young/ Brood	Young/ Female	Young/ Adult	Males/100 Females
1963	12.78	210.4	158.5	51.95	30.32	21.63	12.41	7.33	3.05	140.2
1964	13.09	226.4	158.4	67.98	37.85	30.13	12.10	5.26	2.33	125.6
1965	12.98	209.9	141.9	67.98	39.67	28.30	10.94	5.01	2.09	140.2
1966	16.24	248.6	184.6	63.94	35.06	28.89	11.37	6.39	2.89	121.3
1967	6.37	118.6	62.5	56.07	34.17	21.90	9.82	2.85	1.11	156.0
1968	7.70	124.3	83.4	40.83	23.89	16.94	10.84	4.93	2.04	141.0
1969	11.25	181.8	123.3	58.42	33.21	25.22	10.97	4.89	2.11	131.7
1970	8.40	125.7	91.7	33.97	18.93	15.04	10.91	6.10	2.70	125.8
1971	3.84	62.8	40.5	22.34	13.24	9.11	10.53	4.44	1.81	145.4
1972	12.16	171.3	130.2	41.16	23.23	17.93	10.70	7.26	3.16	129.6
1973	9.27	133.8	90.2	43.67	26.98	16.69	9.72	5.40	2.06	161.6
1974	4.76	69.4	49.3	20.11	11.49	8.61	10.36	5.73	2.45	133.5
1975	5.26	79.4	56.6	22.87	13.36	9.52	10.76	5.94	2.47	140.3
1976	5.85	84.7	60.8	23.91	13.64	10.28	10.39	5.92	2.54	132.7
1977	5.23	82.7	54.4	28.34	16.83	11.50	10.40	4.73	1.92	146.4
1978	4.80	78.4	52.7	25.70	15.35	10.35	10.99	5.10	2.05	148.3
1979	1.92	27.6	15.2	12.34	7.67	4.67	7.93	3.26	1.23	146.3
1980	3.74	52.6	40.3	12.29	6.56	5.74	10.76	7.02	3.28	114.3
$\overline{X}$	8.09	127.1	88.5	38.55	22.30	16.25	10.66	5.41	2.30	138.8

Table 4. Bobwhite population indices from wing collections in Kansas, 1963-70.

Year	Young/ Adult	Young/ Ad. Female	% Young	Males/100 Females	Adult Males/ 100 Ad. Females	Young Males/ 100 Yng. Females
1963	5.48	11.92	84.57	95.50	117.40	91.90
1964	3.20	6.67	76.19	105.00	108.30	104.00
1965	4.98	10.39	83.27	105.70	108.60	105.10
1966	4.24	9.08	80.92	107.40	114.00	105.80
1967	4.15	8.95	80.59	101.70	115.50	98.60
1968	5.65	12.67	84.97	96.50	124.10	92.40
1969	4.48	9.33	81.75	101.20	108.20	99.60
1970	4.64	8.44	82.28	86.50	81.70	87.50
$\bar{X}$	4.60	9.68	81.80	99.90	109.70	98.10

Table 5. Bobwhite harvest data from random hunter bag checks in Kansas, 1961-1972.

Year	Coveys Flushed/Hour	Bag/ Gun Hour	Bag/ Hunter Day	Gun Hours/ Hunter	Cripples/100 Birds Bagged	Males/100 Fem. Bagged
1961	----	0.72	2.53	3.53	11.46	-----
1962	----	0.93	3.46	3.73	8.16	-----
1963	0.82	1.11	2.92	2.64	13.90	103.1
1964	0.77	0.75	2.53	3.36	11.78	104.3
1965	0.80	0.80	2.79	3.50	10.91	100.7
1966	0.93	0.96	2.83	2.95	12.03	105.5
1967	0.68	0.74	2.23	3.03	11.93	103.8
1968	0.82	0.85	2.70	3.19	11.68	101.6
1969	0.87	0.86	2.61	3.02	12.44	101.8
1970	0.73	0.69	2.16	3.15	13.66	104.4
1971	0.67	0.61	1.98	3.26	13.75	107.3
1972	0.79	0.64	1.80	2.81	-----	-----
$\bar{X}$	0.79	0.80	2.54	3.18	11.97	103.6

Figure 1 presents results of correlation testing of selected indices within random bag checks, wing collection, roadside counts, whistle counts, RMCS, and RSBC surveys.

There was no significant relationship ($P > 0.10$) between the number of males/stop from the June whistle count and males/stop from the August whistle count, but there were significant relationships between April RMCS, July RMCS, and October RMCS. Schwartz (1974b) found a significant ($P < 0.05$) relationship between quail heard in July and quail observed in August.

Intersurvey Testing

Significant relationships existed between the April RMCS and various indices from the RSBC (Table 7). The number of adults/100 miles and total quail/100 miles from the July and October RMCS were significantly ($P < 0.10$ to 0.01) related to most RSBC indices. The young/adult index from the July RMCS was significantly ($P < 0.01$) correlated with the young/adult index from the RSBC. Highest r values existed between the indices young/100 miles (July RMCS) and broods/observer (RSBC), ($r = 0.837$, $P < 0.01$) and between quail/100 miles (July RMCS) and males/observer (RSBC), ($r = 0.835$, $P < 0.01$).

Males/stop from the June whistle count was significantly correlated with males/observer (RSBC), ($r = 0.876$, $P < 0.05$), and adults/observer (RSBC), ($r = 0.847$, $P < 0.05$) but weakly correlated ($P < 0.10$) with adults/100 miles (July RMCS), ($r = 0.779$); total quail/100 miles (July RMCS), $r = 0.748$); and females/observer (RSBC), ($r = 0.789$).

Quail/observer from the April roadside count was significantly related to total quail/100 miles (April RMCS), ($r = 0.998$, $P < 0.05$). However, there were only three years' data available for analysis. Males/stop (July whistle

Table 6. Bobwhite harvest data from statewide harvest mail survey in Kansas, 1961-80.

Year	Avg. Bag/ Day	Season Bag/ Hunter	Total Harvest
1961	2.96	10.80	1,076,000
1962	3.48	14.30	1,520,000
1963	4.06	17.66	2,126,000
1964	3.59	19.67	2,573,000
1965	3.83	19.69	2,631,000
1966	3.87	25.07	3,931,000
1967	3.26	15.94	2,426,000
1968	3.50	20.09	3,050,000
1969	3.59	20.68	3,301,000
1970	3.04	17.06	2,733,000
1971	2.56	14.71	2,284,000
1972	2.73	16.55	2,618,000
1973	2.70	15.11	2,307,000
1974	2.06	11.66	1,772,000
1975	2.27	12.90	1,912,000
1976	2.43	13.91	2,068,000
1977	2.72	14.86	2,263,000
1978	2.70	15.96	2,569,000
1979	1.90	9.50	1,193,000
1980	1.87	9.35	1,186,000
$\overline{X}$	2.96	15.77	2,276,950

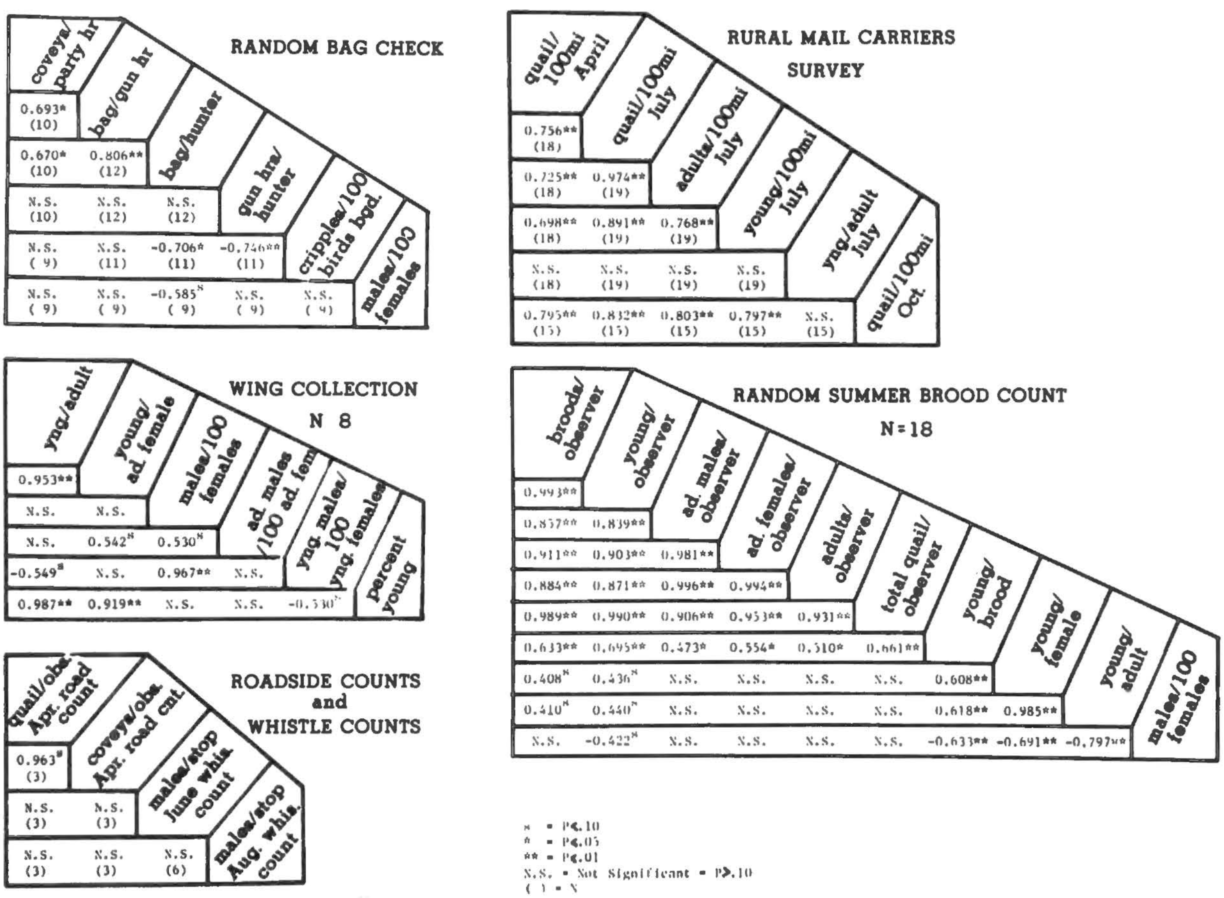

Fig. 1. Correlation coefficients (r) between indices of selected population and harvest surveys in Kansas, 1961-1980.

Table 7. Correlation coefficients resulting from tests between bobwhite population indices obtained from rural mail carriers survey and random summer brood count in Kansas, 1963-1980.

	Q/100mi April (18)	Ad/100mi July (18)	Yng/100mi July (18)	Total Q/100mi July (18)	Yng/Ad July (18)	Q/100mi October (15)
Broods/Obs	0.683**	0.635**	0.837**	0.732**	N.S.	0.731**
Yng/Obs	0.691**	0.560**	0.826**	0.702**	N.S.	0.735**
Males/Obs	0.798**	0.826**	0.726**	0.835**	N.S.	0.775**
Females/Obs	0.782**	0.791**	0.754**	0.816**	N.S.	0.819**
Adults/Obs	0.794**	0.815**	0.742**	0.830**	N.S.	0.799**
Total Quail/ Observer	0.739**	0.675**	0.825**	0.757**	N.S.	0.780**
Yng./Brood	0.460^{s}	N.S.	0.556*	0.406^{s}	N.S.	0.513^{s}
Yng/Ad Female	N.S.	N.S.	N.S.	N.S.	0.775**	N.S.
Yng/Adult	N.S.	N.S.	N.S.	N.S.	0.733**	N.S.
Adult Males/100 Adult Females	N.S.	N.S.	N.S.	N.S.	-0.438^{s}	N.S.

(N) = Number of years compared
^{s} = P < 0.10
* = P < 0.05
** = P < 0.01
N.S. = P > 0.10

count) was weakly related to broods/observer (RSBC), (r = 0.989, P < 0.10), but again, there were only three years' data for analysis. Males/stop from the August whistle count showed a weak negative relationship to the number of young/adult female (RSBC), (r = -0.783, P < 0.10, N = 6).

The index average bag/day (mail survey) was highly correlated with bag/gun hour (r = 0.872, P < 0.01) and bag/hunter (r = 0.748, P < 0.01) (Table 8). The best relationship existed between the season/bag hunter (mail survey) and coveys flushed/party hour (bag check), (r = 0.894, (P < 0.01).

Of those whistle count indices with at least six years of data for analysis, only males/stop from the June count showed a significant relationship with average bag/day from the mail survey (r = 0.734, P < 0.10), (Table 9). No significant relationships existed between August whistle count data and mail harvest indices.

In analysis between whistle counts and random bag checks, where at least six years of data were available for testing, only males/stop from the June whistle count and gun hours/hunter (random bag check) showed significant relationship (R = -0.810, P = 0.05). No August whistle count data were significantly correlated with random bag checks.

Table 8. Correlation coefficients resulting from tests between hunter performance data obtained from random bag checks and statewide harvest mail survey in Kansas, 1961-1972.

	Mail Harvest Survey		
Bag Check	Avg Bag/ Day	Season Bag/ Hunter	Total Harvest
Coveys Flushed/ Party Hour	0.682* (10)	0.894** (10)	0.760* (10)
Bag/Gun Hour	0.872** (12)	N.S. (12)	N.S. (12)
Bag/Hunter	0.748** (12)	N.S. (12)	N.S. (12)

(N)=Number of years compared
^{s} = P < 0.10
* = P < 0.05
** = P < 0.01
N.S. = P > 0.10

Studies have shown the use of whistle counts as an index to quail populations (Bennett 1951, Brown et al. 1978). Ellis et al. (1972) concluded that carefully standardized call counts would provide reliable indices to quail relative abundance in Illinois; however, Preno and Labisky (1971) also working in Illinois, found no significant relationship between spring abundance as determined from whistle counts and fall harvest statistics. In an analysis of Iowa quail survey data, Schwartz (1974a, 1974b) found significant relationships between July whistle counts and the mail survey indices of total harvest ($P < 0.05$) and average bag/day ($P < 0.10$).

Correlations between RMCS indices and bag check data showed high r values between quail/100 miles (October RMCS) and bag/hunter ($r = 0.866$, $P < 0.05$); young/100 miles (July RMCS) and coveys flushed/party hour ($r = 0.855$, $P < 0.01$); and quail/100 miles (October RMCS) and bag/gun hour ($r = 0.832$, $P < 0.05$) (Table 10).

Quail/100 miles (October RMCS) was shown to be the best predictor of the subsequent harvest as measured by the statewide harvest mail survey (Table 11). The best relationship exists between quail/100 miles (October RMCS) and average bag/day ($r = 0.924$, $P < 0.01$), (Figure 2). Significant relationships existed between each harvest parameter and all of the RMCS indices except young/adult in July. Ammann and Ryel (1963) concluded that rural mail carrier surveys were a good index to ruffed grouse populations in Michigan. In Nebraska, they have been in use since 1945 (Dey 1971).

The index coveys flushed/party hour (random bag-check) was significantly correlated ($P < 0.01$) with broods/observer ($r = 0.815$), young/observer ($r = 0.792$), and total

Table 9. Correlation coefficients resulting from tests using indices obtained from random April observations and whistle counts with harvest parameters from the statewide harvest mail survey in Kansas, 1963-1971.

Harvest Parameters	Population Surveys				
	Q/Obs April (3)	Covey/Obs April (3)	Males/Stop June (6)	Males/Stop July (3)	Males/Stop August (6)
Avg Bag/ Day	-0.998*	N.S.	0.734^s	-0.999*	N.S.
Season Bag	N.S.	N.S.	N.S.	N.S.	N.S.
Total Harvest	-0.999*	N.S.	N.S.	N.S.	N.S.

(N)=Number of years compared
^{s} = $P < 0.10$
* = $P < 0.05$
** = $P < 0.01$
N.S. = $P > 0.10$

Table 10. Correlation coefficients resulting from testing between bobwhite population indices obtained from rural mail carrier surveys and hunter performance data from the random bag check in Kansas, 1962-1972.

Harvest Parameters	Rural Mail Carriers Survey					
	Q/100mi April	Ad/100mi July	Yng/100mi July	Total Q/100mi July	Yng/Ad July	Q/100mi October
Coveys flushed/ Party Hour	N.S. (10)	N.S. (10)	0.855** (10)	0.565^s (10)	N.S. (10)	N.S. (7)
Bag/Gun Hour	0.556^s (10)	N.S. (11)	0.546^s (11)	N.S. (11)	0.531^s (11)	0.832^s (7)
Bag/Hunter	N.S. (10)	N.S. (11)	N.S. (11)	N.S. (11)	N.S. (11)	0.866* (7)

(N) = Number of years compared
^{s} = $P < 0.10$
* = $P < 0.05$
** = $P < 0.01$
N.S. = $P > 0.10$

Table 11. Correlation coefficients resulting from testing between bobwhite population indices obtained from rural mail carrier surveys and hunter performance data from the statewide harvest mail survey in Kansas, 1962-1980.

Harvest Parameters	Rural Mail Carriers Survey					
	Q/100mi April (18)	Ad/100mi July (19)	Yng/100mi July (19)	Total Q/100mi July (19)	Yng/Ad July (19)	Q/100mi October (15)
Avg Bag	0.812**	0.751**	0.813**	0.816**	N.S.	0.924**
Season	0.715**	0.791**	0.831**	0.841**	N.S.	0.912**
Total Harvest	0.604**	0.783**	0.743**	0.800**	N.S.	0.896**

(N) = Number of years compared
** = P < 0.01
N.S. = P > 0.10

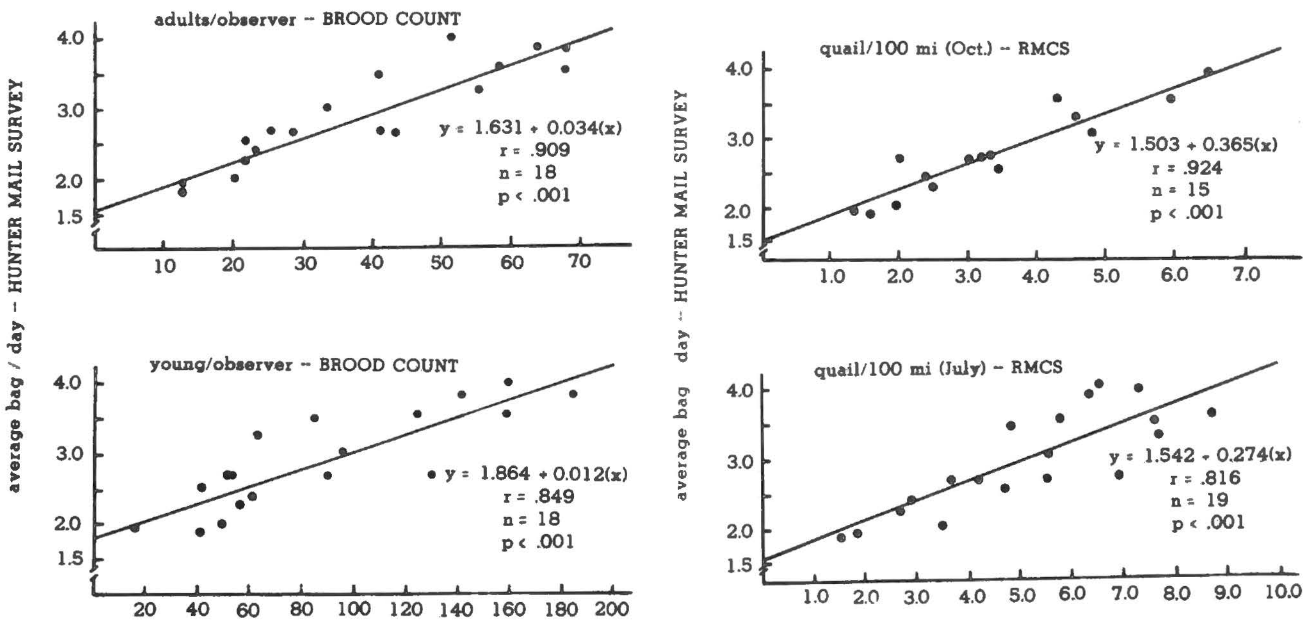

Fig. 2. Relationships of selected random summer brood count and rural mail carrier survey indices to the mail harvest survey index average bag/day in Kansas, 1962-1980.

quail/observer (r = 0.771) from the RSBC, (Table 12). Bag/gun hour was significantly correlated with the young/brood (r = 0.637, P < 0.05) and bag/hunter was significantly (P < 0.05) correlated with males/observer (r = 0.645), females/observer (r = 0.641), adults/observer (r = 0.649), and total quail/observer (r = 0.641).

All of the brood count indices except young/adult female and young/adult were correlated with the statewide harvest mail survey indices (Table 13). The best predicator of 1) average bag/day was adults/observer (r = 0.909, P < 0.01), (Figure 3); 2) season bag/hunter was females/observer (r = 0.875, P < 0.01); and 3) statewide harvest was females/observer (r = 0.740, P < 0.01); however, broods/observer (r = 0.724, P < 0.01) and total quail/observer (r = 0.721, P < 0.01), (Figure 2) also provided high r values. The broods/observer index, which is similar to the production index (PI) described by Stanford (1972), was significantly (P < 0.01) correlated with the statewide harvest mail survey parameters (Figure 2).

There were no significant relationships (P > 0.10) between the wing collection indices young/adult, young/adult female, or percentage young and April roadside counts; June, July, or August whistle counts; RMCS; and mail survey harvest indices.

Multiple Regression Analysis

Stepwise maximum R^2 improvement multiple regression analysis was performed between the statewide mail survey harvest indices (average bag/day, season bag/hunter, and total harvest)

Table 12. Correlation coefficients resulting from testing between bobwhite population indices obtained from the random summer brood count and hunter performance data from random bag checks in Kansas, 1963-1972.

Harvest Parameters	Random Summer Brood Count: Broods/ Obs (10)	Young/ Obs (10)	Males/ Obs (10)	Females/ Obs (10)	Adults/ Obs (10)	Total Q/ Obs (10)	Young/ Brood (10)
Coveys Flushed/ Party Hour	0.815**	0.792**	N.S.	0.608s	N.S.	0.771**	N.S.
Bag/Gun Hour	0.564s	0.617s	N.S.	N.S.	N.S.	0.617s	0.637*
Bag/Hunter	0.552s	0.593s	0.645*	0.641*	0.649*	0.641*	0.581s

(N) = Number of years compared
s = $P < 0.10$
* = $P < 0.05$
** = $P < 0.01$
N.S. = $P > 0.10$

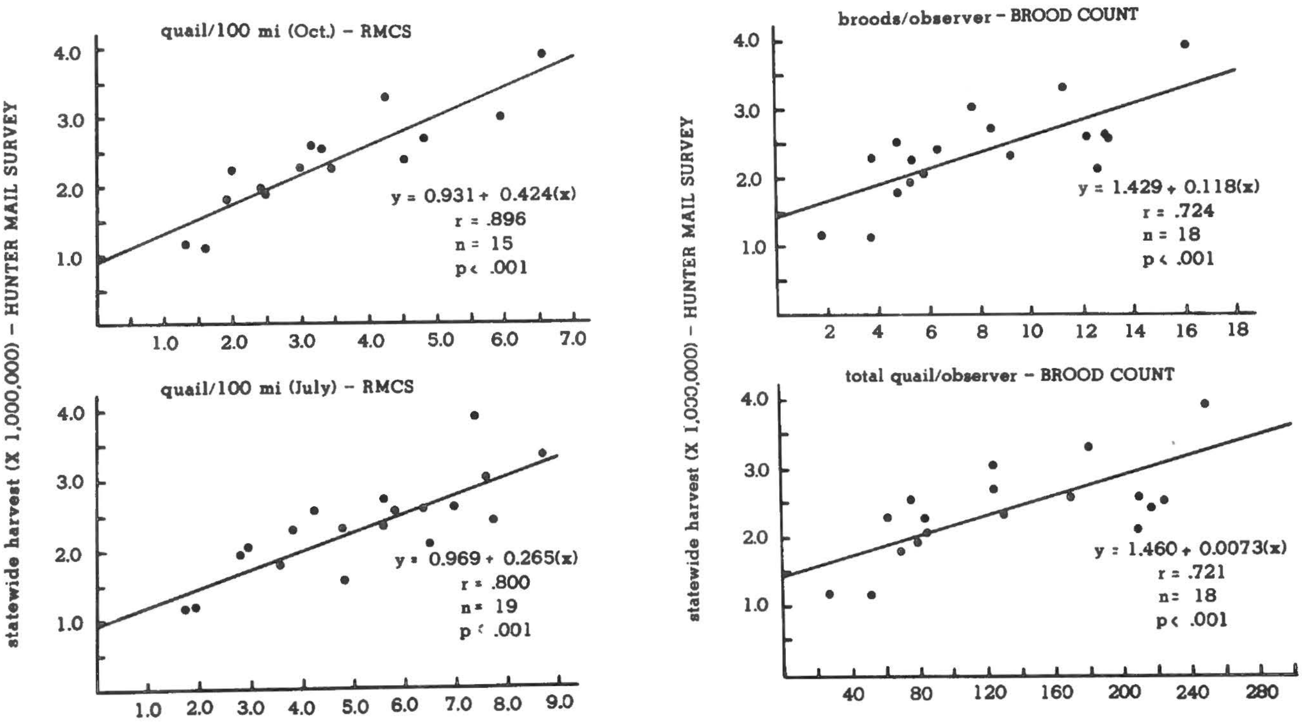

Fig. 3. Relationships of selected random summer brood count and rural mail carrier survey indices to the mail harvest survey index statewide (total) harvest in Kansas, 1962-1980.

and RMCS indices; between the harvest indices and RSBC indices, and between the harvest indices and a group composed of selected indices from both population surveys. In almost every instance the best two variable model was accepted. Although models with three or more variables provided slightly higher R^2 values, the improvement was generally not deemed significant enough to warrant further complication of the predicting formula. In all instances $P < 0.001$.

When RMCS indices alone were used, the best model for predicting average bag/day included quail/100 miles (July) and quail/100 miles (October), ($R^2 = 0.916$, $F = 65.66$). The best model for predicting season bag/hunter included young/100 miles (July) and quail/100 miles (October), ($R^2 = 0.894$, $F = 50.84$). The best model for predicting total quail harvest included young/100 miles (July) and quail/100 miles (October), ($R^2 = 0.879$, $F = 43.42$).

When RSBC indices alone were tested, the best two variable predictor for average bag/day included males/observer and young/brood ($R^2 = 0.873$, $F = 51.44$). The best model for predicting season bag/hunter included males/observer and females/observer ($R^2 = 0.786$, F = 24.32). The best model for predicting total quail harvest included females/observer and adults/observer (R^2 = 0.570, F = 9.96).

Improved R^2 values were achieved when both RMCS and RSBC survey data were used in the same model. The resulting two variable model for predicting average bag/day included the indices quail/100 miles (October RMCS) and adults/observer (RSBC), (R^2 = 0.940, F = 94.08). The index values quail/100 miles (October RMCS) and total quail/observer (RSBC) comprised the best two variable model for predicting season bag/hunter (R^2 = 0 .919, F = 68.36) and total quail harvest (R^2 = 0.896, F = 51.56). Predicting formulas for the above models are

$$\text{average bag/day} = 1.415 + 0.211\,(X_1) + 0.018\,(X_2)$$

$$\text{season bag/hunter} = 6.835 + 1.460\,(X_1) + 0.034\,(X_3)$$

$$\text{total harvest} = 866{,}918 + 243{,}766\,(X_1) + 6{,}191\,(X_3)$$

where: X_1 = quail/100 miles (October RMCS)
X_2 = adults/observer (RSBC)
X_3 = total quail/observer (RSBC)

Substantial improvement in the ability to predict bobwhite harvest parameters may be realized through the use of predictive formulas (Schwartz 1974a). Attempts to estimate harvest parameters using long-term means resulted in average annual errors of 20.0 percent, 18.5 percent, and 21.5 percent for average bag/day, season bag/hunter and total harvest, respectively. Average annual errors of the predicted values (using the multiple regression formulas) from the mail survey harvest parameter estimates were 4.3 percent, 6.5 percent and 8.9 percent for average bag/day, season bag/hunter and total harvest, respectively. Thus an improvement of 15.7, 12.0 and 12.6 percent is achieved for estimates of average bag/day, season bag/hunter and total harvest, respectively, when compared to use of long-term means for prediction purposes.

CONCLUSION

For years wildlife managers have tried to accurately monitor quail populations and predict harvest and harvest rates (Bennett and Hendrickson 1938, Bennett 1951, Kozicky et al. 1956, Preno and Labisky 1971, Ellis et al. 1972). In Kansas, a variety of survey techniques have been used both experimentally and on a continuing basis. These include April roadside counts by Fish and Game personnel counting coveys and individual birds; standardized whistle count routes run during June, July, and August; counts made by rural mail carriers during April, July, and October; and random quail observations (random summer brood count) made by Fish and Game personnel during July and August. Harvest

Table 13. Correlation coefficients resulting from testing between bobwhite population indices obtained from the random summer brood count and hunter performance data from the statewide harvest mail survey in Kansas, 1963-1980.

Harvest Parameters	Random Summer Brood Count								
	Broods/ Obs (18)	Young/ Obs (18)	Males/ Obs (18)	Females/ Obs (18)	Adults/ Obs (18)	Total Q/ Obs (18)	Young/ Brood (18)	Young/ Adult Female (18)	Young/ Adult (18)
Avg Bag/ Day	0.837**	0.849**	0.903**	0.907**	0.909**	0.889**	0.637**	N.S.	N.S.
Season Bag/Hunter	0.850**	0.842**	0.831**	0.875**	0.854**	0.868**	0.586**	N.S.	N.S.
Total Harvest	0.724**	0.695**	0.697**	0.740**	0.719**	0.721**	0.460^s	N.S.	N.S.

(N) = Number of years compared
s = $P < 0.10$
* = $P < 0.05$
** = $P < 0.01$
N.S. = $P > 0.10$

information has been collected using a mail survey of hunting license buyers and random field bag checks conducted by Fish and Game personnel.

Of the population surveys tested, the RMCS and RSBC provide the best parameters. These two techniques have been continued in Kansas because of their relationship to harvest statistics and their cost efficiency.

The RMCS involves only a limited number of Fish and Game personnel to perform the mailing of survey cards and tabulation, analysis, and reporting of the data. During each survey period 520-550 rural mail carriers return useable data and report on quail seen while driving approximately 250,000 miles along country roads during each survey period.

The RSBC survey is performed by Fish and Game personnel who record quail observations during their normal work activities. There is little additional mileage or personnel time incurred.

The statewide mail harvest survey is still performed by the Kansas Fish and Game Commission and is preferred over the random bag check since it too involves few personnel and has proven to be capable of collecting useable harvest statistics of dependable precision with minimum cost.

Through this analysis of population and harvest statistics, we are now capable of accurately predicting and forecasting hunter performance and expectations for the subsequent hunting season.

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