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Research Progress Report: Fox-Pheasant Relationships in South Dakota, 1965

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RESEARCH PROGRESS REPORT

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I. Pheasant Population Indices

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SOUTH DAKOTA STATE UNIVERSITY
Brookings
in cooperation with
SOUTH DAKOTA DEPARTMENT OF GAME, FISH & PARKS
U. S. BUREAU OF SPORT FISHERIES AND WILDLIFE
through
SOUTH DAKOTA COOPERATIVE WILDLIFE RESEARCH UNIT
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This progress report presents the 1965 results of the first year's research study concerning some factors that may relate to changes in pheasant numbers in South Dakota. Much of the study deals with fox-pheasant relationships, but some attention is directed to factors involved in fox predation other than on pheasants.

Ordinarily, results of one year's detailed research of a long-term study are not considered sufficient to justify publication. However, widespread interest in the fox as a possible factor upon pheasant numbers plus lack of prior substantive findings upon which to base a program of action make it desirable that the public be provided with research facts as they are obtained.

Persons using this information are cautioned that results shown are not necessarily complete nor conclusive. Interpretations given are tentative because additional data resulting from continuation of these studies may lead to conclusions different from those based on the results of any one year.

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SUMMARY AND INTERPRETATIONS

A 5-year cooperative study designed to obtain information regarding effects of foxes on pheasant populations in eastern South Dakota was initiated in 1964. Specific objectives were to determine (1) population fluctuations of foxes and pheasants, (2) fox food habits and reproductive characteristics and (3) effectiveness and cost of fox reduction to increase pheasant abundance.

Studies were conducted on four pairs of 100-square-mile areas. Fox populations were reduced on one member of each pair beginning in January 1965, and individual foxes were removed on a complaint basis on the other. Each pair of areas is referred to as a unit.

When summer pheasant data on the fox-reduction and check areas are considered, significant differences are noted in adult pheasants per mile, broods per mile, and brood size from 1964 to 1965. Changes in adult pheasants per mile in Unit 2 showed the decline in the fox-reduction area was significantly (0.01) less than in the check area. However, in Units 1 and 4 the declines in the check areas were significantly (0.01) less than those in the fox-reduction areas.

The difference in decline in broods per mile in the fox-reduction compared to the check area from 1964 to 1965 was negligible in Unit 1. In Unit 2 the fox-reduction area showed a slight increase compared to a decrease in the check area. This difference is significant (0.01). In Unit 4 a smaller decline occurred in the fox-reduction area than in the check area. The difference in Unit 4 is significant (0.05). The proportion of hens with broods showed an increase from 1964 to 1965 in the fox-reduction areas of Units 1, 2, and 4 and a lesser increase or a decrease in the corresponding check areas.

A significant (0.01) increase in brood size occurred from 1964 to 1965 in the fox-reduction compared to the check area of Unit 1. A nonsignificant increase occurred in the check area compared to the fox-reduction area in Unit 2.

The adult pheasant-per-mile averages during the spring of 1965 showed more birds in the fox-reduction area than in the check area of Unit 1, and the reverse in Unit 2. Neither difference is significant. Units 3 and 4 showed significantly (0.01) more adults per mile in the fox reduction than in the check areas during this same period.

Fox data revealed that counting tracks in snow along transects is the best of three methods for determining fox activity in an area. Such counts in reduction and check areas within each unit showed that fox activity was sufficiently comparable in each pair of areas prior to fox reduction. Methods used to reduce fox populations also reduced to some extent other predators, including nest robbers.

Grasses, mice, pheasants, rabbits, and insects, in descending order, respectively, were the most frequently occurring items found in stomachs of foxes taken in the study areas from January to June 1965. Grasses were found in stomachs that also contained mice and insects. Pheasants were the item composing the greatest volume, followed by rabbits and mice. Prairie deer mice made up the majority of small mammal remains. Snap-trapping results showed this species to be the most abundant small mammal in the study areas. Most bird remains consisted of ring-necked pheasant, particularly in Unit 2. Rabbits occurred most frequently from stomachs collected in Unit 3, and indices to rabbit abundance were highest in that unit. Ground squirrels were the only common small mammals not heavily preyed upon by foxes.

When the above data are compared, certain inconsistencies appear. Unit 1 had the most foxes prior to reduction, on the basis of track counts. Nevertheless, the reduction area of this unit showed a greater decline in number of adult pheasants (post-reproduction counts) from 1964 to 1965 than did the check area and almost no difference from the check in decline in number of broods. Unit 4 had the fewest foxes before reduction, on the basis of track counts. The reduction area of this unit, however, showed a considerably greater decline in numbers of adult pheasants (post-reproduction counts) from 1964 to 1965 than did the check area and a slightly lesser decline than the check in number of broods. Unit 3 had the most adult pheasants in 1964 and 1965. It also had the most broods in the reduction area in 1964 and 1965. Contrastingly, fewer pheasant remains were found in fox stomachs collected from January to June 1965 from this unit than from Unit 2, where pheasants were lower in number. Unit 2 had the second lowest number of foxes prior to reduction, based on track counts. The reduction area of this unit had the smalles decline (relative to the check area) from 1964 to 1965 in adult pheasants and the highest increase in broods. However, it also had the smallest increase in proportion of hens with broods and in size of broods. The increase in brood size was less than on the check area where the fox population was not reduced.

Unfortunately, many foxes were killed in the check area of Unit 4, and considerable numbers of predators other than foxes were killed in all the reduction areas. In view of this and the inconsistent data that were obtained, it is the opinion of the authors that no definite conclusions can be drawn after the first year of the 5-year study as to whether reduction of fox populations does or does not result in corresponding increases in pheasant populations.

INTRODUCTION

D. R. Progulske

Intense interest continues in what effects, if any, foxes might have on pheasant populations in South Dakota. Little scientific data are available because previous studies were either too restrictive in scope or involved complicating factors which reduced their effectiveness.

In December 1963 at the first coordinating meeting of the South Dakota Cooperative Wildlife Research Unit, upon recommendation of the Department of Game, Fish, and Parks it was decided that the Unit should begin a study of fox-pheasant relationships. A project plan was drawn up and approved. This plan provided for various methods of study including evaluation of effects on pheasants of a large-scale fox reduction program in northern Clark County, South Dakota by the Department of Game, Fish and Parks and the Branch of Predator and Rodent Control (now Division of Wildlife Services) of the Bureau of Sport Fisheries and Wildlife. Realizing the value of the reduction study approach, these latter agencies subsequently in May 1964 planned an expanded effort involving replicated reduction and check areas. Plans were incorporated into a 3- to 5-year research project (P-R Project W-75-R-7, Job F-8.2-7) which had as its objectives a determination of the following:

1. Distribution, density, and reproductive characteristics of red foxes in relation to distribution and density of important prey animals, particularly ring-necked pheasants, in eastern South Dakota, with emphasis on information gathered from study areas located in representative land-use regions.
2. Food habits of red foxes throughout the year.
3. Biological effects and cost of intensive fox control programs on the study areas with emphasis on the value of such programs in increasing pheasant abundance.

Four units were located in different climatic and land-use regions of eastern farm lands of the state. Each unit was composed of two 10x10-mile areas situated from 5 to 15 miles apart. Unit locations were chosen to include all combinations of high and low populations of pheasants and foxes prior to the fox reduction phase of the study. Unit 1 had low pheasant, high fox populations; Unit 2 had high pheasant, low fox populations; Unit 3 had high populations of both species; and Unit 4 had low populations of both species. Beginning in January 1965, fox populations were reduced by various methods during appropriate seasons on one member (reduction area) of each pair. On the check areas foxes were to be undisturbed except for reduction requested by landowners.

Populations of pheasants were measured by counting birds along routes in each area during the summer of 1964 and the spring and summer of 1965 (P-R Project W-75-R-7, Job P-2.9-7). Fox population indices were obtained from aerial counts of tracks in snow along transects, aerial counts of active dens, and the number of foxes recovered during the reduction program. The track count was found to be a statistically sound method for indexing fox activity. Results from the other methods showed excessive variations.

Pre-reduction counts of pheasants were made in all areas during the summer of 1964; those on foxes were made in December 1964 and January 1965. Post-reduction counts of pheasants were made during the spring and summer of 1965. Statistical analyses could be applied only to counts of adult pheasants per mile, broods per mile, brood size, and fox tracks per mile. The _t_-test was used for statistical comparisons.

General information was obtained on the distribution of foxes and pheasants off the study areas but is not included in this progress report.

Populations of buffer-prey species were investigated. Snap traps were set in each unit in the summer of 1965 to obtain indices of small mammal abundance. Runways, droppings, and cuttings of meadow voles were counted in the fall of 1965. Rabbit indices were obtained during the spring and fall of 1965 by using spotlights to count rabbits along routes in all areas.

Food habits of foxes were studied by examining stomach contents of animals taken in or near the study areas. Most of the stomachs were from foxes killed during January, February, and March 1965. Not enough stomachs were collected during all months to yield suitable information on seasonal feeding habits.

Reproductive tracts were collected and preserved from foxes taken in or near the study areas but have not been analyzed completely.

Pheasant population surveys were supervised by biologists and conducted by trained field assistants of the state Department of Game, Fish and Parks. State game wardens made the rabbit counts. Division of Wildlife Services, Bureau of Sport Fisheries and Wildlife personnel reduced fox populations, collected fox stomachs, and assisted in aerial surveys. Pilots employed or hired by the Department of Game, Fish and Parks were responsible for aircraft operations. Data on small mammal populations and on fox food habits and reproduction were gathered by the project research assistant of the Cooperative Wildlife Research Unit. Data were analyzed statistically by the Agricultural Experiment Station statistician. The project was administered jointly by personnel from the Department of Game, Fish and Parks, the Cooperative Wildlife Research Unit, and the Division of Wildlife Services, Bureau of Sport Fisheries and Wildlife.

A resume of the cost of the study during 1965 is presented in Appendix A.

I. PHEASANT POPULATION INDICES

C. G. Trautman and W. L. Tucker

Summer Roadside Survey

The 1964 summer counts constituted the first survey of pheasant populations on each of the four study units tentatively located in July 1964. Three 30-mile routes were established on each area among the four units.

The summer roadside survey technique consists of recording cocks, hens, and broods observed in each mile along routes run from July 20 through August 24. Observations are confined to an area within 200 feet of the road right-of-way. Adult birds are flushed only when necessary to determine if they are with broods. Runs must begin at sunrise and must be completed not later than 2 1/2 hours after sunrise. Car speed is held between 15-20 miles per hour. Routes are run only on mornings when wind and sunshine conditions conform to prescribed standards.

Brood size data are obtained on mornings when routes are run, but only after coverage of the regular route, and on some mornings when adverse weather conditions prevent operating the regular routes. Brood size is recorded whenever it is believed that a complete count of young has been achieved.

One prerequisite for determining satisfactory sites was that pheasant population densities had to be relatively equal in each of the two study areas of a unit. The main purpose of the first roadside survey was to determine whether the initially chosen sites were satisfactory with respect to pheasant numbers.

Results from the summer 1964 survey indicated that the adult bird and brood densities were sufficiently comparable in three of the four units (1, 2, and 4). These were designated as permanent study sites. The large difference in pheasant density between reduction and check areas of Unit 3 required that a new check area location be selected where the population density more nearly matched that of the reduction area. A new 10x10-mile area was investigated in October 1964 and was found satisfactory for the check area of Unit 3 (bird-per-mile averages: check, 4.75 ± 2.28; reduction, 3.88 ± 1.45).

Roadside survey data gathered in the summer of 1964 were analyzed statistically to determine:

1. Reliability of population density means (averages) derived from roadside data, since these means were used as the basis for determining comparability between area pheasant populations within each unit and, thus, governed final choice of permanent study sites.
2. Whether the number of runs required for sufficiently accurate results varied substantially between study areas located in high and low pheasant density range.

For the relatively high pheasant densities occurring in Units 2 and 3, analyses indicated that 36 to 58 and 60 to 78 runs, respectively, were necessary in the summer for providing adult-bird-per-mile and brood-per-mile means which fell within plus or minus 10% of the population mean at the 90% confidence level. The number of runs required was nearly attained for these units.

For the low pheasant densities found in Units 1 and 4, the number of runs required for achieving comparable accuracy ranged from 48 to 104 and from 140 to 272, respectively, for adult-bird and brood-per-mile means. Obviously, the number necessary to estimate within 10% of the mean at the 90% confidence level was prohibitively high. However, means for the study areas in these units could be expected to fall within 20% of the population mean at the 90% confidence level when an aggregate of 60 to 70 runs was obtained per area. Thus, enough runs were obtained to yield sufficient accuracy for testing differences between areas within units.

Data from the 1965 spring roadside surveys were analyzed to determine (1) whether the same accuracy was achieved in the spring survey as in the summer survey, (2) whether variability in the roadside data was essentially constant among years and, if not, (3) the effect of differing variances (when occurring) upon the accuracy of population means obtained in such years.

Adult bird-per-mile averages for the 1965 summer roadside surveys compared with those for 1964 are shown in table 1.

The average summer adult pheasant population index was down 0.63 bird per mile for the reduction areas and 0.75 for the check areas in 1965 from 1964. Largest declines were observed in the high-population areas of Unit 2 and the reduction area of Unit 3. Average difference in decline in adult bird population index from 1964 to 1965 between reduction and check areas was 0.12 bird per mile smaller for the reduction areas. These differences in declines were 0.08 and 0.22 bird per mile greater for the reduction areas of Units 1 and 4, respectively, and 0.66 smaller for the reduction area of Unit 2.

The differences for each of these units are statistically significant (0.01). The exact adult-per-mile level in Unit 3 is not known for 1964. However, if it is assumed the initial counts in the reduction and check areas were identical, the lesser decline in the reduction area from 1964 to 1965 would be significant (0.05).

Brood-per-mile averages for 1965 compared with those for 1964 are shown in table 2.

Brood counts for 1965 were lower than those for 1964 in all areas except the reduction area of Unit 2. Declines were consistently less for the reduction areas where an average decrease of 0.02 brood per mile was noted. Average decline in brood numbers for the check areas was 0.15 brood per mile.

Average difference in decline in brood density from 1964 to 1965 between reduction and check areas was 0.13 brood per mile smaller for the reduction areas. For each unit individually, these differences in declines were 0.01, 0.35, and 0.04 brood per mile smaller for the reduction areas than the check areas of Units 1, 2, and 4, respectively. The differences in Units 2 and 4 are statistically significant (0.01) and (0.05), respectively. The change in Unit 1 is not significant. If it is assumed that the initial counts in the reduction and check areas of Unit 3 were identical, the lesser decline in the reduction area from 1964 to 1965 would be significant (0.01).

Proportion of hens observed with broods in the 1965 survey compared with 1964 is shown in table 3.

Table 1. Pheasant adult-per-mile averages during the summer.

Unit	Area	Average Adults Per Mile 1964	Average Adults Per Mile 1965	Avg. Per-Mile Change (1965 Compared to 1964)	Avg. Per-Mile Dif. in Amount of Change between Areas (Red. Compared to Ck.)
1	Reduction	0.59 (63)*	0.41 (50)*	- 0.18	- 0.08
	Check	0.56 (35)	0.46 (55)	- 0.10	
2	Reduction	2.66 (74)	1.46 (57)	- 1.20	+ 0.66
	Check	3.07 (59)	1.21 (65)	- 1.86	
3	Reduction	4.06 (53)	1.51 (57)	- 2.55	**
	Check	**	1.62 (54)	**	
4	Reduction	1.23 (28)	0.70 (59)	- 0.53	- 0.22
	Check	0.85 (28)	0.54 (57)	- 0.31	
Average of Averages for Reduction Areas of Units 1, 2 & 4		1.49	0.86	- 0.63	+ 0.12
Average of Averages for Check Areas of Units 1, 2 & 4		1.49	0.74	- 0.75	

* Figures in parentheses indicate the number of runs on which averages are based.

** The original check area within Unit 3 was not comparable to the reduction area. Therefore, a new check area was selected in October 1964, but counts in this area in July 1964 are not available for comparison.

The average number of hens with broods for each 100 hens observed in 1965 in relation to 1964 was 23.3 greater for the reduction areas and 3.5 greater for the check areas.

Average difference in the amount of relative increase in hens with broods in the reduction compared to the check areas from 1964 to 1965 was 19.8. For each unit individually, the differences were 15.3, 14.5, and 30.2 hens greater for the reduction areas of Units 1, 2, and 4, respectively, in relation to those noted for the check areas of these units.

Table 2. Pheasant brood-per-mile averages.

Unit	Area	Average Broods Per Mile 1964	1965	Avg. Per-Mile Change (1965 Compared to 1964)	Avg. Per-Mile Dif. in Amount of Change between Areas (Red. Compared to Ck.)
1	Reduction	0.21 (63)*	0.17 (50)*	- 0.04	+ 0.01
	Check	0.15 (35)	0.10 (55)	- 0.05	
2	Reduction	0.75 (74)	0.78 (57)	+ 0.03	+ 0.35
	Check	0.82 (59)	0.50 (65)	- 0.32	
3	Reduction	1.31 (53)	0.97 (57)	- 0.34	**
	Check	**	0.46 (54)	**	
4	Reduction	0.30 (28)	0.24 (59)	- 0.06	+ 0.04
	Check	0.24 (28)	0.14 (57)	- 0.10	
Average of Averages for Reduction Areas of Units 1, 2 & 4		0.42	0.40	- 0.02	+ 0.13
Average of Averages for Check Areas of Units 1, 2 & 4		0.40	0.25	- 0.15	

* See footnote * in Table 1.
** See footnote ** in Table 1.

Brood size data in 1964 and 1965 are shown in table 4.

Average change in brood size between 1964 and 1965 amounted to an increase of 1.99 young per brood for the combined reduction areas and 1.34 for the combined check areas of Units 1 and 2.

Average difference in increase in brood size between reduction and check areas in 1965 was 0.65 bird greater for the reduction areas. The increase was 1.51 birds greater for the reduction than the check area of Unit 1, and, conversely, 0.21 bird smaller for the reduction than the check area of Unit 2. The change in Unit 1 is significant (0.01); that in Unit 2 is not. If it is assumed that the initial counts in the reduction and check areas of Unit 3 were identical, the greater increase in the reduction area from 1964 to 1965 would be significant (0.01).

Table 3. Proportion of pheasant hens observed with broods.

Unit	Area	Hens with Broods per 100 Hens Observed 1964	1965	Avg. Change per 100 Hens (1965 Compared to 1964)	Avg. Dif. per 100 Hens between Areas (Red. Compared to Ck.)
1	Reduction	56.6 (694)*	67.8 (373)*	+ 11.2	+ 15.3
	Check	51.6 (312)	47.5 (360)	- 4.1	
2	Reduction	39.6 (4147)	72.4 (1842)	+ 32.8	+ 14.5
	Check	35.6 (4036)	53.9 (1789)	+ 18.3	
3	Reduction	39.0 (5335)	74.6 (2237)	+ 35.6	**
	Check	**	42.0 (1766)	**	
4	Reduction	44.2 (564)	70.7 (600)	+ 26.5	+ 30.2
	Check	58.4 (351)	54.7 (437)	- 3.7	
Average of Averages for Reduction Areas of Units 1, 2 & 4		46.8	70.1	+ 23.3	+ 19.8
Average of Averages for Check Areas of Units 1, 2 & 4		48.5	52.0	+ 3.5	

* See footnote * in Table 1.
** See footnote ** in Table 1.

Winter Sex Ratios

Pheasant sex ratios were determined for all areas throughout the 1964-65 winter season. Sex-ratio counts were obtained by using two standardized methods: (1) the roadside count, and (2) the flushing count. Main features of each method are:

1. Roadside Count
   The roadside count is used with complete snow coverage in fair weather throughout the morning, late afternoon, and until pheasants have moved to roosting cover in early evening. Roadside counts are conducted as follows:

   a) Birds are observed by cruising along roads at slow speeds from 10 to 20 miles per hour.

Table 4. Average pheasant brood size.

Unit	Area	Average Brood Size 1964	1965	Avg. Change in Number Yg. per Brood (1965 Compared to 1964)	Avg. Dif. in No. Yg. per Brood between Areas (Red. Compared to Ck.)
1	Reduction	6.13	8.42	+ 2.29	+ 1.51
	Check	6.26	7.04	+ 0.78	
2	Reduction	6.37	8.05	+ 1.68	- 0.21
	Check	6.58	8.47	+ 1.89	
3	Reduction	6.20	8.56	+ 2.36	*
	Check	*	6.60	*	
4	Reduction	6.92	7.54	+ 0.62	
	Check	6.86	No Data		
Average of Averages for Reduction Areas of Units 1, 2 & 4		6.25	8.24	+ 1.99	+ 0.65
Average of Averages for Check Areas of Units 1, 2 & 4		6.42	7.76	+ 1.34	

* See footnote ** in Table 1.

b) Counts are made after the vehicle has been stopped.
c) Counts consist of recording all cocks and hens observed individually or in groups within or outside the road right-of-way. Sex identification is facilitated by use of binoculars.
d) An attempted count of a group, or of a part of a group, is discarded if counting has not been completed prior to the disappearance of an appreciable number of the originally exposed birds.
e) Care is taken to sample all sizes of pheasant groups and all parts of each area. Minimum sample size per area consists of counts of at least 50 separate pheasant groups.

2. Flushing Count
The flushing count is used (1) during stormy weather when the storm is of sufficient intensity to concentrate and hold birds within or adjacent to heavy cover, and (2) in fair weather in late morning or early afternoon when

birds have temporarily returned to areas of heavy cover between feeding periods. These counts are conducted as follows:

a) On stormy days the flushing activity is directed primarily towards sampling the denser cover areas. The birds are flushed by walking through the cover area, and the numbers of each sex are counted and recorded. Birds observed within 1/8 mile of the roadway are also flushed and recorded according to sex.
b) In fair weather the flushing activity is extended to all densities of cover deemed capable of concealing birds. In addition, birds sighted in the open within 1/8 mile of the roadway are also flushed and recorded according to sex.
c) Accuracy of flushing counts is generally improved with the help of an assistant to flush or drive the birds past an experienced observer. Use of an assistant is left to the discretion of the person in charge. As with the roadside count, complete snow cover is a prerequisite.

Sex ratios for the winter of 1964-65 are shown in table 5.

Table 5. Pheasant sex ratios, winter 1964-65.

Unit	Area	Cocks	Hens	Total	Sex Ratio (Cocks per 100 Hens)	Number Pheasant Groups Represented
1	Reduction	196	825	1021	23.8	50 plus
	Check	135	596	731	22.6	50 plus
2	Reduction	412	1580	1992	26.1	70
	Check	406	1878	2284	21.6	60
3	Reduction	201	1241	1442	16.2	50 plus
	Check	523	2016	2539	25.9	113
4	Reduction	119	270	389	44.1	37
	Check	129	316	445	40.8	33
Total of All Reduction Areas		928	3916	4844	27.6*	207 plus
Total of All Check Areas		1193	4806	5999	27.7*	256 plus

* Average of averages.

The 1964-65 sex ratios were similar between the reduction and check areas of each unit and among Units 1, 2, and 3. The sex ratios in Unit 4 were markedly higher. The average sex ratio was 27.6 cocks per 100 hens in all reduction areas and 27.7 in all check areas.

Winter Aerial Survey

Aerial counts are used for gathering information on the following: (1) populations on a given area, (2) storm loss by counts of dead and live birds, and (3) natural mortality occurring between aerial counts obtained early and late in winter. Aerial censusing of pheasants is feasible when birds are clearly visible due to (1) complete snow cover, (2) sufficient accumulation of snow in heavy cover to force birds above concealing vegetation, and (3) bunching of birds. When these conditions materialize, accurate censusing of pheasants is possible by systematic aerial reconnaissance of all woody and heavy herbaceous vegetation cover areas.

Because of generally poor snow cover throughout the winter of 1964-65, aerial counts of pheasants were possible on only the reduction area in Unit 1. Results from this census, made on January 19, 1965, indicate 25 birds per square mile.

None of the pheasant populations were subjected to severe blizzards; hence, no storm mortality checks were made.

Spring Roadside Survey

The roadside survey used for the spring is identical to that used for the summer except that observations are confined to an area extending 400 feet outwards from each side of the road right-of-way and birds are not flushed.

The May 1965 survey was the initial spring roadside survey conducted on the areas. Consequently, no data from preceding years are available for comparison. Bird-per-mile averages from the spring survey are shown in table 6.

Table 6. Pheasant-per-mile averages, spring 1965.

Unit	Area	Number Runs	Average Birds per Mile
1	Reduction	44	1.10
	Check	35	1.03
2	Reduction	32	4.74
	Check	35	4.98
3	Reduction	43	7.22
	Check	52	5.39
4	Reduction	38	2.44
	Check	28	1.94
Average of Averages for All Reduction Areas			3.88
Average of Averages for All Check Areas			3.34

The bird-per-mile averages for all reduction and check areas were 3.88 and 3.34, respectively. The spring adult-per-mile averages indicate no significant differences in Unit 1 where birds were more numerous in the reduction than in the check area and in Unit 2 where the reverse was true. Units 3 and 4 showed significantly more (0.01) birds per mile in the reduction than in the check areas.

II. FOX - PREY RELATIONSHIPS

P. F. Springer, R. L. Drieslein and W. L. Tucker

Fox Populations and Control

An index to populations of red foxes prior to starting the reduction program was obtained by aerial transect counts of fox tracks in the snow and of foxes. These counts were made under the following conditions: (1) snowfall of sufficient depth to show fox tracks, (2) count made in both the reduction and check area of a unit on the day following a night after termination of a snowfall or after blowing snow covered old tracks (8-32 hours after beginning of suitable tracking conditions), and (3) absence of wind sufficient to cover tracks between beginning of suitable tracking conditions and termination of counts in a unit. Flights were made along the east-west mid-section lines of each area in a plane travelling at 65-90 mph at an elevation of 50-75 feet. Counts were made of fox tracks crossing the mid-section line and of foxes seen within 1/10 mile on each side of the plane.

Three 100-mile flights were made over all the reduction and check areas between December 4, 1964, and January 21, 1965. However, intensive fox hunting by private individuals before the third flight over the reduction area in Unit 1 made it necessary to base the pre-reduction figures for this area on the results of the first two flights only. Also, a wind storm during the third count in Unit 3 invalidated part of the fox track counts in the reduction area and all of the track counts in the check area for this flight. Usable counts of fox tracks and foxes are shown in table 7.

Table 7. Aerial counts of fox tracks and foxes, winter 1964-65.

Unit	Area	Number Flights	Avg. No. Tracks per Transect Mile	Avg. No. Foxes Seen per Area
1	Reduction	2	9.84	16.5
	Check	3	8.45	10.7
2	Reduction	3	3.23	14.7
	Check	3	3.32	20.3
3	Reduction	2.6	5.42	11.3
	Check	2	5.06	9.7
4	Reduction	3	2.41	5.0
	Check	3	2.85	12.3
Average of Averages for All Units		Reduction	5.25	11.9
		Check	4.92	13.2

Fox track counts in reduction and check areas within each unit showed that these indices to fox activity varied less than 10% from the overall unit average and thus were sufficiently comparable in each pair of areas prior to initiation of reduction. Counts in each reduction and check area were not made simultaneously. For this reason the differences in numbers of foxes observed within a unit are not considered important because fox activity varies with time of day and with weather. These factors plus differences in habitat conditions and human disturbance could account for the different ratios of tracks to foxes in different areas.

After termination of the track and fox counts in January 1965, foxes were killed in the reduction areas. Methods and devices used included strychnine-treated drop baits placed around draw stations, "coyote getters," and shooting from an airplane. The first two were discontinued when other predators such as raccoons, striped skunks, and badgers became more active with the onset of milder weather in mid-March 1965. Animals recovered in the reduction area of each unit, principally at the draw stations, are shown in table 8.

Table 8. Animals recovered in study areas, January - March 1965.

Unit	Area	Red Fox	Striped Skunk	Raccoon	Badger	Coyote
1	Reduction	98	10	1	3	
	Check	4				
2	Reduction	50	17	3	1	
	Check					
3	Reduction	37	21	3	1	
	Check					
4	Reduction	49*	19	4	3	
	Check	20				9

* Numbers based on preliminary reports.
** Includes one gray fox.
*** Animals killed in coyote control program starting in late October 1964.

Results show that the prescribed methods for reducing fox populations also killed a number of other predators. Removal of these nest-robbing predators should be considered in the final evaluation of the data. Unfortunately, a large number of foxes were killed in the check area of Unit 4 at poison draw stations put out to eliminate coyotes. The numbers of all predators in the preceding table represent only those animals which were recovered from the respective units by cooperating personnel and thus are an unknown portion of all animals killed. Private fox hunters and bounty claimers were active in all areas. Also, some foxes that were killed either wandered too far to be found or were concealed under snow. For these reasons a valid ratio of tracks-to-foxes recovered could not be obtained for use in estimating fox numbers from track counts.

Results of the aerial count of active fox dens in each of the units during the period from May 13-20, 1965, are shown in table 9.

Table 9. Aerial count of active fox dens, May 1965.

Unit	Reduction Area	Check Area
1	3	7
2	1	13
3	6	24
4	1	48

Winter track counts showed fox populations in the reduction areas and in the corresponding check areas were similar prior to reduction operations. If fox movement in and out of these study areas in each unit was also similar, the number of active dens in the reduction areas compared to the number in the check areas should reflect the degree of fox control achieved. There was an inverse relationship between the number of foxes in each reduction area (as measured by the track counts) and the degree of control apparently obtained. However, dens in the check areas were not subsequently inspected from the ground as were those in the reduction areas. Thus, it is possible that not all dens observed in the check areas were active fox dens.

Most dens were located in the denser cover types as shown in table 10.

Results of spring den counts and winter track counts in the check areas of each unit are shown in table 11.

Since no control was to be undertaken in these areas except on a complaint basis, it was hoped that the relationship of dens to tracks would be fairly consistent, thereby providing a standard conversion factor which could be used to estimate the total foxes in an area. Because of the inconsistency shown, the use of factors is not feasible at this time.

Whenever possible, the airplane crew shot adult foxes associated with dens during the May 1965 den counts in the reduction areas. Two ground crews used either a commercial liquid insect larvicide containing chloropicrin or smoke cartridges to gas adults and young in their dens or to drive them out where they could be killed. If animals could not be gassed out, poisoned eggs were sometimes placed in the dens. Also, if both adults were not taken at a den, steel traps were set to capture animals when they returned. Animals killed are shown in table 12.

Additional foxes and other predators were killed between June and December 1965, but complete figures have not yet been obtained.

Table 10. Cover types of fox den locations, spring 1965.

Unit	Area	Soil Bank	Alfalfa	Pasture	Small Grain Stubble
1	Reduction	3			
	Check	5		2	
2	Reduction	1			
	Check	5	3	3	2
3	Reduction	1	1	3	1
	Check	7	6	8	3
4	Reduction		1		
	Check	21	20	5	2
All Units		43	31	21	8

Table 11. Fox den and track counts in check areas.

Unit	Number Dens (May 1965)	Avg. No. Tracks per Transect Mile (Dec. 1964-Jan. 1965)
1	7	8.45
2	13	3.32
3	24	5.06
4	48	2.85

Small Mammal Populations

A snap-trap survey of small mammals was conducted by Cooperative Wildlife Research Unit personnel in all areas to establish (1) indices of abundance useful in interpreting fox food habits, (2) the extent to which these animals might buffer the impact of fox predation on pheasants, and (3) the extent to which the populations of small mammals might be "released" by reduction of fox predation. A total of 288 mouse-size snap traps were set 50 feet apart for a period of 4 days and nights in each reduction area and in each check area of a unit and

Table 12. Foxes killed in reduction areas, May 1965.

Unit	Number Active Dens Located	No. Foxes Taken from Dens		No. Estimated Foxes Killed in Dens		Total Foxes Killed
		Adults	Pups	Adults	Pups	
1	3	3	7	-	5	15
2	1	1	6	-	-	7
3	6	3	13	-	3	19
4	1*	-	-	-	-	-

* Landowner would not allow foxes to be killed.

tended daily. The four units were sampled separately between June 15 and July 22, 1965. Six sections of land were selected randomly for sampling from the inner 36 sections of each area. Two of the four corners of a given section were then selected randomly, and a line of 24 traps was established in the first homogeneous stretch of fencerow cover encountered adjacent to the major habitat types occurring in each area. Results of the trapping are shown in table 13.

The prairie deer mouse was the most common small mammal trapped. Populations were similar in the reduction and check areas in Units 3 and 4 but unequal in these areas in Units 1 and 2. Meadow voles were scarce in spite of substantial amounts of grass cover. The Richardson ground squirrel was found in Units 1, 2, and 3, but none were taken in the traps.

A survey of meadow vole droppings and cuttings in all areas was conducted by Cooperative Wildlife Research Unit personnel between October 30 and November 21, 1965. Six sections of land were selected randomly for sampling from the inner 36 sections of each area. Ten plots, 0.1 of a meter square in size, were laid out within permanent fencerow cover adjacent to the major cover types in each area. These were the first 10 plots that were encountered after proceeding from a randomly selected starting point and that met prespecified cover characteristics. Sign of meadow voles (runways, droppings and cuttings) was recorded. Only fresh sign was evaluated in the survey. An overall rating was then assigned to each of the 60 sample plots in an area, based on the intensity of recent sign if present. Ratings were assigned according to the following scheme:

Rating	Description
1	Indistinct runway system, few droppings, no cuttings.
2	Well-developed runway system, moderate accumulation of droppings, cuttings present.
3	Well-developed runway system, heavy accumulation of droppings, cuttings present.

Table 13. Small mammals trapped in study areas and their frequency in fox stomachs analyzed.

Species	Unit*									
	1		2		3		4			Rank by
	Red.	Ck.	Red.	Ck.	Red.	Ck.	Red.	Ck.	Total	Frequency in Stomachs
Prairie deer mouse	16	38	50	12	69	54	93	99	431	1
Meadow vole	7	1	2	1	**	--	5	2	18	2
Masked shrew	1	--	4	3	4	1	1	2	16	3
House mouse	1	1	--	1	1	--	3	4	11	4
Grasshopper mouse	--	1	1	2	--	1	--	6	11	4
Meadow jumping mouse	--	--	--	5	--	3	--	2	10	6
Western harvest mouse	--	--	--	--	**	--	--	2	2	7
Plains pocket mouse	--	--	--	--	--	1	--	--	1	8
Short-tail shrew	--	--	--	--	--	--	1	--	1	8
Thirteen-lined ground squirrel	12	1	3	9	6	1	4	4	40	
Total (exclusive of ground squirrel)***	25	41	57	24	74	60	103	117	501	

* Trapping periods: Unit 1 - July 13 to 16, Unit 2 - July 19 to 22, Unit 3 - June 15 to 18, Unit 4 - June 22 to 25, 1965.

** Seen or collected by other means during the survey; figures not included.

*** Since mouse-size snap-traps were used, the survey was not considered representative for ground squirrels. In many cases these animals dragged away the traps or escaped outright.

Results of this survey are shown in table 14.

Since the survey of sign was made in the fall and the snap-trap survey in the previous summer, they are not directly comparable. Also, the small number of voles taken in the snap-trap samples makes comparison difficult. The surveys do agree in showing that Unit 3 had the lowest population of meadow voles. The relative rank of the other three units varies in the two surveys.

Table 14. Meadow vole sign ratings, fall 1965.

Unit	Area	Number Plots with sign	Avg. No. Droppings per Plot	Overall Rating Based on Freq. and Intensity of Sign
1	Reduction	7	0.67	9
	Check	14	1.37	20
	Average	10.5	1.02	14.5
2	Reduction	14	3.73	23
	Check	12	1.93	15
	Average	13.0	2.83	19.0
3	Reduction	2	No Data	3
	Check	6	No Data	9
	Average	4.0		6.0
4	Reduction	20	2.05	29
	Check	17	1.52	20
	Average	18.5	1.78	24.5

Rabbit Populations

Counts of rabbits were made in 1965 from automobiles on 50-mile routes in all areas to provide a basis for interpretation of (1) fox food habits, (2) the extent that rabbits might buffer the impact of fox predation on pheasants, and (3) the extent to which the populations of rabbits might be "released" by reduction of fox predation. The work was conducted following preliminary surveys in January 1965 by Cooperative Wildlife Research Unit personnel in Unit 3. Counts were started one-half hour after sunset on nights when the moon had risen and was one-half full to full. Two spotlights operated by two observers were used in the counts during January 9-10 and October 8-14, whereas one spot-light and observer were generally used in the counts during March 12-15. These spotlights had an effective range of 150 feet. Average number of rabbits seen per count are shown in table 15.

Counts were not made prior to the initiation of fox reduction except in Unit 3. Also, counts were limited in number,and the March survey was made with one spot-light during a period when rabbit movement was restricted by water standing in fields and along roadsides. However, the figures are useful in showing general indices of abundance and serving as a base for ascertaining future increases or decreases. Rabbit populations were highest in Unit 3. Lowest counts were in Unit 2 and the check area of Unit 4.

Fox Food Habits

Stomachs of foxes collected in the study areas from July 1964 to August 1965 were examined for food remains. Most animals were taken from the

Table 15. Average number of rabbits seen on spotlight counts.

			Area			
			Reduction		Check	
Unit	Dates (1965)	Number of Counts	Jackrabbit*	Cottontail	Jackrabbit*	Cottontail
1	Mar. 15	1	10	2	7	1
	Oct. 8, 14	2	10.5	0	10	0.5
2	Mar. 12, 15	2	3.5	2	3.5	1
	Oct. 8, 11, 13	3	13	2.7	4	4.3
3	Jan. 9, 10	2	25	21	25.5	3.5
	Mar. 14, 15	2	10	21.5	6	3
	Oct. 8, 11, 12	3	44.7	11	22.3	3.3
4	Mar. 15	1	7	5	1	2
	Oct. 8, 9	2	34.5	2	3	0

* Whitetail jackrabbit.

reduction areas, particularly during January, February, and March 1965. These foxes were nearly a year old or older. In addition, pups and adults were taken at dens in the reduction areas in May and June 1965.

A total of 162 stomachs containing food were examined from the four study units. Of these, 142 were from the reduction areas and 20 from the check areas. Results of stomach analyses are given in table 16. Sample size is not sufficient at present to permit a breakdown by seasons. However, because of the substantial number of foxes taken in the four reduction areas from January to June 1965 in relation to those available, a comparison can be made among the data from these areas. Since relatively few foxes were taken in or near the check areas and since their stomach contents were similar to those in the reduction areas, they are included in the analyses.

When consideration is given to broad groups of food items, the majority of the stomach contents from the four units contained plants, mammals, birds and insects, in descending order of occurrence.

Plants were found in 82% of the stomachs but composed only 2% of the volume. This plant material consisted mostly of grasses occurring with mice and insects. Corn and small grains were frequently found in stomachs containing pheasant or chicken remains. A few stomach contents consisted wholly of corn.

Among the mammalian food, mice (particularly prairie deer mice) as a group were taken most commonly in all units. Snap-trapping results indicated that this species was the most abundant small mammal (table 13). Meadow voles were scarce in fox stomachs, and few were taken in the trap samples. Rabbits (both jackrabbit and cottontail) were found in about one-fourth of the stomachs. The highest occurrence (37%) was from Unit 3, and spotlight surveys showed rabbits to be most common in this unit (table 15). Ground squirrels were the only common small mammals not heavily preyed upon by foxes. Stomachs containing remains of livestock were from foxes taken at draw stations baited with those items, except for one stomach which contained pig.

Birds were found in 72% of the stomachs. Ring-necked pheasant was the principal species involved. Chicken occurred most frequently in stomachs collected in Unit 4. Poultry production is concentrated in that part of the state where Unit 4 is located.

Of the insect remains, grasshoppers occurred most frequently. Most of the insects were in stomachs of pups taken at dens.

Overall, grasses, mice, pheasants, rabbits and insects, in descending order, were the items occurring most frequently in fox stomachs taken in the study areas from January to June 1965. From a volumetric standpoint, pheasants, rabbits and mice, in descending order, were the items occurring in largest quantity.

Table 16. Fox stomach analyses, January-June 1965.

Food Item	Unit 1 (43-7)* Freq.**	Unit 1 Vol.***	Unit 2 (38-8) Freq.	Unit 2 Vol.	Unit 3 (33-5) Freq.	Unit 3 Vol.	Unit 4 (28-0) Freq.	Unit 4 Vol.	Combined Data (142-20) Freq.	Combined Data Vol.
	Areas and Sample Size									
MAMMALS	88	62	77	34	76	53	79	56	80	52
Mice	58	11	39	10	42	16	64	32	50	13
Prairie deer mouse	44	8	28	8	32	11	54	26	38	10
Meadow vole	6	2	2	1	18	5	7	1	8	2
Other mice	14	1	9	1	3		14	5	10	1
Rabbits	18	25	17	12	37	32	25	13	23	22
Whitetail jackrabbit	12	20	11	5	8	9	7	6	10	12
Cottontail	4	5	4	7	8	15	18	7	7	8
Unidentified	2		2		21	8			6	2
Shrews	8		7		5		11		7	
Ground squirrels	8	5							2	2
Livestock (cow, pig, and sheep)	22	11	24	9	5		18	4	18	8
Other mammals	30	10	20	3	16	5	29	7	23	7
BIRDS	70	31	78	61	82	43	54	30	72	42
Ring-necked pheasant	40	27	65	59	47	38	36	12	48	37
Songbirds	6	3	9	1	5		18	9	8	2
Chicken	4	1	2	1	5	4	14	9	6	2
Other birds	20		13		29	1	11		19	1

Table 16. (continued)

	Areas and Sample Size									
	Unit 1 (43-7)*		Unit 2 (38-8)		Unit 3 (33-5)		Unit 4 (28-0)		Combined Data (142-20)	
Food Item	Freq.**	Vol.***	Freq.	Vol.	Freq.	Vol.	Freq.	Vol.	Freq.	Vol.
UNIDENTIFIED VERTEBRATES	4	2	7	2	5	1	21	6	7	2
INSECTS	32		11		18		11		19	
Grasshoppers	24		9		11		11		14	
Other insects	9		2		18				7	
PLANTS	82	2	78		87	2	82	6	82	2
Grasses	62		61		71	1	64	1	64	1
Corn	14	2	7		13	1	21	5	12	1
Other plants	22		19		13		14		17	
UNIDENTIFIED	28	3	22	3	21	1	29	1	22	2

* First figure in parentheses indicates the number of animals from the reduction areas; the second figure, the number near or from the check areas.

** Percent frequency of occurrence (rounded to nearest whole number).

*** Average percent by volume (rounded to nearest whole number).

Appendix A. Funding of Fox-Pheasant Relationship Study,

January 1, 1965 - December 31, 1965.

South Dakota Department of Game, Fish and Parks		
Plane and Pilot	$ 988.00	
Rabbit Counts (Enforcement Div.)	$ 984.00	
Fox Counts (Div. of Wildlife Services)	$ 2,600.00	
Fox Control (Div. of Wildlife Services)	$15,000.00	
Cooperative Wildlife Research Unit (Salaries and Expenses)	$ 3,190.29	
Pheasant Counts	$ 6,001.72	
Game Research Division (Salaries and Expenses)	$ 2,686.39	
Misc. (Coordination, Computor, Aerial, Clerical)	$ 720.68	
		$32,171.08 81.9%
U. S. Bureau of Sport Fisheries and Wildlife		
Cooperative Wildlife Research Unit (Salaries and Expenses)	$ 2,650.00	
Fox Control (Div. of Wildlife Services)	$ 2,000.00	
		$ 4,650.00 11.8%
South Dakota State University		
Advisory and Supervisory Services	$ 670.00	
Statistical Services	$ 1,695.00	
		$ 2,365.00 6.0%
Wildlife Management Institute		
Buffer Species Studies	$ 112.29	
		$ 112.29 0.3%
	Total	$39,298.37 100.0%