1973

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Acknowledgements

Studies on the life history and ecology of the ring-necked pheasant in Nebraska were initiated under the direction of J. Henry Sather in 1954. Since that time, many individuals have been directly connected with the project and have made significant contributions to the data presented in this publication. C. Phillip Agee and the late Max Hamilton initiated the field studies in Clay and Fillmore counties. Raymond Linder, Jim Norman, and David L. Lyon followed with field responsibilities into 1960. Carl W. Wolfe and Raymond D. Evans completed the field portion of the study in 1965 and were responsible for the major portion of data analysis and interpretation. During the entire study period, Commission Director M. O. Steen (retired) provided support and assistance. Major contributions to this report through lengthy and stimulating critical advice have been provided by C. Phillip Agee, now chief of Research, Federal Aid, U.S. Bureau of Sport Fisheries and Wildlife. Earl R. Kendle, chief, Research Division and other personnel of the Game and Research divisions have given generously of their time, assistance, and advice. The authors gratefully acknowledge these many contributors.

The authors extend particular appreciation to the following staff members of the Information and Education Division for their assistance: Elizabeth Huff for editorial help, Michele Angle for layout, Bud Pritchard for art work, and to Jon Farrar and Greg Beaumont for their assistance in securing appropriate photographic material.

This research was supported with funds supplied by the Federal Aid to Wildlife Restoration Act, under Pittman-Robertson projects W-28-R and W-38-R, and by the Nebraska Game and Parks Commission.

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Contents

1. The Study

From the time of its initial stocking in 1915, the ring-necked pheasant, *Phasianus colchicus,* has been the focus of various surveys by personnel of the Game and Parks Commission to follow populations, reproductive success and annual harvest in Nebraska. While each of these field efforts provided some understanding of the pheasant, little basic information was available on the life history and ecological requirements of the bird.

As significant land use changes became apparent in the early 1950's, it appeared necessary to expand our knowledge of pheasant biology to assemble facts necessary for proper management of what had become the top upland game bird of the state.

South-central Nebraska offered what was considered ideal pheasant range at the inception of these studies. A prime agricultural region, this area also contained unique shallow water areas known as rainwater basins and was one of the most productive harvest areas in the state. The combination of habitat types seemed to provide all the requirements for the ring-necked pheasant. Early in the study period, it became evident that the three, nine-section study areas established in Clay and Fillmore counties were very different from each other in basic habitat and in numbers of pheasants. Therefore greater emphasis was placed on the Clay County areas in order to gather more meaningful data. Focus shifted to the Harvard and Clay Center study areas in 1958. The work continued on each through 1964 and provides the base sources for the data and interpretations found in this report. Relationships derived from data tabulations made during 1965-68 provided the basis for many of our findings. As in any study of this length, much information has necessarily been excluded because of time and space limitations.

Objectives of this study have, in our opinion, been fulfilled. The basic information obtained over the 10-year period will allow scientifically based management decisions to be made for enhancement of ringneck populations. However, the problem of translating management practices to private lands, which make up the bulk of pheasant range in Nebraska, will continue to be a stumbling block in maintaining pheasant numbers. The study areas vividly demonstrated the effects of land-use change on pheasant numbers. The importance of nesting habitat, however small, to chick production was dramatically established again and again. Over the years, agricultural technology has increased, resulting in more intense land use, and a corresponding decrease has been noted in pheasant numbers. The adaptable pheasant will continue to exist in the agricultural regions of the state, but probably never at levels recorded in the past.

LOCATION

Field studies were conducted on three areas in Clay and Fillmore counties of Nebraska (Appendix Figure 1). One study area of 7 square miles was located 0.5 miles east and 0.5 miles north of Harvard. Another study area of 9 square miles was located 5 miles east and 3 miles south of Clay Center. The third area was located 0.5 mile south of Fairmont.

TOPOGRAPHY

Clay County (average elevation 1,750 feet) is in the southeastern part of the Loess Plains region of Nebraska. The general topography of the county is that of an almost level southward and eastward sloping plain. A large part of the county is upland, and the remainder is alluvial land or terraces and flood plains along streams. The uplands, characteristic of the Harvard and Clay Center study areas, are flat or gently undulating but are locally modified by shallow rainbasins (Roberts and Gemmell, 1927).

Fillmore County (elevation 1,500-1,700 feet) adjoining Clay County on the east is also characterized as a loess-covered extensive plain sloping toward the southeast, with the original constructional surface slightly modified by stream erosion. The topography ranges from almost flat to slightly undulating, the only relief being that afforded by stream valleys (Meyer et *al.*, 1918).

SOIL

Soil types in Clay County are mainly silt loams belonging to the Crete-Hastings series, with Butler, Fillmore and Scott silt loams occurring in depressions and basin areas. Soil tests taken in Clay County show pH values ranging from 5.4 to 8.4 (Roberts and Gemmell, *op. cit.*). Calcium levels are considered adequate for all crops except alfalfa on the most acid sites.

The main soil type in Fillmore County is Grundy silt loam, with soil of the Scott series occurring in upland depressions and soils of the Waukesa series occurring on terraces along a few of the larger streams (Meyer *et al, op. cit.*).

South-central Nebraska is characterized by long, moderately hot summers, with numerous short periods of rainy weather, and cold dry winters. (Roberts and Gemmell *op. cit.*). As shown in Table 1, Clay and Fillmore counties have very similar climates.

Table 1. Annual mean temperature, precipitation, relative humidity and average growing season for Clay and Fillmore counties.[1]

	Clay	Fillmore
Annual mean temperature (°F)	50.4	50.8
Annual mean precipitation (inches)	27.90	29.77
Average annual relative humidity (%)	—	70
Average growing season (days)	155	150

[1]Data from USDA Soil Surveys

LAND USE PATTERNS

Agriculture on the study areas is devoted to diversified crop and livestock production. Approximately 93 percent of the total land area was intensively cultivated or grazed (Table 2). Of the total acreage, row crops (corn and grain sorghum) occupied about 42 percent, wheat 23 percent, alfalfa 4 percent, and pasture and hay 10 percent. There was little change in land use patterns from year to year. Short term changes were caused primarily by precipitation.

Roadsides, fencerows, and waste or unused areas occupied less than 5 percent of the total land area, but they provided virtually the only suitable cover in severe winter weather. Roadside widths ranged from 5 to 30 feet and averaged 20 feet. Fencerows ranged in width from zero to eight feet, averaging only three to four feet. Waste or unused areas included rainwater basins, abandoned farmsteads, and railroad rights-of-way.

Deep-well irrigation was utilized for supplemental watering of corn, grain sorghum, and alfalfa on the study areas. Corn and sorghum comprised more than 90 percent of the total acres irrigated (Linder *et al.*, 1960). Facilities for irrigation increased during the course of the study. Two types of irrigation systems were used — furrow flooding by pipe or siphon tube and sprinkling.

Table 2. General land use of study areas, 1954-1964

Cover	**Clay Center**[1]		**Harvard**[1]		**Fairmont**[2]		Total	
	Acres	**% Total**	**Acres**	**% Total**	**Acres**	**% Total**	**Acres**	**% of Total**
Corn	847.1	14.6	1176.9	21.6	1531.0	29.1	3555.0	21.7
Grain Sorghum	1423.6	25.3	1009.1	18.6	942.8	17.8	3375.5	20.6
Green Wheat	1270.4	22.6	1477.9	27.2	1086.5	20.4	3834.8	23.4
Wheat Stubble	600.9	10.7	671.8	12.4	368.7	6.9	1641.4	10.0
Fallow	150.3	2.7	169.0	3.1	202.4	3.7	521.7	3.2
Alfalfa	150.7	2.7	177.9	3.3	297.3	5.6	625.9	3.8
Pasture & Hay	565.5	10.1	545.2	10.0	523.0	9.8	1633.7	10.0
Soybeans	8.2	0.2	2.2	Tr.	9.5	0.2	19.9	0.1
Oat Stubble	10.5	0.2	20.4	0.4	65.1	1.2	96.0	0.6
Sweet Clover	2.3	Tr.	—	—	0.4	Tr.	2.7	Tr.
Seed Grass	—	—	2.5	Tr.	0.5	Tr.	3.0	Tr.
Barley Stubble	—	—	1.6	Tr.	—	—	1.6	Tr.
Sugar Beets	—	—	4.2	Tr.	—	—	4.2	Tr.
Unused	252.3	4.5	51.5	0.9	91.6	1.7	395.4	2.4
Fencerows	6.6	0.1	8.8	1.6	19.2[3]	0.3	34.6	0.2
Roadsides	65.7	1.2	57.2	1.1	82.7[3]	0.6	205.6	1.3
Farmsteads	54.8	1.0	41.1	0.8	72.1	1.1	168.0	1.0
Water	238.4	4.2	10.6	0.2	—	—	249.0	1.5
% of Land Cultivated or grazed		89.0		95.4		96.9		93.6

[1]Land use based on 10-year mean values
[2]Land use based on 7-year mean values
[3]Abandoned railroad rights-of-way were placed in both of these classifications depending on land use in the bordering fields.

An aerial view of the Clay Center study area shows the general land-use pattern with variety of cover types on random areas. This portion of the overall study included nine square miles of which an average of 89 percent was cultivated or grazed during the 10 years from 1954-1964.

2. Population Studies

One of the areas of pheasant concentration during the winter was this weedy fencerow adjacent to a grain sorghum field. During the study, these concentrations were censused from the air, and from the ground by observation and by flushing the birds.

Winter and spring pheasant populations lend themselves to techniques of census since vegetation is minimal and the behavior of the bird is more predictable. Thus, these census periods were an essential component of our research studies. Several types of surveys were utilized during this study to estimate numbers, composition, and trends of pheasant populations in south-central Nebraska. Discussion here focuses on census techniques utilized during late winter and spring to estimate breeding populations.

Methods

Winter and spring populations on the three study areas were inventoried via four techniques: (1) aerial counts when weather and ground conditions were suitable, (2) ground counts, (3) roadside counts, and (4) crowing cock counts.

Aerial counts were conducted each year during late January and early February, when severe weather conditions forced the birds into protective cover. Weather conditions were considered suitable when there were three or more inches of snow cover on the ground and low temperatures prevailed for several days prior to the count. Under these weather conditions, it was felt to be necessary to check only concentration areas—that is areas of woody cover, weedy fencerows, roadsides, and other areas having dense weedy cover. All flights were conducted in a high-wing, single-engine airplane contracted from local commercial sources. When conditions permitted, the plane was landed as close as possible to concentration areas, and birds were counted as they flushed.

Flushing counts conducted on foot were used to supplement aerial counts, especially for those flocks which the aerial observer felt were not counted accurately. These counts were also used to determine winter sex ratios.

From 1954 through 1961, later winter and spring roadside counts were conducted to provide information regarding sex ratios on the areas. Roadside counts were made in conformance with procedures used in making a statewide survey of this type. Nebraska's statewide procedures were patterned after those used in Iowa and Pennsylvania (Bennett and Hendrickson, 1938; Randall and Bennet, 1939). Data collected on these surveys were used to provide supplementary sex ratio information. The roadside census was begun on April 1 each year from 1961 through 1964 and run through mid-May. Nebraska data from earlier studies indicated that winter concentrations had all disbanded by this time (Mohler, 1959). We felt this technique gave a reliable index on the sex composition of pheasant populations.

Two types of crowing cock counts were conducted during the course of this study. During the first six years routes were set up and run in a manner similar to that first described by Kimball (1949). Data from this census were used to supplement population estimates based on aerial and flushing counts.

During the last five years of the study, 1961 through 1965 inclusive, modification of the crowing count provided estimates of spring breeding populations. Crowing cocks were located by a triangulation technique (Graham, 1940; Robertson, 1958). Data thus obtained were then used in conjunction with sex ratio data to estimate the total spring population.

SAMPLING PROBLEMS

A major problem encountered during the course of the study was the periodic change in personnel assigned to the project. Personnel changes led to changes in techniques and shifting emphasis on various phases of the study. Prior to 1962, spring population estimates were based on aerial and ground counts conducted in late winter. From 1962 on, they were based on triangulation audio censuses and sex ratio data in conjunction with winter counts. Therefore, valid comparisons of populations during the two periods was not possible.

It must be realized that there are variables which could affect each type of census employed in this study.

AERIAL AND GROUND COUNTS

Population estimates based on aerial and ground flushing counts rely on the tendency of pheasants to concentrate in heavy cover during periods of adverse winter weather. Nebraska data from 1943-44 indicated that during the most severe weather all of the hens and a very high percentage of the cocks congregated in sheltered areas (Mohler, 1959; Kimball et *al.*, 1956) observed similar characteristics during aerial census, stating "The outstanding feature of the aerial census is that it is a total count of birds on a given area rather than an index."

Primary problem with basing population estimates on this type of census is that it makes no allowance for differential behavior patterns of the sexes. The tendency of hens to concentrate in large flocks in winter, while cocks tend to segregate in smaller groups and as individuals, is well documented for a major portion of the midwest pheasant range (Wight, 1945; Shick, 1952; Stockes, 1954; Wagner et *al.*, 1965). Therefore, cocks are more likely to go unnoticed in this type of census, and estimates of population numbers and sex ratios based on this technique could be biased toward hens.

Another behavioral difference between the sexes tends to bias supplemental ground flushing counts toward the hen segment of the population. Cocks tend to run and hide, while hens are more prone to flush when approached (Leedy and Hicks, 1945; Wagner et *al.*, 1965).

ROADSIDE COUNTS

The roadside count as a method for censusing pheasant populations and problems associated with this technique have been discussed in detail by Bennett and Hendrickson (1938), Randall and Bennett (1939), McClure (1945), Stiles and Hendrickson (1946), Fisher, Hiatt and Bergeson (1947), Kozicky (1952), and others. There is no universal agreement as to how, when, or even if this technique should be employed. Bennett and Hendrickson (1938), Randall and Bennett (1939), Stiles and Hendrickson (1946), and Kozicky (1952) concluded that the roadside count was a valuable or promising tool for measuring pheasant population. McClure (1945) stated, "Roadside counts are best used in the autumn as an indication of the post-breeding population." Fisher, Hiatt, and Bergeson (1947) concluded that "The variability in results secured by the roadside census technique as employed for pheasants is sufficiently great to make conclusions drawn therefrom unreliable."

Kimball (1949) noted that one particular variable factor is believed to have introduced the greatest error into all types of roadside surveys. That is the failure to conduct the surveys at exactly the same point in the reproductive cycle of the pheasant each year.

We agree with Kimball that the yearly chronology of pheasant nesting has an important influence on results of the roadside census. Therefore, it is important to conduct the survey after the breakup of winter concentrations and before the onset of nesting to obtain an accurate index to the relative composition of sexes in the population.

Roadside counts were our primary source of spring sex ratio data. We felt that this census provided a reliable index to spring sex composition of pheasant populations on the study areas.

CROWING COUNTS

Audio-indices have been used by wildlife workers primarily to census populations such as mourning doves, ring-neck pheasants, bobwhite quail and ruffed grouse in two ways: (1) as an index to changes in population density and (2) as an estimate of total population when corrected with sex ratio data.

Kimball (1949) found that the accuracy of the crowing count and the success with which it can be used depend largely on several factors: (1) variation in the ability of the individuals conducting the survey to hear cock calls; (2) daily trend and duration of maximum cock crowing; (3) seasonal trend and duration of maximum cock crowing; (4) uniformity of results, and (5) effect of variable factors, such as weather and cover, upon the count.

We would suggest that cock behavior is another variable which may be a source of error in the crowing cock census. Since this census is based on the number of male birds crowing, no allowance is made for that segment of the male population which does not crow. However, we observed males which did not crow, and they were included in population estimates along with vocal members of the population.

Results and Discussions

BREEDING POPULATIONS

Spring population estimates on the three study areas are shown in Appendix Table 1. The populations on each area fluctuated considerably from year to year, and the number of each sex fluctuated independently (Appendix Figure 1).

While populations on each area fluctuated from year to year, they did not fluctuate in concert (Figure 1). Populations on the Clay Center area generally fluctuated at a higher level than populations on the other areas. The yearly fluctuations in spring populations were also greater at Clay Center, indicating that while there is a greater diversity of habitat, the environment was less stable.

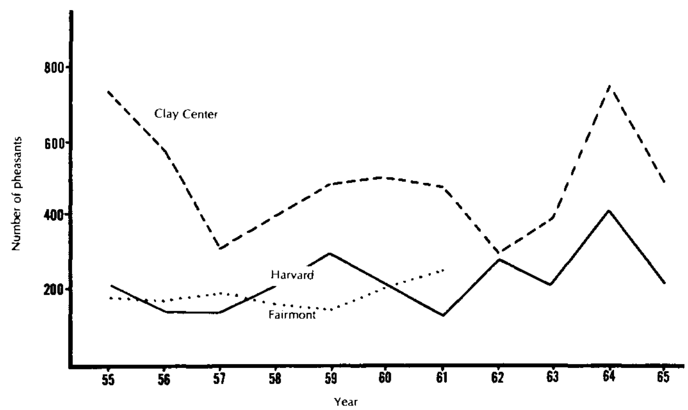


Figure 1. Spring population estimates

COMPARISON OF TECHNIQUES

Spring census data for the last four years of the project were compared, using the crowing cock counts as a base (Table 1). If the crowing counts for this period do represent a valid base, then only about one-third of the spring cock population is observed when using the ground or aerial census techniques. Over the 4-year period (1962-1965) aerial censuses averaged 35.9 percent as many cocks as the triangulation method of crowing cock census. Ground counts averaged 34.8 percent.

Ratio comparisons using the crowing cock counts as a base were also made (Table 2). The aerial count: crowing cock count ratios for cocks only on both areas were more consistant and similar than any other ratios.

Analysis of variance indicated that there was a highly significant difference ($P<0.01$) between methods on both areas (Appendix Tables 2 and 3). Dunnett's t-test showed that the crowing count census detected significantly more cock pheasants ($P<0.01$) than the aerial or ground counts.

The validity of comparing these census methods is speculative. Although the sample period was not extensive (4 years) and variability existed between the various observers, this analysis indicated that statistically significant differences existed between population estimates based on concentrations of birds and those obtained by an audio-census sex ratio method.

Table 1. Comparisons of ground and aerial counts with crowing cock counts.

	1962	Percent of crowing cock count	1963	Percent of crowing cock count	1964	Percent of crowing cock count	1965	Percent of crowing cock count
HARVARD AREA								
Both sexes								
Ground	217	71.4	–	–	84	20.0	210	94.0
Aerial	155	51.0	151	69.6	142	33.8	141	63.0
Crowing	304	100.0	217	100.0	420	100.0	224	100.0
Cocks only								
Ground	53	53	–	–	18	16	42	53
Aerial	33	33	30	39	38	35	33	41
Crowing	101	100	78	100	110	100	80	100
CLAY CENTER AREA								
Both sexes								
Ground	218	76.0	189	49.0	481	63.0	226	47.0
Aerial	160	56.0	114	29.0	147	19.0	181	38.0
Crowing	287	100.0	389	100.0	760	100.0	478	100.0
Cocks only								
Ground	44	44	30	23	70	38	35	25
Aerial	56	56	64	50	37	20	39	28
Crowing	99	100	129	100	182	100	139	100

Table 2. Comparison of ground, aerial, and crowing cock counts.

Harvard	**Ratios – All birds**			**Ratios – Cocks only**		
Year	G:CC	A:CC	A:G	G:CC	A:CC	A:G
1962	1:1.40	1:1.96	1:1.40	1:1.90	1:3.06	1:1.61
1963	–	1:1.44	–	–	1:2.60	–
1964	1:5.00	1:2.96	1:0.59	1:6.11	1:2.89	1:0.47
1965	1:1.07	1:1.59	1:1.49	1:1.90	1:2.42	1:1.27
Mean	1:2.28	1:1.98	1:0.87	1:2.58	1:2.75	1:1.09
Clay Center						
1962	1:1.32	1:1.79	1:1.36	1:2.25	1:1.77	1:0.79
1963	1:2.06	1:3.41	1:1.66	1:4.30	1:2.02	1:0.47
1964	1:1.58	1:5.17	1:3.28	1:2.60	1:4.92	1:1.89
1965	1:2.11	1:2.64	1:1.25	1:3.97	1:3.56	1:0.90
Mean	1:1.72	1:3.18	1:1.85	1:3.07	1:2.80	1:0.91

RELATIONSHIP OF LAND USE TO SPRING POPULATIONS

The most meaningful way to look at the relationship between land use patterns and pheasant populations is to compare long-term populations with the long-term land use patterns. This tends to compensate for the high variability between years.

Our data show that while the three study areas were all intensively cultivated or grazed, the degree of utilization varied between the areas. Utilization was 89.0 percent at Clay Center, 96.7 percent at Fairmont, and 95.3 percent on the Harvard area.

Eleven-year mean spring pheasant populations in birds per 100 acres (Figure 2, Table 3) were tested against the mean percent of land under intensive agriculture by linear correlation. A near perfect negative correlation existed (Appendix Table 4). As the intensity of agricultural operations increased, the carrying capacity of that unit of land decreased proportionately.

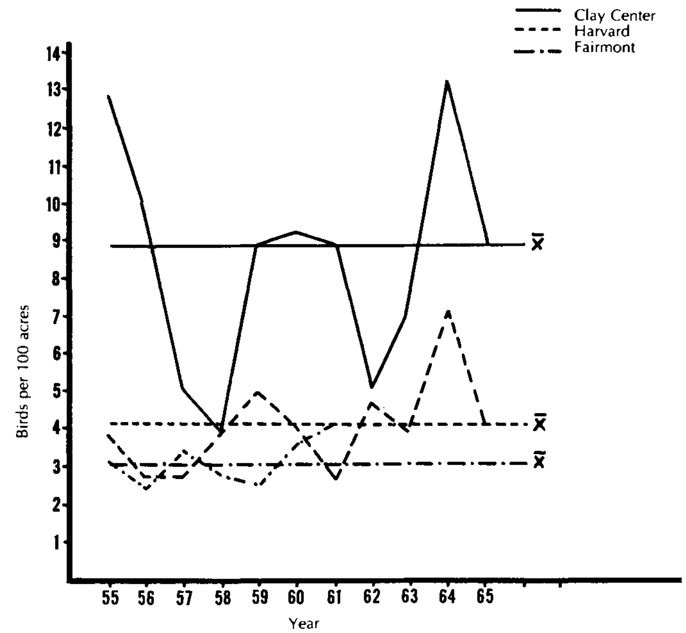


Figure 2. Spring population estimates (Birds per 100 acres)

Table 3. Spring pheasant populations, in birds/100 acres, on the Clay County and Fillmore County Study Areas, 1955 through 1965.

Year	Clay Center	Harvard	Fairmont
1955	12.67	3.63	3.12
1956	10.07	2.83	2.69
1957	5.12	2.83	3.33
1958	3.77	3.77	2.66
1959	8.07	4.70	2.46
1960	8.28	3.78	3.35
1961	7.88	2.62	4.03
1962	4.98	4.60	
1963	6.75	3.77	
1964	13.19	7.29	
1965	8.30	3.89	
Mean	8.10	3.97	3.09

It would be interesting to have comparable long-term data from other areas of less intensive agriculture to determine if this relationship remains constant. We assume that a land use pattern exists for south-central Nebraska which would provide optimum conditions for pheasant populations. Below the optimum, an increase in cultivation would bring about an increase in pheasant populations; while above this point, an increase in agricultural use brings about a decline in numbers. In south-central Nebraska, we need not worry about being below or returning to the optimum point. The trend in the region is for the already intensive land utilization to increase.

SEX RATIO COUNTS (1961-1965)

The purpose in conducting spring sex ratio counts was two-fold: (1) to acquire accurate sex ratios for estimating populations and (2) to provide management personnel with information concerning the proper seasonal period for conducting annual surveys.

Several authors have noted that census results are affected by climatic factors (Bennett and Hendrickson, 1938; Randall and Bennett, 1939; Fisher, Hiatt, and Bergeson, 1947; Kozicky, 1952).

We agree with these authors and recognize that weather changes do affect census results. Therefore, we attempted to conduct counts under similar weather conditions.

SEASONAL TIMING OF SEX RATIO COUNTS

Sex ratio counts were initated on April 1 each year from 1961 to 1965 to eliminate bias associated with differential winter flocking behavior of the sexes. As noted previously, Mohler indicated that winter concentrations had all dispersed by this time. In addition, vegetative cover is minimal at this time of year, and during most years hens are not yet actively engaged in nesting activities.

The seasonal and daily time of observation for 1,997 pheasants was recorded during the period 1962 to 1965.

Pheasant numbers, male and female, observed on spring counts increased to a peak during the week of April 14-20, declined during the next week, and rose to a subdominant peak and then declined sharply (Figure 3). The number of hens per mile followed a slightly different pattern (Figure 4 and Table 4). A general downward trend from the week of April 7-13 was noted. However, the subdominant peak still exists for the week of April 28-May 4.

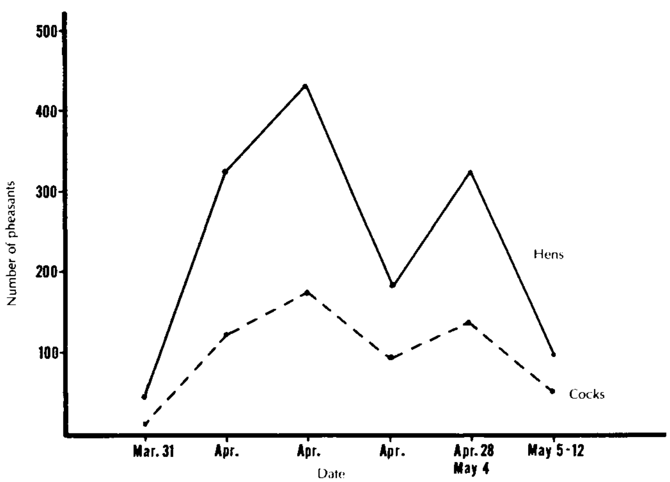


Figure 3. Number of pheasants observed by weekly period during spring.

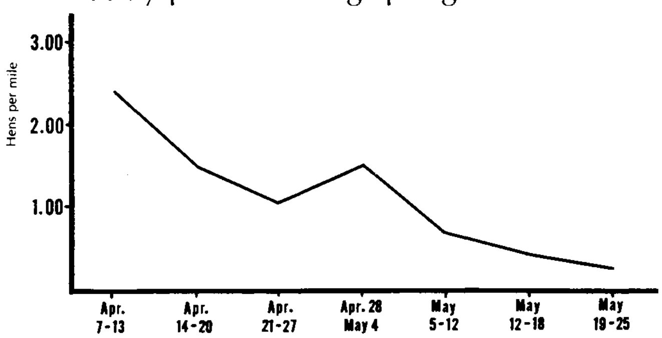


Figure 4. Hen pheasants observed per mile, 1962-65

Table 4. Observations of hen pheasants and hen pheasants per mile by weekly period 1962-1965.

Period (week)	Hens	Miles	Hens/mile
April 7-13	324	46.5	6.97
April 14-20	428	190.0	2.25
April 21-27	184	84.0	2.19
April 28-May 4	328	134.0	2.45
May 5-12	104	138.0	.75
TOTAL	1,368	592.5	3.31

Table 5. Observation of pheasants on roadside census by weekly time periods (1962-1964).

Week	Males	Females	Total
March 31-April 6	6	40	46
April 7-April 13	119	324	443
April 14-April 20	173	428	601
April 21-April 27	93	184	277
April 28-May 4	144	328	472
May 5-May 12	54	104	158
TOTAL	589	1,408	1,997

SEASONAL TIMING OF SPRING COUNTS BASED ON REPRODUCTIVE DATA

Data collected during reproductive studies provide additional support to the premise that spring sex ratio counts should be conducted before the middle of April. Knowledge of pheasant reproductive biology and the chronology of the reproductive season allows us to estimate quite closely the time of year when hens and cocks will appear in a ratio that is representative of the population.

Our reproductive studies provided the following information regarding pheasant nesting in south-central Nebraska: (1) the 10-year mean date of hatch is June 10; (2) each hen averages 3.4 nests per year; (3) incubated clutches average 8 eggs per nest, and (4) abandoned nests or false starts averaged 7 eggs per nest.

Wisconsin studies have shown that pheasants lay eggs at the rate of one egg per 1.3 days (Buss, Meyer, and Kabat, 1951; Wagner, *et al.*, 1965).

Backdating from June 10, we were able to arrive at an average date when nesting activities began (Table 6). This would indicate that spring sex ratio counts should generally be terminated by the middle of April.

Table 6. Seasonal timing of spring sex-ratio counts based on reproductive data.

June 11	= 10 year mean date of hatch (calculated from nesting study)
-23 days	= Incubation period
May 19	= 10 year mean date of initiation of incubation
-10 days	= Time required to lay average clutch of eggs = (1.3 days/egg x 8 eggs = 10 days)
May 9	= 10 year mean date of initiation of incubated clutches
-22 days	= Time required to lay eggs in abandoned nests and false starts (2.4 nests x 7 eggs x 1.3 days/egg)
April 17	= Average date of beginning of nesting activities

TIME OF DAILY OBSERVATION

Pheasants exhibit two activity periods during the day when it would be possible to obtain sex ratio data utilizing the roadside census technique. These periods occur during evening and early morning hours, while the birds are moving to and from roosting cover. All of our sex ratio counts were conducted during the morning period, because work in other states indicated that morning counts were less variable than evening counts (Bennett and Hendrickson, 1938; Randall and Bennett, 1939).

The total number of pheasants observed on the Harvard and Clay Center studies were tabulated on the basis of the number of observations occurring per 15-minute time intervals after sunrise (Table 7). The mean sunrise for each weekly time period is recorded in Table 8.

This analysis was based on 1,997 pheasant observations on early morning roadside counts from 1962-1964. Not included for analysis are observations for which the actual time of the observation was not recorded.

Table 7. The number of male and female pheasants observed during 15-minute time intervals after sunrise (1962-1964).

Time Interval Minutes After Sunrise	Males	Females	Total
1- 15	1	7	8
16- 30	7	66	73
31- 45	34	112	146
46- 60	59	182	241
61- 75	91	207	298
76- 90	80	246	326
91-105	95	252	347
106-120	92	117	209
121-135	47	87	134
136-150	32	63	95
151-165	25	29	54
166-180	14	19	33
181-195	7	12	19
196-210	5	9	14
	589	1,408	2,015

Table 8. Mean weekly sunrise Clay County, Nebraska for the period March 31 through May 12.

Weeks	Mean Sunrise
Mar. 31-April 6	6:13 AM
April 7-13	6:02 AM
April 14-20	5:51 AM
April 21-27	5:40 AM
April 28-May 4	5:29 AM
May 5-12	5:18 AM

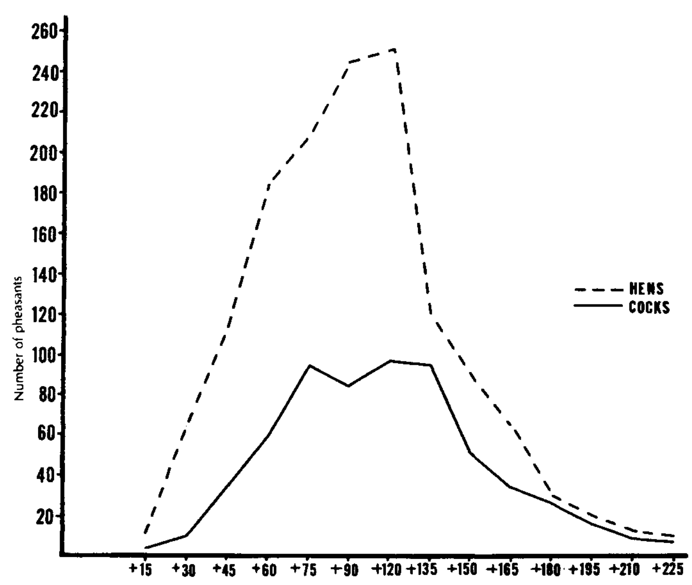


Figure 5. Number of pheasants observed during 15-minute intervals after sunrise

Figure 5 represents the number of male and female pheasants observed during 15-minute time intervals from sunrise to 3 hours and 45 minutes past sunrise. More than 89 percent of all pheasant observations occurred during the first 2 hours after sunrise, and approximately 94 percent of all observations occurred in the first 2½ hours (Appendix Table 5).

The number of pheasants observed in the first half hour after sunrise during the three-year sampling period was quite low—81 birds total. Observations during this time period comprised slightly more than 4 percent of the total observations. Fisher, Hiatt and Bergeson (1947) noted high variability during this time period and stated "It is apparent that in Montana censusing should not begin until a half hour after sunrise." While our data does not lend itself to a statistical analysis of variability during this time period, we are inclined to agree with this interpretation.

If spring roadside sex-ratio counts are to be utilized in Nebraska, censusing should begin one-half hour after sunrise and continue for two hours. These time periods accounted for approximately 90 to 95 percent of all our observations.

RATIONALE OF SPRING SEX RATIO COUNTS

Several authors have indicated that spring sex ratios do not accurately represent population values, but rather they overemphasize the proportion of males in the breeding population (Hickey, 1955; Robertson, 1940; and Wagner et *al.*, 1965). We agree that the plumage and territorial activity of cocks during this time of year would appear to bias spring counts in favor of the male segment of the population. However, we do not feel that this is an important bias on our study area where 90 to 97 percent of the total land area was intensively cultivated.

Our purpose in conducting this census was to provide an index to the relative abundance of the two sexes in our population, so that this information could be used with other census methods to provide accurate population estimates.

Having conducted both spring and winter sex ratio counts on our areas, we feel that utilization of the spring count injected less bias in our population estimates than making estimates based on winter surveys.

Accurate spring populations are an integral part of a study designed to determine the life history of an animal species. But, are they essential to a management program?

We feel a statewide census of spring pheasant populations is of little value as a general management practice. A census conducted at this time of year does not provide information on which recommendations or regulations can be formulated. Reproductive success is the single most important factor in determining fall populations.

While it may be argued that reproductive success is related to the number of hens in the spring population. Our data indicates that this may be a true hypothesis over a large area (See "Nesting Studies"). However, our data also indicated that on our study areas, especially the Harvard area, that the number of hens successful in bringing a brood was the primary factor in determining chick production (Linder, Lyon, and Agee 1960). Furthermore, our data also denoted that we have a surplus of hens in our breeding population each spring. Our techniques of predicting environmental conditions are not so refined that we can predict the number of hens that will be successful.

Spring population censuses make no allowance for two other factors—compensatory reproduction related to population density and spring and summer hen mortality. Recent evidence indicates summer hen mortality is highly variable and that it comprises a significant portion of total hen mortality in a given year (Wagner, 1957, and Dahlgren, 1963).

Spring population estimates, while not important as a general management tool, may be useful in certain situations. They can provide valuable information for life history studies, to evaluate changes in harvest regulations, and to measure the effects of changes in land use patterns or management practices. Spring population censuses may also be important from a public relations standpoint.

3. Nesting Studies

Reproduction is one of the most important biological phases in the annual life cycle of the ring-necked pheasant. Reproductive success or failure, in turn, determines the success of the hunting season. Because of these relationships, particular emphasis was placed on the reproductive segment of this study.

Pheasants possess a tremendous reproductive potential, and annually produce surplus young that exceed the carrying capacity of the land. The irruptive nature of pheasant reproductive capacities has been well documented where the birds are placed in favorable habitats (Einarsen, 1942; Stokes, 1954).

This high capacity for multiplication is present in pheasants in Nebraska, and if this explosive breeding potential were to proceed unchecked, pheasant numbers would rapidly increase to the point where they would achieve pest status. Nebraska pheasants seldom, if ever, fully achieve their reproductive potential because of environmental resistance factors. Pheasant populations also experience high turnover, with annual losses approaching 70 percent. The resistance factors responsible for these losses vary from area to area and year to year, but they do hold populations in line with the carrying capacity of the range.

The primary objectives of this chapter are to analyze nesting as a factor in population changes, determine the relative importance of various cover types to reproduction, and to evaluate the role of environmental factors affecting nesting success. Nesting data were collected on the Harvard study area from 1955 through 1964 and on the Clay Center study area from 1959 through 1964.

Methods

SAMPLING TECHNIQUES

Sampling methods used in this nesting study were patterned after the study conducted by Stokes (1954) on Pelee Island, Ontario. Pheasant production for each cover type was estimated on the basis of a thorough search of a sample of each cover type. All cover types were sampled except row crops and small grain stubble existing from the previous year.

Cover types sampled were classified as roadsides, wheat, alfalfa, fencerows, pasture and hay, and unused areas. Sampling rates for each cover type were based on the expected nest densities in that cover type. Rates chosen as representative during this study included:

Roadsides..1:6
Wheat..1:10 to 1:16
Alfalfa..1:6
Fencerows..1:6
Pasture and Hay................................1:6
Unused Areas...................................1:6

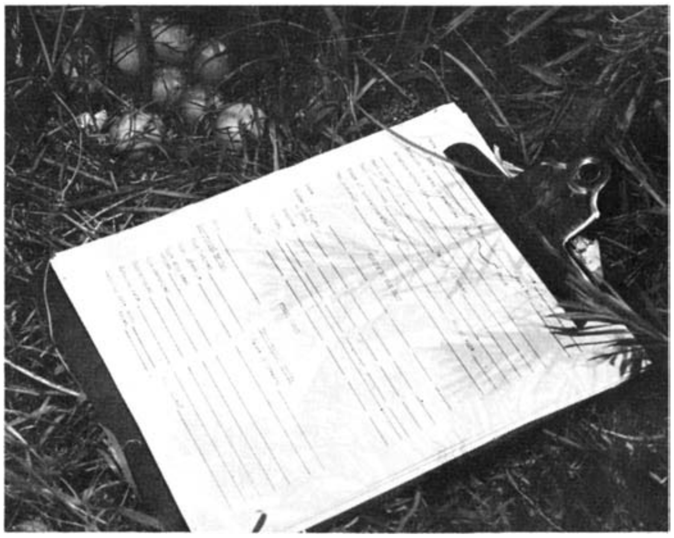
Sample plots were laid out as transects which extended the length of each field. The width of each transect was adjusted so the plot covered the pre-selected sample ratio of each field. The location of each transect within the field was selected at random. Linear or strip cover, roadsides and fencerows were divided into six equal segments and one was selected randomly as the sample plot.

Nest searchers spaced themselves at appropriate distances and traversed the plots systematically, using sticks to lift and part the vegetation. Roadside plots were searched twice each year—once between May 15 and June 15 and again between July 15 and August 15. Sample plots in other cover types were searched only once, usually between mid-June and the end of August. Nests initiated late in the season may not have been detected. However, a limited number of searches in late summer and data collected from brood studies indicated that these late nests made only a minor contribution to total production.

NEST CLASSIFICATION AND DATA RECORDS

A nesting form containing one or more eggs was classified as a nest. Nests, which were not destroyed and were suspected of being active (egg laying or incubation in progress), were revisited regularly until the eventual fate was learned. The observer was careful not to disturb hens on the nest or the surrounding vegetation. Visitations to active nests increased as the expected hatching dates drew near.

All data concerning the nests and eggs were recorded on



Detailed forms were used during the study to report location, condition and other data on each pheasant nest.

mimeographed plot and nest records (Appendix Figures 1 and 2). The number of nests found on sample plots in each cover type was projected according to the sampling rate to estimate the total number of nests in that type. The estimated number of nests, multiplied by the mean clutch size for that type, provided an estimate of the number of eggs for that type. Chick production was calculated by multiplying the percentage of eggs successful in each type by the estimated eggs in that cover type.

All data were transferred to standard key punch cards for tabulation and analysis on an IBM 1620 computer. Key punching, tabulation, and analysis were performed by personnel of the Statistical Laboratory at the University of Nebraska in Lincoln.

Results and Discussion

SAMPLE SIZE

Analysis of nesting data was based on a sample of 1,152 pheasant nests located on sample plots and 589 supplemental nests. The supplemental category included all nests located off of the sample plots, all nests from the Fairmont area, nests located on the Clay Center area prior to a systematic nesting study (1955-1958), and nests found at Harvard during 1955 when a different sampling procedure was used. Unless otherwise specified, analysis of reproduction was based on 1,152 nests found on sample plots.

EFFICIENCY OF NEST SEARCHING

The number of nests (1,152) located on sample plots during the course of this study probably represented fewer nests than were actually initiated. Observers may have missed some nests, and some nests may have been completely obliterated prior to nest searching.

To evaluate efficiency of searching sample plots, 32 dummy nests were secretly placed on sample plots in various cover types in 1958. Thirty or 94 percent of these were found during nest searching. Labisky (1968) reported similar rates of efficiency for a nesting study in Illinois. In one efficiency test, he found that 12 percent of the nests were missing. This indicated that nesting studies of this design are relatively efficient at discovering nests and that data based on these studies is statistically reliable.

AVAILABILITY OF NESTING COVER

Cover mapping studies were conducted on the nine-square-mile Harvard and Clay Center areas from 1955 through 1964. Acreage values were recorded annually on base maps of each study area. To make the nesting studies and cover mapping studies for the Harvard area comparable, the base maps were used to recalculate acreage data for the seven sections.

Approximately 41 percent of the total acreage of the study areas was classified as potential nesting cover (Table 1, Appendix Tables 1 and 2). Ranked by occurrence these cover types were wheat, pasture and hay, unused areas, alfalfa, roadsides, and fencerows. While the 41 percent represents the mean value, the actual acreage varied between areas and years depending on cultural practices and the amount of water present in wetlands.

Nest density varied between cover types on the study areas (Table 1). Densities were highest in roadsides and alfalfa fields and lowest in wheat. The number of nests established per acre was intermediate for the remaining cover types.

Table 1. Estimated nest densities in cover types on the Harvard and Clay Center study areas (pooled data).[1]

Cover Type	Acres	Percent of Total Area	Estimated No. of Nests	Nests Per Acre
Roadsides	139.1	1.36	266	1.91
Wheat	2,539.9	24.80	515	.20
Alfalfa	287.6	2.81	270	.94
Unused	317.6	3.10	176	.55
Pasture & Hay	872.2	8.52	371	.43
Fencerow	19.2	0.19	12	.63
Conserving Acres[2]	27.0	0.26	12	.43
TOTAL	4,202.6	41.04	1,622	.386

[1]Mean values based on 6 and 9 years data, Clay Center and Harvard areas, respectively.
[2]Only occurred in three fields during study period.

Nest densities on the study areas are low when compared to density levels cited for similar cover types on Pelee Island and in South Dakota (Stokes, 1954; Trautman, 1960). The difference in nest density was attributed to two factors: (1) a significantly lower spring population density, and (2) a lower percentage of the total area devoted to cover types suitable for nesting.

Nesting effort and chick production varied between cover types.

During the course of this study, nesting effort was concentrated in three cover types—roadsides, alfalfa, and wheat. However, as seen in Table 2 the majority of chicks produced was hatched in wheat and roadsides.

Table 2. Nesting effort and estimated production for pooled data from the Clay Center and Harvard study areas 1956-1964.[1]

Cover Type	Total Nests on Sample Plots	Percent of Total Nests	Estimated Chicks Produced	Percent of Total Chicks
Roadside	308	26.7	2,050	25.2
Wheat	280	24.3	4,273	52.6
Alfalfa[2]	310	26.9	255	3.1
Unused	96	8.3	556	6.9
Pasture and Hay	128	11.1	715	8.8
Fencerow	18	1.6	0	0.0
Conserving Acres	12	1.0	277	3.4
TOTAL	1,152	100.0	8,126	100.0

[1]Nesting studies were conducted on the Harvard area from 1956-1964 and on the Clay Center area from 1959-1964. Data was pooled for analysis.
[2]Includes 36 nests and an estimated 24 chicks from experimental alfalfa fields which were not mowed until after July 1 in 1964.

Winter wheat, a major crop on the area, was the most important cover type from a production standpoint. Approximately one-quarter of the total area was devoted to its culture. Of more importance, this crop provided more than half of the total available nesting cover on the areas. Although nest densities were low (0.20 nests/acre), nest-establishment and chick-production rates were high (Table 2).

Roadsides comprised less than 1.4 percent of the total acreage on the study area. However, nest densities were high (2 per acre), and more than 25 percent of all chicks were produced in this cover type.

While a small proportion of the total chicks was produced in alfalfa, it must be considered one of the most important cover types for nesting because of the high percentage of nests established there. The low rate of chick production is directly attributable to the high rate of nest destruction associated with harvest operations.

Pastures were heavily grazed during the nesting season, and nest densities were low. This cover type accounted for approximately 11 percent of the total nests initiated and 9 percent of the chicks produced. Baskett (1941) and Trautman (1960) reported similar findings of relatively low production for pastures in Iowa and South Dakota.

Unused areas comprised an average of 3.1 percent of the total land area. However, actual acreage fluctuated annually with the amount of water present in wetlands on the Clay Center area (see Wetlands and Pheasant Production). An average of 8 percent of all nests and 7 percent of all chicks hatched were in unused areas.

Fencerows ranked third in terms of nest density (0.63 nests per acre), well below densities in other studies. Reports ranged from 3.1 nests per acre in Illinois (Labisky, 1968) to 11-13 nests per acre in South Dakota (Trautman, 1960). There were no chicks produced in fencerows during the course of this study because of losses to predation and abandonment. Low rates of success in this cover type have also been reported for other states (Baskett, 1947); Trautman, 1960, and Labisky, 1968). However, Labisky (1968) found that while nest success was low, the density of hatched nests from this cover type was surpassed only by that of unharvested hay.

Conserving acres were not common on the study areas. Farmers participating in USDA feed grain programs in south-central Nebraska seldom plant a cover crop on lands idled in compliance with this program. These fields were normally disced several times during the nesting season. Only three diverted fields, totaling 189.7 acres, were planted with a cover crop. Mean nest densities were low, but success was high with 3.4 percent of all chicks produced here.

One field, classified as conserving acres, is of particular interest since it demonstrates the relationship between pheasant nestng and cover quality. This field was 21.7 acres in size, and vegetation consisted of western wheat grass and alfalfa sown in wheat stubble the preceding fall. Cover was excellent, and nest densities approximated two per acre. Nest success approached 30 percent, and an estimated 150 chicks were produced in this field. This was approximately 54 percent of all chicks produced in this cover type.

Pheasant utilization of the various cover types as nesting cover also varied from year to year and between the two areas (Appendix Tables 3, 4 and 5). Nest establishment was a fluid parameter that varied with the quality of the nesting cover in each type. For example, during dry years, the growth of alfalfa was retarded and nest densities were low. Wetlands on the Clay Center area showed an opposite trend. During years when the basins were dry and vegetation was abundent in and around these areas, nest densities and production increased. The relationship of vegetative canopy to chick production in roadsides is another indication that the quality of nesting cover determined the rate of nest establishment (see Roadside Nests).

NEST INITIATION AND COVER SELECTION

Of the 1,741 sample and supplemental nests observed, 1,340 (77 percent) were found in roadsides, alfalfa fields, and wheat fields. Nest initiation dates were used in an attempt to determine if any differences existed in the dates when these cover types were utilized by pheasants for nesting (Table 3).

Table 3. Mean nest initiation dates for selected cover types.

	Alfalfa	Roadsides	Wheat
Successful	May 10	May 20	June 5
Unsuccessful	May 23	May 23	June 5
Mean	May 21	May 21	June 5

The mean date of nest initiation for alfalfa and roadside nests was the same (May 21). Separately and combined, these dates (May 21) were significantly earlier than nests in wheat (June 5). The mean date of nest initiation of successful nests in alfalfa (May 10) was significantly earlier than the mean date (May 23) for unsuccessful nests ($t = 2.56$, $t_{.05} = 1.67$). Establishment of nests in alfalfa and roadsides prior to the use of wheat for nesting cover was apparently related to available cover. Alfalfa was the earliest crop to provide adequate nesting cover because of its rapid growth in the early spring. Roadsides were important as early nesting cover because of residual vegetation and a predominance of cool-season grasses. At the time pheasants began use of these two cover types, there was usually not sufficient cover in wheat fields to conceal a nesting hen. The success of early nests in alfalfa was related to the timing of the first cutting of hay. In south-central Nebraska, the first cutting is usually completed by the first week in June. The nests that hatched usually did so only a few days prior to cutting.

It is felt many nests initiated in wheat represented attempts by hens that were previously unsuccessful in alfalfa fields since the dates of nest initiation in wheat conform very closely to the dates of the first cutting of alfalfa. Buss (1946) and Gates (1966) found that renesting attempts most commonly occurred in hay fields. No such indication was noted in the present study. Hay fields are commonly mowed three weeks later in Wisconsin (Gates, 1966) than in Nebraska, while pheasants start nesting in Nebraska only one week earlier than in Wisconsin. Thus, there is less time in Nebraska between onset of nesting and alfalfa mowing. Further evidence that nests in wheat fields represent renesting attempts is shown by the mean clutch size of 6.8 while that for roadsides was 9.1.

VEGETATION ASSOCIATED WITH NEST SITES

We have demonstrated that pheasants in south-central Nebraska show a preference for certain cover types as nesting cover. However, this data provides little information regarding why certain areas within the cover types are selected for the actual nest site. Therefore, analysis of vegetation complexes associated directly with the nest site was considered necessary.

More than 74 species of plants were recorded at pheasant nest sites during the course of this study (Appendix Table 6). Analysis of this data indicated that pheasant hens showed a definite preference for certain plant complexes when establishing their nests (Figure 1). Eighty-two percent of all pheasant nests was established in cover where vegetation made its maximum growth during the spring months. Thirty-two percent of all nests were found in alfalfa, 27 percent in cool-season grass stands, and 23 percent in winter wheat. Mixed plant communities of forbs, grasses, and semi-aquatic plants occurred at 16 percent of all nest sites. Vegetation complexes of mixed warm and cool-season grasses and complexes that were entirely warm-season species occurred at slightly more than two percent of all nest sites.

Grode (1972) reported similar findings for penned hen pheasants in his study near Grand Island, Nebraska. Vegetation and its relationship to pheasant nest establishment were analyzed for three one-acre pens, which were divided into one-half acre of alfalfa and one-half acre of warm-season grasses. He found differences in nest establishment rates and characteristics of each vegetative complex (Table 4). Analysis of variance indicated that a highly significant difference (PV-.01) existed between the number of nests established in alfalfa (89) compared to the number of nests established in the warm-season grasses (10). He concluded that hens selected the alfalfa for nesting because of the favorable microclimate.

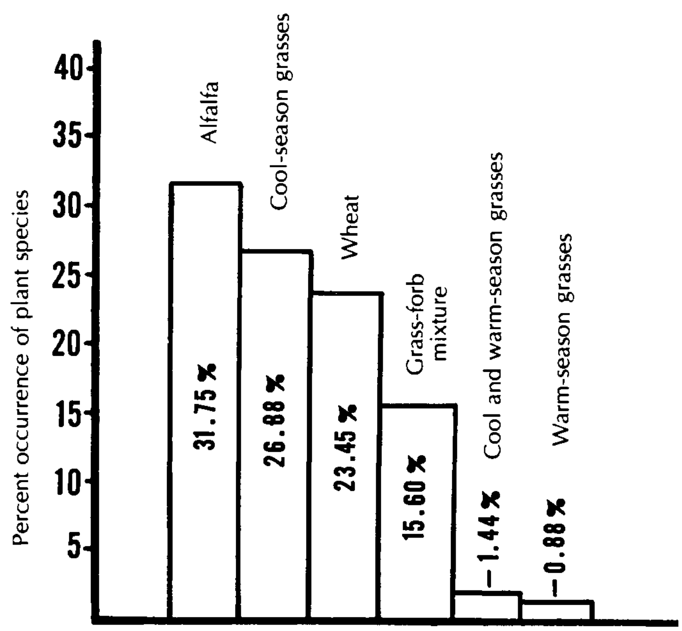


Figure 1. Nesting cover preference

Table 4. Characteristics of vegetation used for nesting by game farm hens[1]

Number of Nests		Incident Light (footcandles)[2]		Density Index	
Alfalfa	Warm Season Grass	Alfalfa	Warm Season Grass	Alfalfa	Warm Season Grass
89	10	550	3365	18.2	11.6

[1]Table from Grode (1972:27)
[2]Measured on the ground at the base of the plant

Waterfowl in south-central Nebraska exhibited a tendency to select similar cover types and plant associations as nesting sites (Baxter and Wolfe, 1972). Roadsides and alfalfa were preferred cover types, and alfalfa and cool-season grasses were preferred plant complexes within cover types. An obvious difference between pheasants and waterfowl was the lack of importance of wheat to waterfowl production.

In conclusion, it appears that certain plant complexes offer higher quality nesting cover and that hen pheasants actively select these complexes as nest sites in major cover types. The preferred plant complexes consist of plants which make their major growth during the fall and early spring.

Nest Parasitism

The importance of the Clay Center study area as a pheasant and waterfowl nesting area has been well documented (Linder, 1959; Linder, et *al.*, 1960; Evans and Wolfe, 1967, and Baxter, 1971). This section provides information on interspecific relationships which occurred between pheasants and waterfowl during the course of this study.

Waterfowl use of the study area for nesting was determined by the amount of water present in the basins, and the availability of safe nesting cover. Table 5 shows the amount of water present in the basins and estimated duck production.

Table 5. Acres of water in rainbasins and estimated duck production on the Clay Center study area, 1956-1964.

Year	Acres of Water	Estimated Duck Production
1956	Dry	0
1957	Dry[1]	0
1958	575.6	346
1959	681.6	137
1960	686.3	183
1961	188.5	126
1962	199.5	0
1963	Dry	0
1964	Dry	0

[1]Rains in late spring of 1957 filled most of the basins. However, the spring waterfowl migration was over and no ducks nested on the area.

The primary interaction between pheasants and waterfowl was the parasitism of duck nests by pheasant hens. Of the 206 duck nests located during the study, 14 or 6.8 percent were parasitized by pheasants (Table 6).

Table 6. Nest Parasitism of duck nests by ring-necked pheasants.

Species	Ratio of Parasitized Nests/Total Nests	Percent Parasitized
Blue-winged teal	9/104	8.7
Mallard	4/34	11.8
Shoveler	1/5	20.0
Pintail	0/37	0.0
Gadwall	0/1	0.0
Unidentified	0/25	0.0
Total	14/206	6.8

The percentage of successful nests parasitized was even higher, 3 of 23 nests or 13 percent. The ratio of duck eggs to pheasant eggs ranged from 0.6:1 to 11:1 and averaged 3.7:1. Seven of the parasitized duck nests contained only one pheasant egg. The most heavily parasitized nest contained three duck eggs and five pheasant eggs. This nest contained one blue-winged teal egg when first discovered, and three blue-winged teal eggs and one pheasant egg on the next visit. No more duck eggs were deposited but the pheasant continued to lay in this nest. The nest was not incubated.

Only one pheasant egg hatched in the three parasitized successful duck nests. The remaining pheasant eggs were all fertile and contained dead embryos.

The parasitized nests were not distributed in relation to species composition, but occurred most frequently in roadsides, where pheasant nest density was the highest. Only 28 percent of all duck nests were found in roadsides, but 78 percent of all parasitized nests were located in this cover type.

Blue-winged teal, the primary species of waterfowl nesting on the area, was the most common duck found nesting in roadsides. Of the duck nests parasitized by pheasants, 64 percent were blue-winged teal.

Nests identified as being established by pheasants and parasitized by ducks were rare. Only 2 of the 874 pheasant nests examined from 1958 through 1962 contained duck eggs. Both of these nests were found in burned wheat stubble and were not incubated. One nest contained 11 pheasant eggs and 2 unidentified duck eggs. The other nest had eight pheasant eggs and one mallard egg.

Effects of Nest Searching on Nest Fate[1]

To determine the effects of nest searching on the fate of pheasant nests, data from 1,276 pheasant nests were examined. Analysis included 822 nests discovered on sample plots and 454 nests found during supplemental searching. Because of high nest destruction (91.2 percent), 310 sample nests and 164 supplemental nests located in alfalfa fields were not included in the analysis.

Hens were present at 244 nests discovered by the investigators. Investigators had no known contact with the hen on the remaining 1,032 nests. This section briefly reviews the effects of human activity in the form of nest searching on nest fate.

For purposes of analysis, nests were grouped as follows:

Group I —Nests where the hen flushed at least once
Group II —Nests where the hen was present but never flushed
Group III—Nests which were terminated before they were found.

Pheasant nests were categorized by fate as follows: successful, abandoned, depredated, and other. The data concerning the fate of the nests are presented in Table 7.

Table 7. Fate of 1,276 pheasant nests found in Clay County, Nebraska, 1955-64.

				Fate							
				Successful		Abandoned		Depredated		Other	
Nesting State		No.	%	No.	%	No.	%	No.	%	No.	%[1]
	Incubating	73	50.3	19	26.0	13	17.8	26	35.6	15	20.6
Group I	Laying	40	27.6	0	0.0	10	25.0	14	35.0	16	40.0
(Hen flushed)	Unknown	32	22.1	0	0.0	10	31.2	14	43.8	8	25.0
	Total	145	100.0	19	13.1	33	22.8	54	37.2	39	26.9
Group II	Incubating	81	81.9	48	59.3	2	2.5	24	29.6	7	8.6
(Hen not	Laying	10	10.0	0	0.0	1	10.0	8	80.0	1	10.0
flushed)	Unknown	8	8.1	0	0.0	3	37.5	4	50.0	1	12.5
	Total	99	100.0	48	48.4	6	6.1	36	36.4	9	9.1
Group III	Incubating	231	22.3	107	46.3	5	2.2	84	36.3	35	15.2
(Hen not	Laying	635	61.2	0	0.0	128	20.2	397	62.5	110	17.3
present)	Unknown	166	16.5	0	0.0	28	16.9	105	63.2	33	19.9
	Total	1,032	100.0	107	10.4	161	15.6	586	56.8	178	17.2

[1]This classification includes all nest losses not attributed to abandonment or depredation. These included farming, flooding, hail, road maintenance and other miscellaneous causes of nest losses.

NEST SUCCESS

The percentage of successful nests varied between the three categories. Success was lowest in Group III and highest in Group II (Table 7). The percentage of successful nests in Group I (hens flushed) was higher than in Group III, but considerably below Group II where the hen was not flushed.

Group III had the lowest rate of success because all nests which had failed prior to being found were placed in this category. The other two groups contained only active nests where the hen was present.

The difference in the rates of success for nests in Groups I and II can be partially explained by the hen's stage in the nesting sequence. In Group I, only 50 percent of the hens were incubating, whereas 82 percent of the hens in Group II were incubating. A test for independence showed a highly significant relationship between flushing and incubation, $X^2 = 24.75$ ($X^2 0.005 = 12.84$, 3df).

ABANDONMENT

Abandonment of pheasant nests following flushing of the hen by investigators has been reported by Baskett (1947), Stokes (1954), Robertson (1958), and Gates (1966). Buss (1946) reported that abandonment depended more on individual characteristics of the hen then on the stage of incubation.

Data from our studies show a difference in abandonment rates for nests from which the hen was flushed and for those where the hen was not flushed (Table 7). Rates of nest abandonment in all three groups were higher during the laying phase of the reproductive cycle than during the incubation phase. Abandonment of nests by flushed hens appeared to be independent of incubation. Hens that were still laying when flushed abandoned 25.0 percent of their nests, while flushed hens that were incubating abandoned 17.8 percent of their nests. This difference was not statistically significant ($X^2 = 0.74$, $X^2 0.05 = 3.84$, ldf). However, since laying hens are more prone to flush than incubating hens, we suggest that nest searching will result in higher abandonment when hens are in the laying sequence of the reproductive cycle.

Combined data from active nests (Groups I and II) was compared to data from terminated nests. The abandonment rate of 16 percent for active nests was not significantly different from the 15.6 percent rate found in nests where investigators had no contact with the hens. The similarity in abandonment rates indicates that in both groups there are hens that were psychologically or physiologically predisposed to abandon their nests. The disturbing stimulus of the investigator's presence was not added stimuli, but replacement stimuli for that which would have occurred naturally. We therefore concluded that hens which flushed in the presence of the investigator and subsequently abandoned did so because of individual differences in response.

PREDATION

Increased predation of pheasant and duck nests which were visited by investigators has been reported by Hammond and Forward (1966), Bach and Stuart (1942), and others. In contrast to these findings, Buss (1946) found little difference between predation rates or pheasant nests visited while active and those found after they were terminated.

In this study, hens which flushed had 37 percent of their nests destroyed by predators, while the corresponding figure for hens which did not flush was 36 percent. The calculated X^2 value between flushing and predation was a nonsignificant 19.01 ($X^2 0.05 = 3.84$, 1df). These rates compare with a 57 percent predation rate for nests which had been terminated when found (Group III). These observations do not indicate that nest searching activities of investigators increase predation rates.

VALIDITY OF GROUPINGS

The separation of the nests into the three groups was made on the basis of a difference between the reactions of the birds, that is, whether present or absent, and if present, whether flushed or not flushed. Inherent in this separation was the fact that some nests were terminated before being found and hence had no opportunity to be included in Groups I or II. If nests had been examined only after the termination of the nesting season, all nests would have been placed in Group III. For this reason separation of the nests into the three groups depended more on the stage at which the nest was found (active or terminated) than on the reaction of the hens. Hence combined data from Groups I and II should approximate the findings from Group III. In order to make comparisons, data from Groups I and II were combined to encompass all nests at which the investigator had contact with the hen (active). These were compared to data from Group III representing all nests at which he had no contact with the hens (terminated). The combined data showed that 43.6 percent of the *incubating* hens on active nests were successful. This compared closely with the 46.3 percent success of *incubated* nests recorded in Group III. The data from active nests showed an abandonment rate of 16.0 percent, not significantly different from the 15.6 percent found among terminated nests.

It is incorrect to assume that when a hen flushed as a result of the nest studies, abandonment would automatically follow. Some hens flushed and yet they returned to incubate the nests

[1]This section is a summary of data presented in a publication entitled *Effects of Nest Searching on Fates of Pheasant Nests,* 1967. R. D. Evans and C. W. Wolfe which appeared in The Journal of Wildlife Management, (31) 4:754-759.

and bring off broods. One nest was visited on three occasions and a hen flushed each visit, yet returned each time and eventually was successful.

The data clearly showed a difference in percent success and percent abandonment for nests from which the hens flushed (Group I) compared to those from which the hens did not flush (Group II). However, it also showed that the rates of success and abandonment of all incubated nests where the investigator had contact with the hens (Groups I and II combined) were not different from those of hens with which he had no contact (Group III). It was therefore concluded that the hens which flushed when approached by the investigator, and subsequently abandoned their nests, did so because of individual differences in response. Those hens that flushed and abandoned apparently had their counterparts among the hens which had no contact with the investigator, since abandonment occurred at a similar rate. It must be assumed that these individuals, in both groups, were physiologically or psychologically predisposed to abandonment. In Group I the investigator's presence provided a disturbing stimulus, not as an added disturbance, but as a replacement for a disturbance that would have occurred naturally in his absence.

Nesting Chronology

Nesting chronology on the Clay Center and Harvard study areas varied from year to year and affected other reproductive parameters. Our purpose in this section was two-fold: (1) to examine factors that affect nesting chronology and (2) to examine the effects of nesting chronology on selected reproductive parameters. Brood data and data from nesting studies were combined to accomplish this purpose.

During the course of this study, a U.S. Weather Bureau reporting station existed at Clay Center, Nebraska, approximately 6 miles from the Clay Center study area and 9 miles from the Harvard study area. Analysis of the effects of weather on nesting chronology was based on data collected at this station for the five-month period, February through June.

MEAN DATE OF HATCH

The mean date of hatch was the variable chosen as a base line for measuring yearly changes in nesting chronology. The mean date of hatch was calculated using the following formula:

$$\frac{\text{(no. of broods x day of hatch)}}{\text{number of broods}} = \text{mean date of hatch.}$$

For any one year this date may or may not conform to the peak of hatch, depending on the configuration of the hatching curve. The data from brood routes were arranged to depict the range in hatching occurring over the 10-year period (Table 8).

Table 8. Mean date of hatch in study areas.

	Harvard		Clay Center		Combined	
	No. of broods	Mean date of hatch	No. of broods	Mean date of hatch	No. of broods	Mean date of hatch
1955	26	5/31	35	6/4	61	6/2
1956	80	6/17	73	6/11	153	6/14
1957	57	6/4	41	6/8	98	6/6
1958	202	6/8	160	6/9	362	6/9
1959	67	6/18	100	6/16	167	6/17
1960	65	6/20	43	6/21	108	6/21
1961	184	6/15	159	6/15	343	6/15
1962	250	6/10	175	6/14	425	6/11
1963	184	6/6	236	6/8	420	6/7
1964	175	6/11	177	6/8	352	6/9
All years combined	1,290	6/11	1,199	6/11	2,489	6/11

In 1955, when the earliest hatching peak was recorded, the earliest nest observed was initiated on April 25. In 1960, when the hatching peak was the latest during the period of study, the earliest nest was initiated on May 16, some 3 weeks later than in the earliest year. In both the earliest and latest years, the nesting season was concluded at essentially the same time with the last brood hatching between July 29 and August 4. The 10-year mean date of hatch in south-central Nebraska was June 11, one week earlier than that observed in Wisconsin (Wagner, et *al.* 1965). Seubert, (1952) noted a terminal date, about the first week in July, after which a hen would not renest. In contrast to Seubert's (1952) terminal date, 9.4 percent of the broods observed during this study hatched from nests initiated after July 7. Our latest observed nest initiation date for a successful nest was July 22. It appears that the effective portion of the nesting season in south-central Nebraska began at least one week earlier and lasted two weeks longer than in more northern latitudes.

In the following discussion, the term "early years" refers to years in which the mean date of hatch occurred prior to the 10-year mean, while in "late years" the mean date of hatch occurred after the 10-year mean.

FACTORS THAT CAUSE CHANGES IN NESTING CHRONOLOGY

Climate

Regression analyses were performed using temperature and precipitation measurements in the following forms: monthly mean, monthly high, monthly low, and monthly deviation from normal. All of these measurements were shown to exert an influence on the mean date of hatch, but the clearest example of this influence was noted in a multiple regression of the total deviation from normal of temperature and precipitation for the months of February, March, April, May, and June. In this analysis, a significant r value (0.619) was obtained. Warmer temperatures were associated with an earlier mean hatching date, while above normal precipitation delayed hatching. Using a standard partial regression analysis on the above r value, it was calculated that 33.5 percent was attributable to temperature, while 66.5 percent was attributable to precipitation. It appeared from this analysis that in south-central Nebraska, seasonal precipitation deviation from normal had more effect on the mean date of hatch than did temperature deviation from normal. The earliest hatching peak occurred during a year classified by the Weather Bureau as "warm and dry", while the latest occurred during a "cold and wet" year.

No relationship between degree-days and mean date of hatch was shown using analysis of variance for the regression ($P>.05$).

A non-significant F value ($P>.05$) using analysis of variance for the regression indicated that no relationship existed between percent of possible sunshine (Lincoln Station) and mean date of hatch.

Density of Hens

A regression analysis of the number of hens present on the study areas in the spring and the mean date of hatch yielded a non-significant r value. From the data examined, it was concluded that spring hen numbers had no effect on the mean date of hatch.

NESTING CHRONOLOGY AND REPRODUCTIVE PARAMETERS

Phenological factors, nesting chronology, and their actions have been credited with yearly changes in pheasant reproductive parameters (Wagner et al. 1965). In order to examine the effects of nesting chronology on certain reproductive parameters in this study, the following analyses were undertaken.

Clutch Size

The depressant effect of late nest initiation on mean clutch size is well established in the literature (Errington and Hammerstrom, 1937; Randall, 1939; Stokes, 1954). Data from this study substantiated findings by previous investigators and has been included primarily to show that Nebraska pheasants operate under some of the same principles that govern this species in other states.

If egg laying begins at about the same time each year but the date of first incubation varies from one year to the next as shown by Wagner (1965), then in years when incubation is late, mean clutch size should be smaller since more clutches would have been laid prior to the one that was incubated. We have already demonstrated that clutch size decreases as the date of nest initiation becomes later.

Based on 469 incubated nests found during the 10-year study, mean clutch size was 9.4. Regression analysis indicated that none of the 10 individual yearly means differed significantly from the overall mean. To determine the effects, if any, on mean clutch size, the 10 years of data were divided on the basis of the mean date of hatch into early and late years (Table 9). Analysis of variance indicated no difference in mean size of incubated clutch regardless of whether the hatching peak was early (9.4) or late (9.5).

Table 9. Mean clutch size of incubated nests, both areas, early vs. late years.

Early Years				Late Years			
Year	Nests	Eggs	Mean	Year	Nests	Eggs	Mean
1955	21	211	10.1	1956	22	215	9.8
1957	17	198	11.6	1959	70	614	8.8
1958	53	550	10.4	1960	29	282	9.7
1963	48	387	8.1	1961	50	496	9.9
1964	114	1,036	9.1	1962	45	412	9.2
Total	253	2,382	9.4	Total	216	2,019	9.5

Percent of Nests and Eggs Incubated and/or Abandoned

Buss, *et al.* (1951) concluded that egg laying began on approximately the same date each year. They further observed that the penned hens in their study laid an average of 12.5 eggs at random, 2 clutches that were not incubated, followed by one clutch that was incubated. They concluded (based on follicle counts) that essentially the same condition existed with wild birds.

Since the design of this study precluded determination of the dates of random egg laying, no data were available to indicate the time pheasants in south-central Nebraska start laying. Therefore, the reference point adopted in this study was the date on which egg laying **in a nest** began. Hence if changes in the hatching curve indicate yearly changes in nesting chronology, then it follows that the peak of nest initiation of clutches that will be incubated varies from year to year.

Wagner, *et al.* (1965) concluded:

> "If egg laying begins at about the same time each year and if it is nest establishment that varies between years, it follows that the length of the period of egg dropping and laying in dump nests varies between years. As a result the total number of eggs laid would vary between years. In an early nesting year, the period between onset of laying and nest establishment would be relatively short, and few eggs would be dropped before nesting. In a late year when nesting did not begin until late, the egg-dropping period would be prolonged..."

It would appear that for the above stated mechanism to operate, there would need to exist a highly significant and negative correlation between the percentage of nests incubated and the percentage of nests abandoned. In years when abandonment was high, incubation would be low. In years when abandonment was low, the rate of incubation would be high. Analysis of data in this study between the percentage of nests incubated and the percentage of nests abandoned was accomplished by linear regression. On the Clay Center study area, the observed relationship between incubation and abandonment was positive and non-significant. On the Harvard study area, 9 miles away, the relationship was negative and non-significant. Thus, no interdependence of abandonment and incubation could be demonstrated.

To determine the relationships of early and late hatching years to nest abandonment and eggs laid per hen, regression analysis was used to compare the mean date of hatch with the percent of nests abandoned and with the average number of eggs laid per hen. In no instance were any significant r values approached. It was concluded that the mean date of nest initiation as determined by the mean date of hatch had no significant effect on the percentage of nests abandoned or the average number of eggs laid per hen. Analysis of variance of pooled data from early, as opposed to late, hatching years indicated no significant difference in the mean number of nests per hen. In early nesting years each hen averaged 3.5 nests, while the corresponding figure for late years was 3.4 nests per hen.

The percentage of nests incubated varied yearly, but in no year did it vary significantly from the 10-year mean. From this, it was concluded that a certain amount of abandonment of incubated and unincubated clutches represented a natural phenomenon for pheasants in the environment under study. This apparent biological waste seems inconsistent in light of the evolutionary processes, but data from this study tended to substantiate what has been described by previous authors (Buss *et al.*, 1951; Evans and Wolfe, 1967). Analysis has shown that the percentage of nests incubated may vary between years but varies within bounds that do not differ significantly from the long term mean. Regression analysis of hen density and the percentage of nests incubated yielded non-significant r values for pooled as well as individual study area data. This analysis demonstrated no significant relationship between the number of hens present in the spring and the percentage of nests incubated.

Comparison of the percentage of nests incubated and the percentage of nests abandoned showed that: (1) these two parameters operate independently of each other, (2) separately they varied independently of the number of hens present in the spring, (3) they fluctuated yearly but never varied significantly from the 10-year mean, and (4) they were not significantly correlated with nesting chronology. It was therefore concluded that the abandonment of incubated nests and the lack of incubation in other nests represented the natural characteristic of pheasant population in south-central Nebraska. Both abandonment and incubation varied annually but within well-defined limits. They were not correlated with each other, nor with any other variable which was measured during the course of the study.

These observations perhaps seem inconsistent with Errington's principle of inversity. However, our hen density may never have been high enough nor fluctuated enough to cause any significant changes.

Egg Fertility, Hatchability, and Dead Embryos

Seasonal decline in hatchability has been described for the chicken (Upp and Thompson, 1927) and for the domestic turkey (Marsden and Martin, 1944). A decline in hatchability rates has not been reported in pheasants (Stokes, 1954; Klonglan, 1962, and Labisky, 1968). Stokes (1954) demonstrated a decrease in the number of chicks leaving each successful nest as the week of hatch progressed. This he interpreted as a function of decreasing clutch size. He further stated, "the percent of eggs to hatch from successful nests varied little throughout the season".

All successful nests for which the number of eggs and fate of each could be determined and for which a nest initiation date could be established were grouped according to week of nest initiation. For all weeks combined, the percentage of fertile eggs was 91.7. Analysis by linear regression showed no significant correlation between week of nest initiation and any of the following parameters: percentage of eggs fertile, percentage of eggs hatched, and percentage with dead embryos. It was concluded that: (1) lack of egg fertility was not a factor in production and did not decrease as the season progressed and (2) embryonic mortality did not increase as the season progressed.

Brood Size

To test effects of hatching chronology on brood size and brood decrement a 10-year mean date of hatch (June 11) was computed. Broods were then tabulated as to whether they were hatched before or after this date. The following discussion of early and late hatched broods follows this classification. Since analysis had indicated that age groups 6-10 weeks were the most accurate indicator of brood size (see Brood Studies), only these age groups were used for comparison. Early broods averaged 5.7 chicks per brood, while late broods averaged 5.5 chicks per brood. This difference was not statistically significant.

Our findings also appear to be in contrast to findings reported by Linder et *al.* (1960). They found that as the population increased, the number of eggs per nest declined, while the total number of eggs remained fairly constant. They concluded that in years of higher population there was more nesting effort, about equal laying effort and less incubation effort.

However, their conclusions were based on the premise that the number of nestings was indicative of the effort exerted by the hen. Analysis was based on total nests and successful nests and not the percentage of nests incubated. All hatched nests were of necessity incubated. However, not all incubated nests hatched.

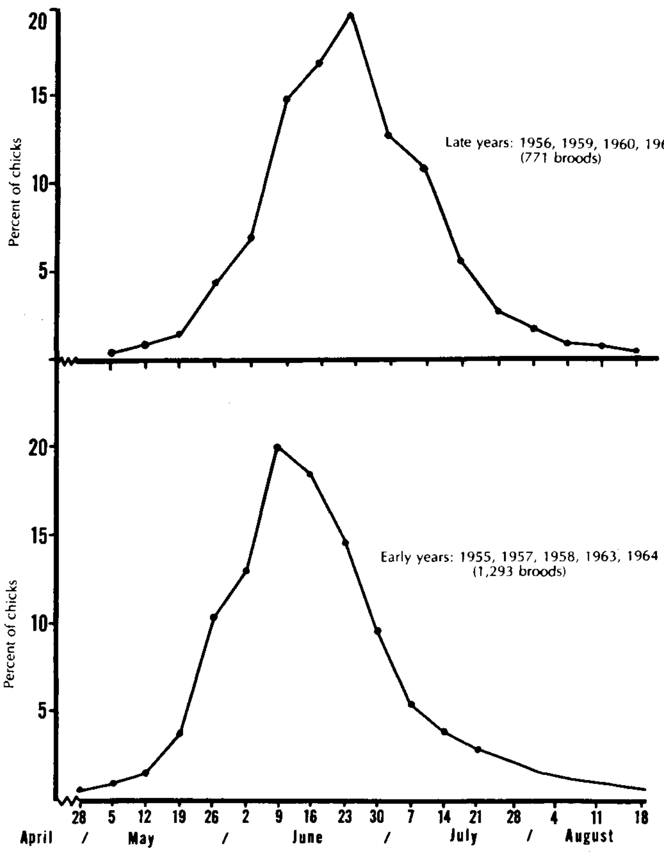


Figure 2. Comparison of hatching peaks, early and late years.

Configuration of the Hatching Curve

Wagner et *al.* (1965) noted a difference in the configuration of hatching curves from years when the peak of hatch was earlier or later than the long-term mean. Curves from late years tended to be higher, more acute, and with one week obviously dominant. Early years provided a less acute peak of hatch brought about by one to three other points that seemed to have almost as high a rank as the peak hatching week. Wagner interpreted this as, "Differences such as these would occur if the hatch were distributed over a longer period in the early years, while being concentrated in a shorter period in the late years." The broader curve with subdominant peaks in early years may represent the effects of renesting. If in early years the nesting season was longer, then more time would be available for renesting (Wagner et *al.*, 1965; Stokes, 1954).

Examination of yearly hatching curves from this study provided no regular differences in the configuration of the hatching curve in early and late years (Appendix Figure 3). Examination of pooled data for early years opposed to late years (Figure 2) provided some apparent differences similar to that noted by Wagner, et *al.* (1965). The difference between the peak week of hatch for the two curves was two weeks. In both, 75 percent of the broods were hatched in a 4-week period, 2 weeks either side of the peak of hatch. In the early years, the peak was skewed to the right, which was interpreted as an effect of renesting. The curve based on late years was skewed to the left, indicating a slow start and a rapid decline in brood production. This was not necessarily interpreted as an indication of low brood production, but merely as an indication of the time period during which the broods were produced and the rate at which peak production was attained and then subsequently declined. In the curve based on early years, 20.3 percent of the broods were produced during the peak week of hatch; the corresponding figure for late years differed only slightly—19.6 percent.

Percentage of Hens with Broods

Theoretically, the percentage of hens with broods starts at zero, and increases as summer progresses until brood production ceases. If no hens or broods died during the summer, the resultant curve would then approximate a sigmoid distribution (Wagner, 1965). Observations of this type are highly problematical, since these limitations do not exist in the natural state. Hens do die both before and after producing broods. Broods can incur mortality or become separated and later mixed with other broods.

In spite of these variables, which complicate analysis, the percentage of hens with broods obviously increased as the season progressed. Data from this study were analyzed with two principal objectives in mind: (1) to determine the effect of date of observation on the percentage of hens with young and (2) to describe any difference existing in this percentage when the mean date of hatch was early or late.

Analysis of data was made with a linear regression (Figure 3). The separation of early and late years was based on the data in Table 1. Analysis of regression coefficients (early = .00980, late = .00595) indicated a lack of homogeneity and a significant difference between the two lines, with an obtained F ratio of 4.18 ($F_{.05}$ (1/286df) = 3.84). In late years on any given date prior to the mean, the percentage of hens with young was lower than that observed for early years. After August 11, the percentage of hens with young during late years continued above that observed during early years. A curvilinear expression of the data plotted using three-point moving averages (Appendix Figure 4) yielded the same relationship as the two plotted lines crossed in mid-August. Wagner, et *al.* (1965) noted an inflection in early August in the curve depicting the percentage of hens with young.

This study showed a similar configuration for both early and late years (Figure 3). Kimball, et *al.* (1965) noted not only an inflection in early August, but a decline through the remainder of the month. An indication of this decline was noted in the present analysis (Figure 3). Data from Wisconsin and South Dakota (Wagner, et *al.*, (1965) indicated that the percentage of hens with young, on any given date, was higher in phenologically early years than in late years. This relationship was constant throughout the period of observation, and the curves showed no tendency to cross as exhibited in our data. Wagner et *al.*, (1965) could show no significant relationship between average hatching date and the percentage of hens with young but stated, "These trends are suggestive of a relationship, but are not statistically significant."

We can demonstrate a significant difference between the slope of the lines for early and late years (Figure 3). However, we cannot explain their relationship to one another or why the relationship reversed as the season progressed.

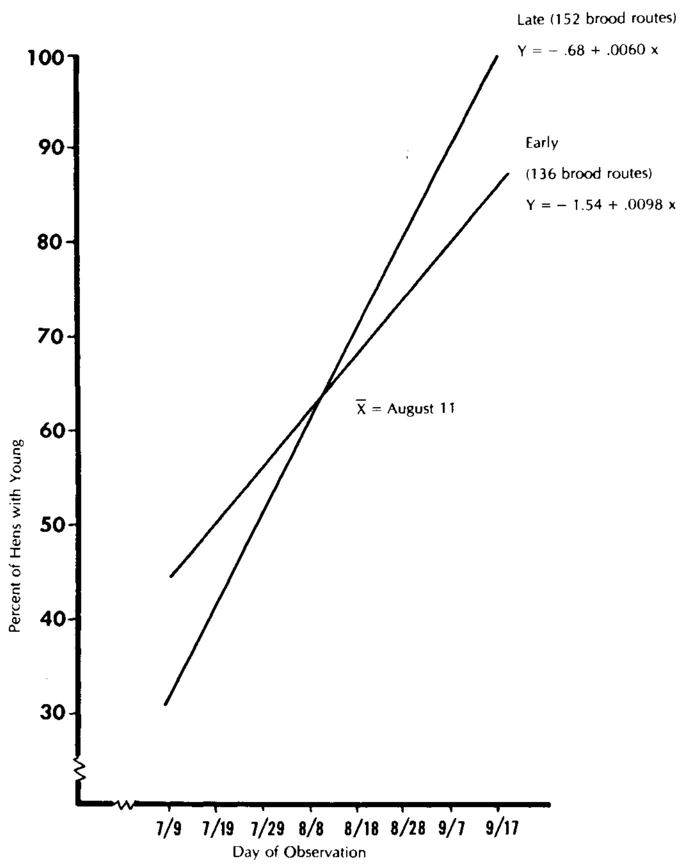


Figure 3. Percent of hens with young during years with an early hatching peak and years with a late hatching peak.

Hen Population the Following Spring

Kabat, Thompson, and Kozlik (1950) noted a higher rate of winter mortality in adult hens following a late nesting season. Wagner et *al.* (1965) suggested that the hardiness of the chick crop might be lower in a late-nesting year and hence more vulnerable to over-winter losses. From the discussions of these authors it seems apparent that the population in years in which the mean date of hatch was late would be followed by a decrease in the following spring population or, if not a decrease, at least a smaller increase than expected.

Regression analysis of spring to spring hen numbers from the present study yielded, r=0.611(r.05(13df)=.514) indicating a positive and significant relationship between the number of hens present in any one spring and the number of hens present on the study area the following spring. A multiple regression analysis with number of hens in the spring and mean date of hatch as the independent variables was used to examine any depressing effects that might have occurred on the number of hens on the study area the following spring. The r value obtained from this analysis was 0.640 (r.05 (13df) = 0.514). This showed that by including the mean date of hatch in the multiple regression analysis, it was possible to explain more of the variation between the number of hens one spring and the number of hens present on the study area the following spring.

Using standard partial regression analysis, 90 percent of the variation was due to the number of hens present in the spring, while only 10 percent was associated with the mean date of hatch. The effect of mean date of hatch on the following spring's hen population was not great, but was demonstrable with data from the present study. Because of the design of the study, it was not possible to determine if this relationship was brought about by increased adult hen or chick mortality.

Roadside Nests

The importance of roadsides as nesting cover has been documented earlier in this chapter. On the two study areas, the total acreage of roadsides available for nesting cover constituted 1.36 percent of the total land area. However, during the course of this study 25.2 percent of all pheasant chicks hatched in this cover type.

To analyze the distribution of nests along north-south and east-west roads, roadsides on the study areas were paired. For example, the north side of an east-west road was paired with the corresponding south side of an east-west road. Pairing was similar for east and west sides of north-south roads. Only nests found on paired roadsides were used for analysis. Included in the data were only 20 miles of north-south roads and 20 miles of east-west roads. Data were paired, with each pair representing one mile on both sides of the road. A sample of 209 nests was available for comparison.

Data from 191 nests were used to examine nest placement in the roadside profile. Three location categories were used to analyze placement within roadsides: (1) the road shoulder (area from the edge of the road to approximately half the slope of the ditch), (2) the ditch bottom (including half of both slopes), and (3) the fence slope (the area from the edge of cultivation and half of that slope).

NEST DISTRIBUTION AND PLACEMENT

The distribution of nests established along east-west and north-south roadsides are shown in Table 10. The data array was analyzed by Chi Square. Testing resulted in a nonsignificant 3.34 (X^2 0.05 = 7.81) indicating that nesting preference and distribution were not affected by direction of the roadside or by exposure differences.

Table 10. Distribution of pheasant nests along north-south and east-west roads on two study areas in Clay County, Nebraska

	East-West Roadside			North-South Roadside	
	Number of Nests	Percent of Total		Number of Nests	Percent of Total
North Side	49	23.4	East Side	58	27.8
South Side	59	28.2	West Side	43	20.6
TOTAL	108	51.6		101	48.3

Placement of pheasant nests on the roadside profile is shown in Table 11, which includes data from sample plots and supplemental searching.

Table 11. Location of 191 pheasant nests in roadside profiles

Location	Number of Nests	Percent of Total	Percent Successful
Road Shoulder	48	25.1	12.5
Ditch Bottom	80	41.9	15.0
Fence Slope	63	33.0	14.3
TOTAL	191	100.0	

Analysis of the profile data array (Table 11) by use of Chi Square indicated that there is a significant difference in selection of nesting sites within the components of the roadside profile (X^2 = 8.03, X^2 0.05 = 5.99). Roadside bottoms were preferred nesting sites, followed by the slope adjacent to the fence.

SUCCESS OF ROADSIDE NESTS RELATED TO DATE OF INITIATION

Stokes (1954) indicated that nests initiated early in the season were less frequently incubated than nests initiated later in the nesting season. Buss, *et al.* (1951) reported a high rate of abandonment and a low rate of incubation for nests initiated early in the season.

A sample of 467 nests for which the date of nest initiation could be estimated were located during the course of this study.

This sample includes nests located on both sample plots and through supplemental searching. All sample plots were searched twice during each nesting season. The average date of completion of the first search was June 1. We assumed that nests found during the second search were initiated after completion of the first search. We thus had a convenient date for separating the nests into two categories: early (236 nests) and late (231 nests). Table 12 shows the fate of these nests.

Table 12. The fate of 467 roadside nests found on sample plots and through supplemental searching

	Number Nests	% Incubated	% Successful	% Abandoned	% Predated	% Farm	% Other
Nests found before June 1	234	26.7	11.9	21.6	54.2	0.9	11.4
Nests found after June 1	231	28.5	13.6	12.7	59.3	3.1	11.3

Analysis of the data in Table 12 indicated no difference between periods except in the percentage of nests abandoned. Abandonment was 21.6 percent in the early period and 12.7 percent in the later period, indicating that hens are more prone to abandon early nests. The percent of nests incubated in the early category was similar to the incubation rate during late periods, 26.7 and 28.5 percent respectively. This difference is not statistically significant and does not support the hypothesis that early nests are less frequently incubated than later nests.

Nest success was quite similar between periods, 11.9 percent for early nests and 13.6 percent for late nests. Nest success did not increase during the late period, even though abandonment declined markedly. Nests not lost to abandonment were lost to increased rates of predation and increased farming losses.

RELATIONSHIP OF CHICK PRODUCTION TO VEGETATIVE CANOPY

Linder and Agee (1963) reported that the number of chicks hatched in roadsides was determined by the density of vegetation during the nesting season. Density of roadside canopy was measured in terms of the percentage of light intercepted. Our final analysis (regression analysis), which included Linder and Agee's data, showed that the relationship between the density of roadside canopy and the number of chicks hatched is statistically significant. Analysis also showed a significant correlation between the number of successful nests and the vegetative canopy of roadside vegetation ($r = .657$, $r\ 0.05 = 0.632$, 8df). However, the data also shows that in years of high canopy there is no decrease in the rate of abandonment and no increase in the rate of incubation.

We interpret these findings as follows: In years of high vegetative canopy in roadsides, more hens select this cover type for their nests sites. Incubation and abandonment rates do not vary significantly with density of vegetation, but there are more successful nests and more chicks hatched because more nests are established in roadsides when the cover is good. Thus nest establishment and chick production in roadsides are a function of the quality of the available nesting cover.

Nesting in Experimental Alfalfa

The importance of alfalfa as nesting cover was mentioned earlier in this chapter. We found that less than three percent of the total area was devoted to its culture. However, pheasants prefer this crop as nesting cover and approximately 27 percent of all nests were found in this cover type. Even though alfalfa was a preferred nesting cover, chick production in this cover type was minimal, because the majority of nests were lost to mowing operations.

Alfalfa is commonly planted on state-managed game lands as nesting cover because of its attractiveness to pheasants. Mowing of these lands has habitually been delayed until after the first of July to minimize the loss of nests and hens. Prior to 1964, there was no evaluation of this management practice.

To evaluate the effects of delayed mowing of alfalfa on pheasant production, three alfalfa fields were leased on the Clay Center study area during 1964 at a rate of $19.06 per acre. They ranged in size from 5 to 17 acres and totaled 32 acres. Additional data regarding delayed mowing was collected from 56 acres of alfalfa on the Cornhusker Game Management Area near Grand Island.

NESTING AND PRODUCTION

Hen pheasants were attracted to the three experimental alfalfa fields, and established 36 nests there (Table 13). Of the 36 nests, 2 (5.6 percent) were successful and 34 (94.4 percent) were not.

Table 13. Nesting effort and production in experimental alfalfa fields on the Clay Center Study Area, 1964.

	FIELD NUMBER			
Field Number	One	Two	Three	Total
Acres	10	5	17	32
Nests	23	6	7	36
Successful	2 (8.7)[1]	0 (0)	0 (0)	2 (5.6)
Unsuccessful	21 (91.3)	6 (100)	7 (100)	34 (94.4)
Nests/Acre	2.3	1.2	.41	1.12
Chicks Produced	24	0	0	24

[1]Figures in parenthesis represent percentages.

The three fields in Table 13 were ranked on the basis of plant density and growth. Field Number One offered the best nesting cover, Number Two was intermediate, and Number Three was classified as poor. Nest densities were related to the quality of the available cover, rather than field size. Nest densities ranged from 0.41 to 2.3 nests per acre, and totaled 1.12 nests per acre for pooled data (Table 13).

Chick production in experimental alfalfa was limited to the field with the highest quality nesting cover (field Number One). Twenty-four chicks were produced in two successful nests located there. Unsuccessful nests in experimental alfalfa were lost through predation, abandonment, farming operations (mowing), and a hail storm (Table 14).

Table 14. Fate of unsuccessful nests in experimental alfalfa fields.

	Field No. 1	Field No. 2	Field No. 3	Total
Predated	7 (33.3)[1]	4 (66.7)	3 (42.6)	14 (41.2)
Abandoned	10 (47.6)	0 (0.0)	2 (28.7)	12 (35.3)
Farming	3 (14.3)	2 (33.3)	2 (28.7)	7 (20.6)
Hail	1 (4.8)	0 (0.0)	0 (0.0)	1 (2.9)
TOTAL	21 (100.0)	6 (100.0)	7 (100.0)	34 (100.0)

[1]Figures in parenthesis are percentages

Predation and abandonment were the major factors responsible for nest failure, and accounted for 76.5 percent of all nests lost. Had mowing occurred during the first week of June, which is the normal harvest time on the area, the majority of nest losses would have been attributed to this factor.

Hail killed one incubating hen in field Number One. However, the effects of that storm may have had a greater impact than just the loss of a single nest. Storm damage to the vegetation in the field was extensive. Therefore, the farmer was released from his contract approximately 1½ weeks early to clean up the field and insure that he would get a second cutting. This operation was responsible for the loss of three incubated nests. Production figures could have been considerably higher had these lost nests been successful.

COST OF YOUNG PRODUCED

Total cost of leasing the 32 acres of alfalfa was $610. Dividing this figure by the 24 chicks produced, gives a cost of $25.40 per chick. If we consider only the high quality field (Number One) and assume that the four nests lost to hail and farming operations were successful at the same rate, the cost per chick produced would still be $2.64. Therefore, leasing of private alfalfa fields is an economically unfeasible method of increasing pheasant production on private lands.

Alfalfa Management Comparisons

Productivity data from the three experimental alfalfa fields were pooled and compared with data from alfalfa fields on the study area that were harvested at the regular time (Table 15). Data from the Cornhusker Special Use Area are included in Table 15. However, pheasant population levels and land use patterns are considerably different than on the Clay County study areas.

Table 15. Nesting effort and production in experimental, private, and state special use area alfalfa fields.

	Experimental Alfalfa	Private Alfalfa[1]	Cornhusker SUA Alfalfa
Acres	32	61	56
Nests	36	31	18
Nests Per Acre	1.12	0.50	0.32
Successful Nests	2 (5.6)[2]	0. (0.0)	5 (27.8)
Unsuccessful Nests	34 (94.4)	31 (100)	13 (72.2)
Chick Production	24	0	45

[1]Includes all other alfalfa fields on the Clay Center area during 1964.
[2]Figures in parentheses are percentages of total nests.

The greatest number of nests and the highest nest densities were found in the experimental alfalfa (Table 15). The nest density of 1.12 nests per acre was twice as high as densities in private alfalfa, and three times as great as densities at Cornhusker SUA. There were more successful nests and more chicks produced at Cornhusker than in the experimental alfalfa fields. There were no successful nests or chicks produced in private alfalfa because the majority of nests were destroyed by mowing operations.

The fate of unsuccessful nests in the three categories of alfalfa fields are shown in Table 16.

Table 16. Fate of unsuccessful nests in experimental, regular and state game land alfalfa fields.

	Experimental	Private	Cornhusker SUA
Predation	14 (41.2)[1]	1 (3.2)	3 (23.1)
Abandonment	12 (35.3)	2 (6.4)	8 (61.5)
Farming Operations	7 (20.6)	28 (90.3)	1 (7.7)
Hail	1 (2.9)	0 (0.0)	0 (0.0)
Unknown	0 (0.0)	0 (0.0)	1 (7.7)

[1]Figures in parentheses represents percent of total unsuccessful nests.

Farming operations caused 90.3 percent of nest failure in private alfalfa. In experimental alfalfa and that at Cornhusker SUA, abandoment and predation were the principle causes of nest failure. Combined, they accounted for 76.5 percent of the unsuccessful nests in experimental fields and 84.6 percent at Cornhusker.

The high rates of nest failure due to predation and abandonment may be related to the concentration of nests and the increased amount of time the nests were vulnerable.

Nest abandonment may be an inherent characteristic of pheasant populations in south-central Nebraska (see Nesting Chronology), and high nest densities may represent some renesting. Abandonment was the principle cause of nest failure on the Cornhusker SUA, and predation was second (Table 16), a reversal of the order found in experimental fields. Differences in nest densities, rates of success, and rates of abandonment and predation can be partially explained by differences in land use on the areas.

In 1964, Cornhusker SUA, 815 acres of state managed lands, consisted of several large fields of alfalfa. In contrast, alfalfa fields on the Clay Center area were much smaller in size, and interspersed with other cover types. Nest densities in alfalfa appears to be inversely related to the field size. Other cover types such as wheat exhibit a similar relationship between field size and nest density.

Although nest densities were low, the rate of nest success at Cornhusker (27.8 percent) was relatively high. Nest failures due to abandonment and predation expressed as a percent of total nests were also lower at Cornhusker (Table 17).

Table 17. Total number of nests and nest failure due to predation and abandonment at Cornhusker SUA and in experimental alfalfa.

	Cornhusker SUA		Experimental	
	Number	Percent	Number	Percent
Total Nests	18	100	36	100
Predated	3	16.7	14	38.8
Abandoned	8	44.4	12	33.3
Total Lost to Abandonment and Predation	11	61.1	26	72.2

Differences in abandonment and predation rates can partially be explained by the problem of accurately measuring abandonment rates. It was not possible to measure the number of nests in the experimental fields abandoned prior to destruction by a predator. The opportunity for a predator to destroy an abandoned nest was reduced on the Cornhusker area because the nests were dispersed over a larger area.

NEST PLACEMENT IN ALFALFA FIELDS

In conducting the nesting study, we noted that pheasant nests were not located at random in alfalfa fields, but appeared to be concentrated within 35 yards of the field border. Therefore, nesting data was analyzed to see if a special relationship existed between nest placement and the field edge.

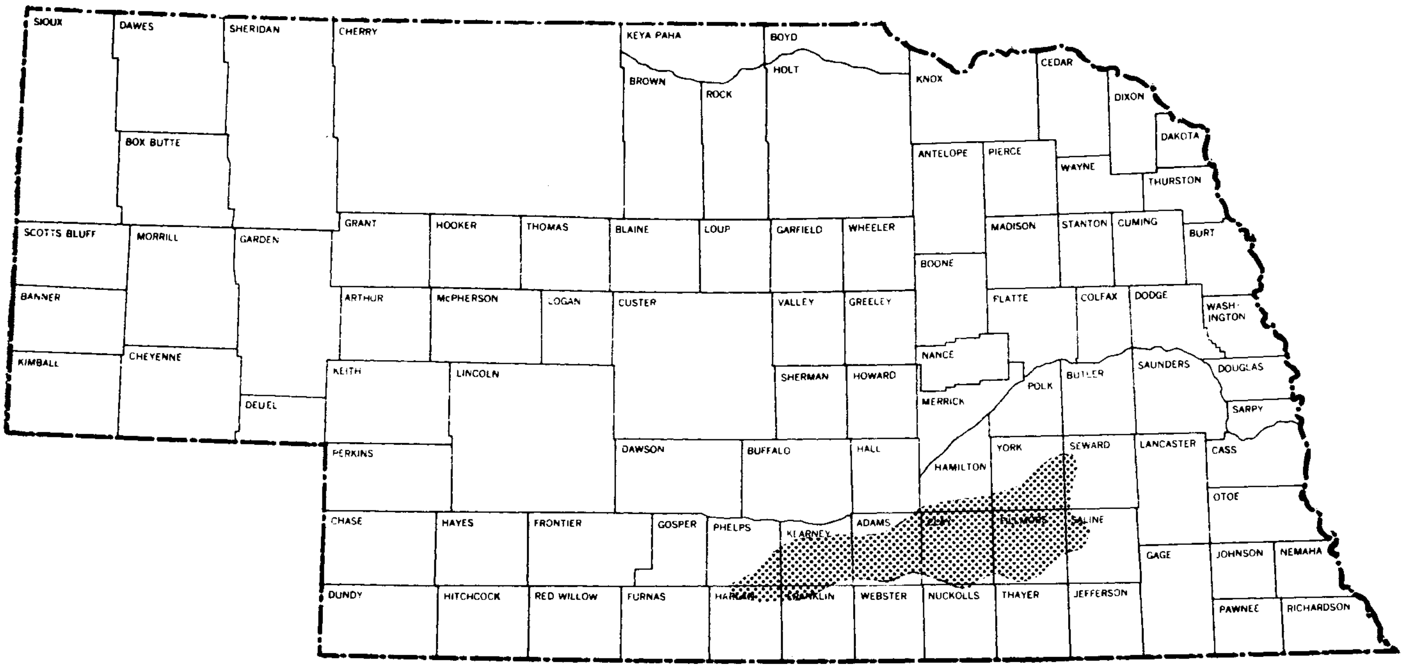
Data concerning the exact location of pheasant nests in relation to field borders were available for 34 nests in experimental alfalfa and 250 nests found in alfalfa during regular nesting studies. We were unable to establish the exact location of two nests in experimental fields and 24 nests in regular fields from the nest records. Appendix Tables 7 and 8 show the placement of pheasant nests in experimental and regular alfalfa fields.

Nest placement data (Appendix Tables 7 and 8) were not normally distributed, and therefore could not be analyzed by standard statistical methods. However, there is a relationship between nest location and the edge of the field. More than 50 percent of all nests in both types of alfalfa fields were established within 50 feet (16.7 yards) of the field boundry, and approximately 75 percent were within 100 feet (33.3 yards).

Pheasant Production in Wetlands

The Clay County study areas are located in the rainwater-basin area, which encompasses some 3,745 square miles in 10 counties in south-central Nebraska (Figure 4). A large part of the region has well-defined drainages and enclosed systems known as rainwater basins.

Most basins range from 1 to 40 acres in size, but some are as large as 1,000 acres. Peculiar to most of these wetlands is Scott silt loam, a soil type which is characterized by an impervious



Location of the rainwater basin region of south-central Nebraska.

layer of clay. Evaporation accounts for the primary loss of water which collects in these basins (50 inches annually).

A number of rainwater basins occurred on the Clay Center study area, comprising 4.5 percent of the total land area. The Harvard area had only a few basins, representing 0.9 percent of the total area. Therefore, only data from the Clay Center study area were used in this evaluation.

NESTING

Wetlands on the Clay Center study area provided important nesting cover, and made significant contributions to total chick production. Table 18 shows nesting and production data for the rainwater basins.

Table 18. Nesting effort and estimated chick production in wetlands on the Clay Center area 1959-1964.

Year	Number Of Nests	Percent of Total Nests	Estimated Chick Production	Percent of Total Chicks
1959[1]	0	0.0	0	0.0
1960	1	1.3	0	0.0
1961	3	3.1	0	0.0
1962	11	14.3	42	7.6
1963	28	28.3	179	23.5
1964	36	19.6	276	30.8
TOTAL	79	12.2	497	11.6

[1]Basins not sampled because of high water and lack of vegetation.

During the 5-year nesting study, 1.3 to 28.3 percent of all nests initiated on the area were established in vegetation in the basins. The 6-year mean for nests established in this cover type was 12.2 percent. Estimated chick production ranged from zero to 30.8 percent of the total number of chicks produced, with a 6-year mean of 11.6 percent.

The basins are of additional importance to pheasant reproduction, because many exert an influence on agricultural use of adjacent land. Because of moist soil conditions, basin perimeters are used most profitably for haying or grazing of the native sedges and grasses. These patches of native hay or pasture provide additional nesting cover and produce additional chicks.

BROOD COVER

Hammer (1964) reported that rainwater basins also provide high quality brood cover. He found densities of 60 chicks per 100 acres in cover associated with basins. Brood use of wetlands showed no apparent time-use patterns as observations in this cover type were evenly distributed during all time periods.

Basins provide brood cover even in wet years when the presence of water during the nesting season precludes use as nesting cover. Many of these wetlands are dry and vegetated by midsummer. We feel that these wetlands tend to draw broods from other cover types which are used for nesting, thereby reducing hen-check interaction which could result in nest abandonment. Linder (1964) demonstrated that an incubating hen pheasant could be induced to abandon her nest upon full contact with chicks.

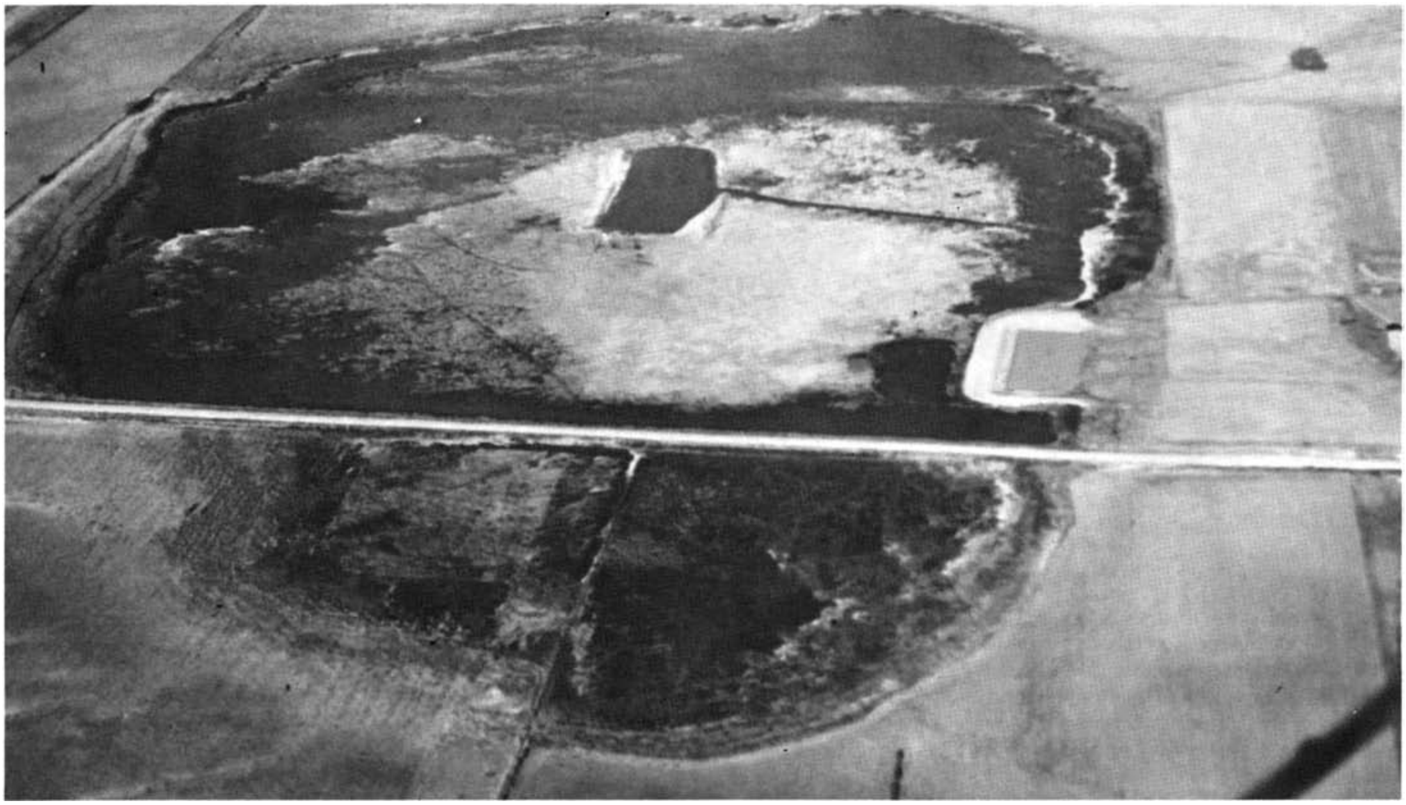
MAN'S INFLUENCE ON WETLANDS

Human activity has had a definite impact on wetlands in south-central Nebraska. Originally 3,909 wetlands, with a combined surface area of 92,000 acres were present in the 10-county region. Intensified agricultural activities have resulted in permanent distruction of more than 3,200 (83 percent) of these basins. Approximately 37,000 acres or 40 percent of the original acreage has been lost. The size of the wetlands lost to intensified agricultural operations is an important factor. Seventy percent of all the destroyed basins covered 10 acres or less, and 93 percent were under 25 acres in size. Thus, the greatest loss has occurred in the smallest wetlands with a resulting decrease in the diversity and interspersion of cover types.

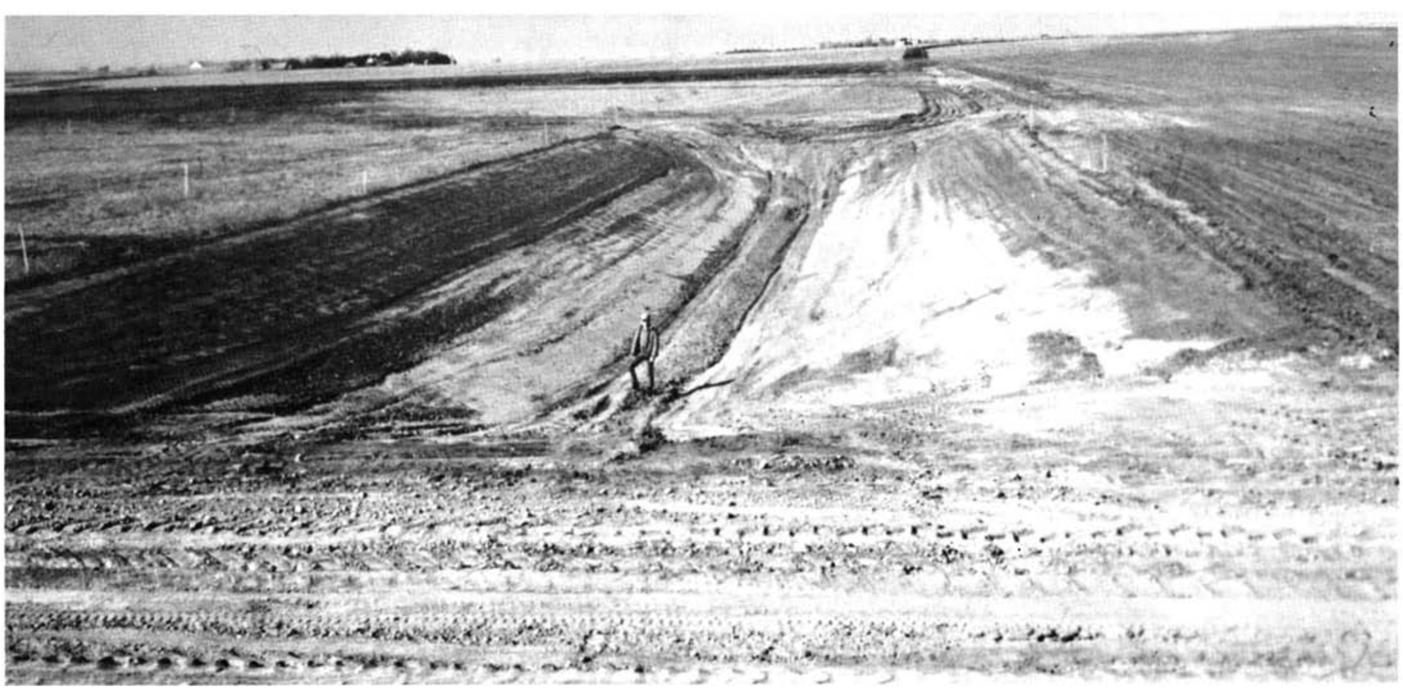
The 692 basins not destroyed have been reduced in size by approximately 44 percent. Permanent destruction of wetlands and size reduction of those that remained was caused by drainage, land leveling, concentration of water in dugouts, and siltation.

Several notable changes in wetlands were recorded on the study area during 1959-1964. Land-leveling practices to prepare fields for irrigation caused losses, in some instances of entire basins. Evidence of other methods of encroachment on basins was noted during the course of the study (Figure 5). Stock ponds and irrigation runoff pits caused significant damage to productive basins in an unusual manner. Excavated material was not piled at the pond edge in all cases. Rather, it was spread and leveled around the newly-constructed pond, thus filling in the basin area. In most cases, this leveled spoil was eventually farmed. Basins were particularly vulnerable to excavation during dry years.

The future looks bleak for the remaining, privately-owned wetlands. The trend in the area is to intensify agricultural operations even more, and most farmers do not feel that they can leave this expensive land idle. Loss of these areas will be accompanied by a decline in pheasant populations.

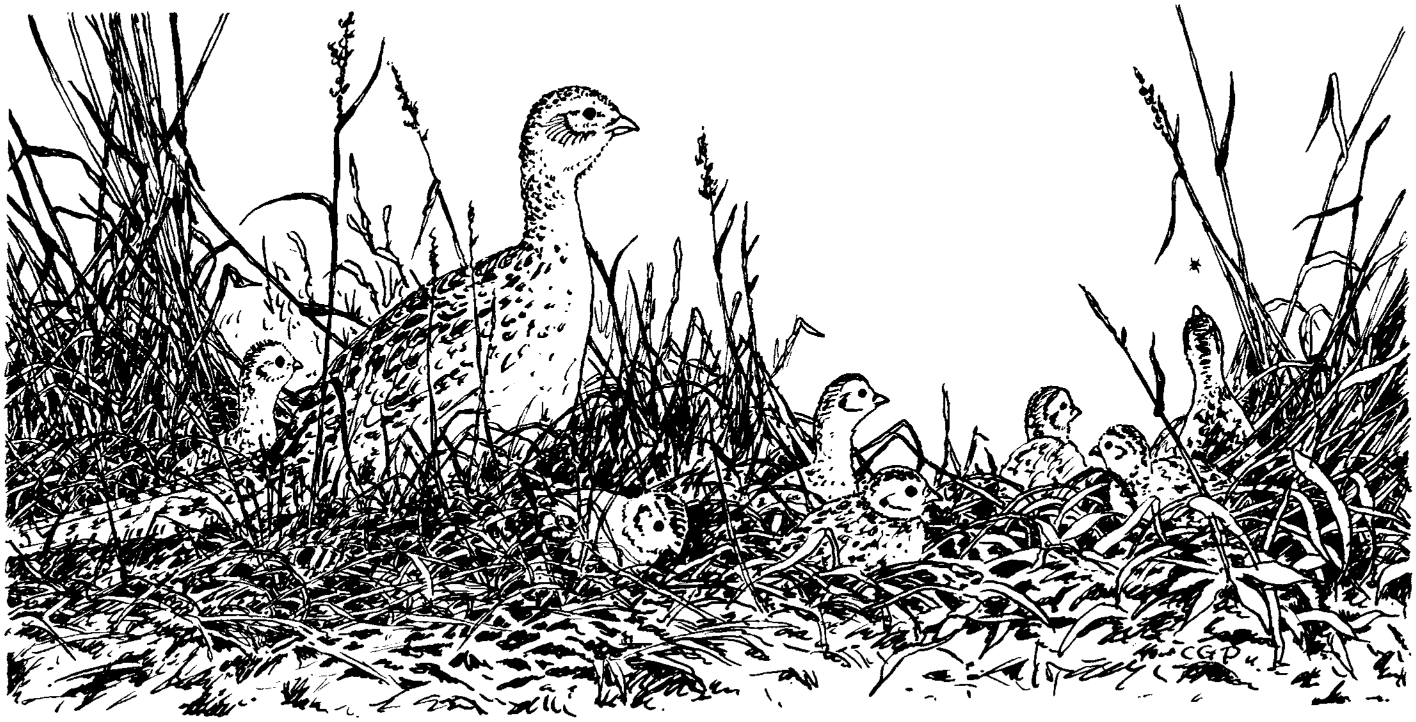


Aerial view of rainwater basin showing intrusion of dugouts and stock ponds.



Dugout excavation (20,000 cubic yards) showing method of leveling spoil with subsequent destruction of rainwater basin.

4. Brood Studies



The roadside census was the major technique used in brood studies, and this method has been an integral part of most pheasant management programs and research studies. The roadside census was developed by Bennett and Hendrickson (1938a) in Iowa, and was rapidly accepted by several other states (Randall and Bennett, 1939; McClure, 1945, and Berner et *al.*, 1960). The widespread use of the roadside census can be attributed to three basic advantages: (1) extensive areas can be censused in a short period of time, (2) large quantities of relatively accurate data can be obtained, and (3) costs are minimal.

Brood studies were originally initiated to provide brood survival data (Hamilton and Linder, 1956). The scope of these studies was expanded to provide: (1) indices to reproductive success, (2) measures of the chronology of hatching, and (3) indices to fall population levels.

Methods

Brood counts were conducted along standardized 30-mile routes which included a portion of each study area (Appendix Figures 1 and 2). The routes were driven daily during July and August except during unfavorable weather condition, such as when (1) rain occurred during the census period, (2) if a rainstorm occurred during the preceding night, or (3) if wind velocities exceeded 15 miles per hour. Beginning at sunrise, observers left a designated point and drove the routes at approximately 15-20 miles per hour.

While the collection of brood data was concentrated on routes on the Clay County study areas, additional data were collected on the Fillmore County area. Included in the census were pheasant broods on or adjacent to the routes, as well as those routinely observed while performing other field activities. When a brood was seen, the observer(s) would stop and study it through binoculars. Binoculars were used only after a brood was spotted and not to locate broods. An attempt was made to flush as many broods as possible in order to obtain a complete count of chicks. The observer recorded the number of chicks in the brood, their age, time of observation, and data regarding the completeness of the count (Appendix Figure 3).

The age of all broods observed on routes or at random were estimated by comparison with photographs of known-age chicks and by criteria which accompanied the photos. During the course of the study, brood aging appeared to be fairly consistent between observers and reasonably accurate. We felt that consistency and accuracy were attained through a combination of the photographs, written criteria, and on-the-job training of new personnel.

Sampling Problems

The importance of hatching phenology in interpreting annual variation in brood statistics has been pointed out by numerous authors. Kimball (1949) discussed the importance of conducting roadside surveys at exactly the same point in the reproductive cycle each year. Klonglan (1955), Labisky (1968) and Wagner, et *al.* (1965) pointed out the need to consider distribution of the hatch in making annual comparison of pheasant productivity statistics.

The importance of obtaining complete counts of pheasant broods was first recognized by biologists conducting pheasant population studies during the 1940's (Shick, 1952; Stokes, 1954, and Robertson, 1958). A pheasant chick's ability to disappear rapidly in cover, plus their innate behavior of remaining immobile when confronted with danger, would indicate that even at their best, complete counts are minimum counts. Wagner, et *al.* (1965) in their interpretation of South Dakota brood data stated "the extent of year to year variation is partly a function of the completeness of the counts." They concluded that "Failure to restrict average brood sizes to carefully counted, complete broods may also be responsible for some of the large variation in pheasant brood sizes reported in the literature."

Stokes (1954) reported that high density pheasant populations on Pelee Island made it difficult to obtain reliable brood counts. Broods commonly mingled, and chicks were often prematurely independent of the hens, with many broods entirely independent by eight weeks of age. Wagner *et al.* (1965) reported some brood mingling in Wisconsin's better pheasant range, although it was not nearly the problem reported by Stokes. Labisky (1969) reported negligible brood mingling on the Sibley study area in Illinois. Brood mingling rates reported by these authors are minimum rates, because mixing of broods in the same age groups is a source of error that is difficult to assess. Mixed broods present a problem in data analysis because brood-size biases cannot be accurately measured.

Quantitative data regarding the loss of complete broods and brood hens are two additional sources of error which complicate statistical analysis of brood data. Juvenile mortality estimates based on field observations are inherently low because of the inability to determine the number of entire broods that are lost from the population (Stokes, 1954; Wagner *et al.*, 1965, and Labisky, 1968). Labisky (1968) points out another potential bias that can occur with the loss of an entire brood. He stated, "And if the entire brood dies, but the hen survives, the hen can be subsequently, but erroneously, classified as broodless or nonproductive."

Hens which die and leave an orphaned brood present another source of bias which cannot be quantified in the usual observational study. Wagner (1957) presented field evidence of the existence of accelerated, annually varying, late-summer mortality of adult pheasant hens. Dahlgren (1963) concluded that adult pheasant mortality from spring-to-fall is the major share of the yearly loss. Such losses of hens during the brooding season may be related to the stresses of reproduction (Kabat *et al.*, 1956; Wagner, 1957, and Dahlgren, 1963). Orphaned broods face three potential fates: partial or total loss of members, adoption by another hen, or independent survival. The age of the brood at the time of hen mortality influences the fate of the chicks. Observation of a brood that is not attended by a hen does not necessarily mean that the brood is orphaned. The hen may actually be attending the brood but not observed.

The influence and importance of climatological factors on the roadside census were recognized early (Randall and Bennett, 1939). The presence or absence of dew is the most important physical factor affecting the roadside census. The importance of this variable has been shown to be statistically significant by Fisher *et al.* (1947), Kozicky (1947), and Klonglan (1955). These authors have indicated that other physical factors such as wind velocity, cloud cover, and temperature do not appear to signficantly affect the number of birds observed. However, Klonglan (1955) noted that rainfall during the census or in the night preceding had an adverse effect on observations.

Statistical reliability of data collected using the roadside census is affected by variation and sampling biases. McClure (1945) found high variation in roadside counts on two 15-mile routes in central Nebraska. He concluded that the roadside count is of value only when used repeatedly prior to the hunting season. Fisher *et al.* (1947) stated, "It is clear that the variability in results secured by the roadside census technique as employed for pheasants is sufficiently great to make conclusions drawn therefrom unreliable."

Other authors have concluded that the fall roadside census is reliable when used to provide an index to population levels and trends (Stiles and Hendrickson, 1946; Kozicky *et al.*, 1952). Berner *et al.* (1970) report that standardized roadside censuses are of considerable value in predicting harvest and production.

Results and Discussions

A total of 4,184 broods was observed on roadside census routes and at random. Observations included 3,875 single-age class and 309 mixed-age class broods. We have utilized these data as indicators of reproductive success, hatching distribution, and juvenile mortality. Emphasis was placed on analysis of data from Harvard and Clay Center, since nesting studies were concentrated on these areas.

AVERAGE BROOD SIZE

Average brood size or the mean number of chicks per brood has been widely used as an index to reproductive success. Labisky (1968) assembled mean brood size data from different states for a number of years and found low variation for this parameter. He concluded that mean brood size must operate within reasonably narrow limits for all pheasant populations.

Analysis of brood data from this study indicated that age groups 6 to 10 weeks inclusive were the least variable as determined by standard error and hence, the most accurate estimate of brood size. Broods in these age groups (6 to 10 weeks) were also the most frequently observed (Appendix Table 1). Hamilton and Linder (1956) used linear regression analysis to analyze data concerning 609 broods. Their analysis also showed no significant difference in brood size from 6 to 10 weeks of age. Wagner *et al.* (1965) also found that the most frequently observed age classes were 6 through 10 weeks. Illinois data indicated that brood size stabilizes without significant variation in the 7 through 9-week classes (Labisky, 1968).

Based on these findings it appears that a strong case exists for using brood size by selected ages. Therefore, we have limited our analysis and discussion of brood size to 6 through 10-week-old broods.

Analysis of yearly changes in brood size was based on 1,094 flushed broods in the 6 through 10-week age classes. Analysis indicated yearly changes in brood size, but these variations were never significantly different from the 10-year mean. The lack of significance in year-to-year variations was due to high variation within years and expressed as standard deviations from the mean. Since a greater amount of variation existed within years than between years, it was concluded that the 10-year mean was the best estimate of the mean for any one year. No other parameter was found with which mean brood size of age groups 6 through 10 weeks could be significantly correlated.

A basic assumption, when working with brood data, is that the brood sizes from a one-chick brood through the largest brood observed approximates a normal distribution. This may be an erroneous assumption, since plotting of data from this study more closely approximates a linear-quadratic distribution. This type of distribution occurred because 39.1 percent of the broods observed fell within the one through four chick-brood classes. If brood sizes do not follow a normal distribution, then the usual statistical treatment could yield misleading results.

In summary, analysis of brood size data from our studies indicate:

(1) The best estimator of mean brood size was the 6-10 week-old age group;
(2) No significant yearly differences occurred in brood size when compared to the 10-year mean;
(3) The lack of demonstrable differences in brood size between years was related to large standard deviations within years that overshadowed differences between years;
(4) That brood size distribution in this study approximates a linear quadratic rather than normal distribution.

JUVENILE MORTALITY AND NESTING CHRONOLOGY

The average number of chicks in pheasant broods progressively decreases from hatching to the age of brood dispersal. This shrinkage in brood numbers is normally referred to as mortality (Stokes, 1954; Wagner *et al.*, 1965, and Labisky, 1968). Juvenile mortality rates are an important statistic in any study of pheasant population dynamics. Stokes (1954) in referring to these rates stated, "But this remains probably the most elusive statistic among population studies of upland game birds, if not for all animals, in the wild."

Brood data were analyzed using an analysis of variance with a one-way criteria classification. From analysis of the data, we could detect no significant decrease in brood size of age groups from 1 through 14 weeks. One-week-old broods average 5.70 chicks while 14-week-old broods average 5.40 chicks per brood. Hence, using brood data alone, no measure of chick mortality was available. Brood data was therefore combined with data from nesting studies to provide an estimate of chick mortality rates. Since analysis of our data indicated that the 6 through 10-week age classes were the best estimate of brood size, chick mortality was calculated from hatching to this point (Table 1).

Table 1. Average number of chicks leaving nests, mean brood size 6-10 weeks and percent mortality.

	Chicks Leaving Nests	Mean brood size (6 weeks)	Percent Mortality
Early	9.4 (40)[1]	5.7 (597)	39.4
Late	8.0 (87)	5.5 (497)	31.3
Total	8.5 (127)	5.6 (1,094)	34.1

[1]Numbers in parentheses equal sample size

Several investigators have reported that a relationship exists between chick mortality and nesting chronology, with late-hatched broods incurring increased mortality (Stokes, 1954, and Wagner *et al*, 1965). Data from our study areas did not confirm this hypothesis.

Analysis of variance indicated that at age 6 through 10 weeks, the mean number of chicks in early hatched broods was not significantly different from the mean number of chicks in late hatched broods (Table 1). However, the difference between the mean number of chicks leaving early or late successful nests was significant, and the corresponding mortality figures were significantly different. Hence, our data indicated that early broods experience greater decrement between hatching and 6-10 weeks of age than do late hatched broods. Though this difference is not demonstrable using brood data alone, it can be inferred since early nests produced more chicks than did late nests as a function of decreasing clutch size. Broods hatched before June 11 experienced 39.4 percent decrement from hatching to 6 through 10 weeks of age, while broods hatched after this date decreased 31.3 percent during the same period.

On the basis of this data, it was apparent that late hatched broods incur proportionately less mortality than early hatched broods in south-central Nebraska. Based on Illinois data, Labisky (1968) also rejected the hypothesis that late hatched broods suffered proportionately higher mortality. He noted that the environment in late summer is more favorable to chick survival and that pheasant hens may be more effective in brooding the smaller number of chicks hatching from late season clutches.

We found average mortality similar to that reported by other authors. This poses a question as to why this similarity existed on widely divergent study areas and over approximately a 30-year period (Table 2).

Table 2. Mean estimates of annual juvenile mortality.

State	Percent Mortality	Source
Michigan	48	Shick, 1952
Wisconsin	30	Wagner *et al.*, 1965
Pelee Island	36-56	Stokes, 1954
Nebraska	34	This study
Illinois	34	Labisky, 1968
Iowa[1]	39-43	Errington & Hammerstrom, 1937
South Dakota	35	Kimball *et al.*, 1956

[1]Calculated mean

Knowledge of the factors responsible for the high mortality rates of juvenile pheasants has eluded investigators for more than 35 years. The majority of chicks lost go undetected even in intensive studies. Stokes (1954) aptly stated the scope of the problem; "The disappearance of so many thousands of chicks in the short space of a summer almost beneath one's eyes and yet not noticed is a baffling experience and an enigma still to be solved." We agree with Stokes, for during this study only isolated cases of chick mortality could be documented.

Even though we were unable to determine the causes of chick mortality and to relate mortality rates to brood age, it was apparent the mortality of pheasant chicks was very pronounced. It also appeared that the majority of the losses occur within a few days after hatching. This was in agreement with other authors (Stokes, 1954; Kimball *et al.*, 1956; Wagner *et al.*, 1965, and Labisky, 1968).

YOUNG PER ADULT FEMALE RATIOS

The observed ratio of young to adult female pheasants has been used as an index to reproductive success for more than 25 years. Mohler (1948) stated, "After several years of roadside counts it is believed that the ratio of young per adult female is a more reliable index of pheasant reproductive success than is the result in terms of pheasants seen per mile of driving." He then cited an instance of a three-year period when pheasant populations in Nebraska were declining and the birds per mile index increased. The young per adult female ratio for this same period declined.

Young per adult female ratios are always lower than young per successful female in late summer, because even hens that are not successful in hatching a brood are included in calculation of the ratio. Young per adult female ratios also fail to account for summer hen mortality, which is reportely high in some areas (Wagner, 1957; Dahlgren, 1963). Thus, it is entirely possible to obtain a favorable ratio of young to adult hens and still have poor reproductive success.

We did not calculate young per adult female ratios as an index to reproductive success. However, we did use brood data and nesting data to arrive at a corrected young per adult female ratio. This ratio was then compared with a young per adult female ratio calculated from hunting season data in the manner described by Wagner *et al.* (1965).

A paired t-test indicated that there was no significant difference between these ratios for either Clay County study area (Appendix Figures 4 and 5).

Hen pheasant with chicks.

5. Cover Utilization by Pheasant Broods[1]

In 1965, a study was carried out to determine the types of cover utilized by broods of pheasants throughout the summer and early fall.

Although many studies have dealt with ring-necked pheasant chicks, only limited information was available on cover utilization by pheasant broods. In Ohio, McCormick (1948) observed that broods spent most of their time in alfalfa and other hay crops, moving to brush patches, waste fields, and woodlots when the hay was cut. In September and October, chicks scattered to all types of cover, with the greatest number utilizing cornfields.

From observations made in New York, Brown and Robeson (1959) stated that a brood's daily travel took them into open areas in the early morning when the grass was wet with dew, into heavier cover during midday, and into hay or weed fields for the night's roost. "Recently cut fields of hay or grain are favored feeding places during the summer and early autumn, although some feeding is done in nearly all types of cover traversed during the day's activities. Fall finds the birds continuing to feed in cover offering seeds of such weeds as foxtail *Setaria spp.* and ragweed *Ambrosia spp.* At this time of year, there is a tendency to shift the roosting site to nearby marshes and swamps."

In Illinois, Hanson and Labisky (1964) found that pheasants were disproportionately associated with forage crops, small grains, and row crops during August. Although more birds per linear unit of cover were associated with forage and small grain crops, the actual number of birds associated with row crops was highest. They therefore concluded that row crops, as well as forage crops and small grains, must be considered as important habitats for pheasants during the brood season. The rate of association of pheasants with different kinds of forage crops reflected the proportion of each type that was left undisturbed.

Based upon observations in Nebraska, Mohler (1959) reported that weeds, grass, sweet clover, and small grain stubble were used to the greatest extent by broods during July and August. Although few broods were actually observed in tree cover or brush, many were seen near these types of cover. Mohler suggested that such woody cover was of considerable value to broods in that it provided shade in hot weather. Hanson and Labisky *op. cit.* stated that the shade offered by woody cover in summer might be more beneficial to pheasants than the protection offered by woody cover in winter. They found that the number of pheasants near woody cover in summer was proportionately greater under warmer and drier weather conditions than under cooler and more moist conditions. Small trees and shrubs were utilized more frequently than tall trees or hedgerows or osage orange *(Maclura pomifera)* or multiflora rose *(Rosa multiflora.)*

Linder (1964), also working in Nebraska, found that broods utilize the same cover types important for nesting—pastures, wheat stubble, odd areas, and alfalfa.

Kozicky (1961), reporting on cover utilization by juvenile pheasants in northern Iowa, found that broods utilized hayfields to the greatest extent, then pastures, noncultivated land, small grains, corn, and oil grains. Fields of corn and oil grains were not used extensively by chicks until after small grains were harvested. Statistical analysis of the utilization of three degrees of cover density in various cover types varied significantly. Cover with a medium density was frequented more than light or dense cover.

With the exception of Kozicky's study in Iowa, none of the above conclusions have been based on actual studies on the types of cover utilized by pheasant broods, but rather on roadside and random field observations. The purpose of this study was to collect information concerning cover utilization by pheasant broods that would be useful for habitat management or calculating population indices.

[1]This section taken from Hammer (1968)

Methods

To determine the types of cover utilized by pheasant chicks, random transects were established in the various cover types. These cover types were plotted on base maps of the study areas. The major cover types sampled were alfalfa, grain sorghum, pasture and native hay, wheat stubble, and noncultivated land, which included roadsides, fence rows, unused areas, and diverted acres under the Federal Feed Grain Program. Corn and forage sorghum were not sampled because the height and density of these two crops made in impossible to flush and observe pheasant chicks satisfactorily.

On each study area, 12 one-half mile transects were randomly located in each of the 5 major cover types. The number of days required to cover all transects on both study areas are referred to as one sampling period. The first sampling period extended from July 19 through August 11; the second from August 12 through September 13; the third from September 14 through October 6, and the fourth from October 7 through October 22. During the first two sampling periods, an additional set of 12 transects was sampled in grain sorghum and wheat stubble on each area. The initial set of transects is referred to as grain sorghum 1 and wheat stubble 1; the additional set is referred to as grain sorghum 2 and wheat stubble 2.

Sampling was restricted to morning and evening periods during the first two sampling periods to avoid observational biases introduced by high midday temperatures. The morning period began at one-half hour after sunrise and extended to 3½ hours after sunrise, while the evening period ran from 3 hours before sunset to sunset. During each morning and evening period one transect was walked in each of the five major cover groups. An equal number of mornings and evenings were spent on each area, and work on the areas was alternated daily. Under ideal conditions, a 12-day sampling period was required to cover all transects on both study areas. Sampling of each cover type was arranged so that no cover type was sampled at the same time every day. All transects were covered on foot, and a Vizsla pointer was used at all times to aid in finding and flushing chicks.

Although transects were walked under varying weather conditions, they were not sampled under extreme conditions such as very high temperatures, strong winds, or rain. High temperatures in July and August often curtailed field work because of the adverse effects on the dogs.

During the third and fourth sampling periods, transects were sampled during a three-hour midday period in addition to the morning and evening periods. An equal number of transects were sampled during each period of the day. The total number of transects was the same as for the first two sampling periods. Thus, it was possible, weather permitting, to cover all the transects in eight days.

During the first three sampling periods, record was kept of the number and size of all broods flushed while walking each transect. For purposes of this study the term brood was defined as a sighting of one or more chicks. Other data recorded at the sight of each flush included existing weather conditions and information concerning the cover. Because of difficulty in distinguishing juveniles from adults during the fourth period (October 7-22), record was kept of all birds flushed during that period.

PERIODIC COVER MEASUREMENTS

Periodic cover-mapping sites were randomly located in the major cover types to measure changes in cover during the summer and early fall. At these sites, plant species present, height of vegetation, percentage of ground cover, and percentage of canopy were recorded. Percentage of canopy was a measurement of light intercepted by vegetation at four inches above the ground [percent canopy = (light above vegetation – light at 4 inches)/light above vegetation]. A Sekonic light meter was used to make readings directly in foot candles. At least four cover-mapping sites were located in each of the major cover types on each area. Each site was visited four times through the summer and early fall to correspond with the four sampling periods. Results for each cover type were combined and averaged to gain an overall picture of cover development through the summer and early fall.

Brood Observations

Although analyses were completed on both brood and chick data, the following discussion of results will be concerned primarily with analysis of the brood data. To perform an analysis of variance where no observations were recorded on sample transects, all raw data were transformed to $D + 0.5$ where D = data recorded. Emphasis was placed on the brood analysis on the assumption that broods traversed and selected cover as units rather than as individual chicks. In nearly all instances, there was a close agreement between the brood and chick analyses. Findings for the two study areas are presented separately, and the analysis for each sampling period is discussed individually. Results for the statistical analyses appear in the appendix.

HARVARD

During the first sampling period (July 19-August 11), 17 broods including 97 chicks were observed on the Harvard study area (Table 3). There was a significant difference in brood utilization of cover. Application of Duncan's multiple-range test indicated significant differences between: wheat stubble 1 and alfalfa; wheat stubble 1 and grain sorghum 2; pastures and alfalfa; and pastures and grain sorghum 2. No broods were observed in alfalfa or grain sorghum 2, and five broods were observed in pastures and wheat stubble 1. Recent hay harvest had made cover in alfalfa sparse and cover in grain sorghum was made up of immature grain sorghum and a relatively few contaminate species. Because of the above-average rains in spring, vegetation in pastures and wheat stubble made rapid growth and became quite dense. Results for analysis of cover utilization by chicks was identical to that for broods.

Five broods were observed during the morning period, and 12 broods were observed during the evening period (Table 1). This difference was significant at the 0.10 level. The cover-time interaction was nonsignificant. Brood observations were evenly distributed between the cover types within each time period. Analysis of the chick data showed there were no significant differences between time periods or cover-time interaction.

During the second sampling period (August-September), 39 broods including 211 chicks were observed on the Harvard area (Table 1). Analysis of the brood data showed that differences among cover types, morning and evening time periods, and cover-time interactions were all nonsignificant.

The ranking of the adjusted means varied somewhat from the same ranking for the first sampling period. Relative to the other cover types, more broods were observed in alfalfa, and fewer broods were observed in pastures. Because alfalfa had not been cut since prior to the first sampling period, available cover had increased. Dry weather and grazing had decreased the amount of cover in pastures. There was good agreement between the duplicate sets of plots in grain sorghum and wheat stubble, as brood observations varied from 2 on each set of grain sorghum plots to 11 and 9 broods, respectively, on the two sets of wheat stubble plots. Of the five broods observed in noncultivated areas, two each were observed on roadsides and unused areas.

Table 1. Results: Brood and Chick Sampling, Harvard Study Area, 1965.

Sampling Period	Time of Day	Number of Broods and Total Number of Chicks in Each Cover Type: Alfalfa	Grain Sorghum 1	Grain Sorghum 2	Noncultivated	Pasture	Wheat Stubble 1	Wheat Stubble 2	Total
1	Morning	–	1 (11)	–	1 (2)	2 (14)	1 (8)	–	5 (35)
	Evening	–	1 (1)	–	3 (12)	3 (15)	4 (27)	1 (7)	12 (62)
2	Morning	1 (3)	1 (1)	1 (16)	3 (7)	4 (23)	2 (14)	3 (12)	15 (76)
	Evening	2 (16)	1 (3)	1 (1)	2 (3)	3 (11)	9 (67)	6 (34)	24 (135)
3	Morning	–	4 (10)		1 (7)	2 (4)	3 (15)		10 (36)
	Midday	–	–		7 (15)	–	2 (4)		9 (19)
	Evening	1 (2)	1 (5)		1 (1)	–	9 (66)		12 (74)
4	Morning	–	2 (2)		5 (17)	1 (1)	1 (1)		9 (21)
	Midday	–	2 (5)		6 (18)	1 (1)	1 (2)		10 (26)
	Evening	2 (4)	4 (5)		5 (12)	1 (2)	4 (19)		16 (42)

Analysis of the chick data did show a significant difference in cover utilization by chicks at the 0.10 level. In a Duncan's multiple-range test, chick utilization of wheat stubble 1 was found to be significantly greater than grain sorghum 1, noncultivated areas, and grain sorghum 2.

The differences in number of chicks observed during the morning (76) and evening (135) time periods was not significant. Although the cover-time interaction was not significant ($F = 1.40$), there were definite indications that chicks preferred certain cover types within each time period. Of the 127 chicks observed in wheat stubble, 101 were observed during the evening sampling period. In grain sorghum and pastures, 17 of 21 and 23 of 34 chicks, respectively, were observed during the morning period.

To detect differences in cover use between the first and second sampling periods, an analysis was run on the combined data for the two periods. During the two periods, there was a significant difference in brood utilization of cover. The number of broods observed in wheat stubble 1 was significantly greater than the number of broods observed in grain sorghum 2, alfalfa, and grain sorghum 1. Total broods observed in pastures were significantly greater than in grain sorghum 2. The time span from the start of the first sampling period to the end of the second sampling period (July 19-September 13) made it difficult to explain use differences in terms of cover. There were significant changes in available cover within and between cover types during the two periods.

From the first to the second sampling period, there was a significant increase in observed broods. Seventeen broods were observed during the first period and 39 broods observed during the second period. Ten of the 39 broods observed during the second period were less than 6 weeks old. Therefore, a large portion of the increase was composed of broods hatched after plots were sampled the first period or broods that were too young to be flushed easily the first period. The influx of late-hatching broods was apparently a result of the very wet spring and subsequent renesting.

There was not a significant difference in cover use between the two sampling periods. The overall increase in broods from the first to the second period was distributed over all the cover types; but, the proportional increase was much greater on the wheat stubble plots than in other cover types.

For the two periods combined, 20 broods were observed during the morning period, and 36 broods were observed during the evening period. Difference between time periods was significant at the 0.10 level. The following interactions were nonsignificant: (1) time and cover, (2) sampling period and time, and (3) sampling period, cover and time.

Analysis of the chick data compared closely to that for the brood data. Significant differences were denoted between cover types, sampling periods, morning-evening time periods, and the cover-time interaction (0.10 level). With Duncan's multiple-range test, chick observations in wheat stubble 1 were significantly greater than in grain sorghum 2, grain sorghum 1, alfalfa, and noncultivated areas. Observations in pastures were significantly greater than in grain sorghum 2.

Chick numbers increased from 97 for the first period to 211 for the second period. A total of 111 chicks was observed during the morning period, and 197 chicks were observed during the evening period.

The significant cover-time interaction was primarily the result of the disproportional use of wheat stubble by chicks. Of the 165 chicks observed in wheat stubble, 131 were observed during the evening sampling period. Chick observations in the other cover types were more evenly distributed between the morning and evening time periods. However, there were tendencies for more chicks to be observed during the morning in grain sorghum and pastures, and more chicks to be observed during the evening in alfalfa and noncultivated areas.

During the third sampling period, 31 broods including 129 chicks were observed (Table 1). Plots were sampled during a midday period in addition to the morning and evening periods. The duplicate sets of plots in grain sorghum and wheat stubble were then eliminated.

There was a significant difference in brood observations between cover types. Brood use of wheat stubble varied significantly from alfalfa and pastures. Differences between wheat stubble, grain sorghum, and noncultivated areas were not significant, nor were differences between alfalfa, pastures, grain sorghum, and noncultivated areas. Hay harvest and grazing coupled with dry weather had greatly reduced the amount of cover in alfalfa and pastures. In addition to there being maximum cover in grain sorghum, most contaminant species of weeds had matured and abundant seed was available. Available cover in wheat stubble was still abundant, and nearly half of the broods were observed there.

Analysis of the chick data revealed a significant difference between wheat stubble and grain sorghum, which had not been detected with the brood analysis. The variation in results for the two analyses might be explained by the difference in average brood size between the two cover types. Average brood size in grain sorghum was 3.0 chicks and in wheat stubble it was 5.7 chicks. A difference of 9 broods between the 2 cover types accounted for a difference of 70 chicks between the 2 cover types.

To account for this difference, it should be noted that the nature of grain sorghum growth limited the effectiveness with which the observer was able to flush and observe chicks. It was often difficult to make a complete flush of a brood in such cover.

Differences in time periods were not significant. The cover-time interaction, however, was significant at the 0.10 level. Ten broods were observed during the morning, 9 during midday, and 12 during the evening. During midday, 7 of the 9 broods observed were in noncultivated areas, while during the evening, 9 of the 12 broods observed were observed in wheat stubble. Broods exhibited a tendency to utilize noncultivated areas at midday and wheat stubble during the evening. The 10 morning observations were distributed over 4 of the cover types. No morning broods were observed in alfalfa, but four were observed in grain sorghum.

Analysis of the chick data denoted no significant differences between time periods or between the time-cover interaction.

During the fourth sampling period (October 7-22), all birds flushed on transects were counted because of the difficulty in distinguishing juveniles from adults at that time. During this period, cover usage by both groups of birds would be expected to be similar. Although adults were counted the fourth period, there was a substantial decrease in number of birds between the third and fourth sampling periods. During the third sampling period, 114 birds including 14 adults were observed on transects. During the fourth sampling period, only 89 birds were recorded in 35 observations. Increased wariness on the part of the birds may account for this difference. Average brood (or observation) size decreased from 4.2 chicks the third period to 2.5 birds the fourth period. Any one of the following four factors could have affected the decrease in brood size: (1) mortality, (2) increased wariness, (3) observation of individual adult birds, and (4) breakup of broods.

Differences in cover utilization by broods and chicks were highly significant during the fourth period. Brood utilization of noncultivated areas was significantly greater than alfalfa. Differences between wheat stubble, pastures, and alfalfa were not significant. Cover conditions were much the same as they were during the third sampling period. Cover in alfalfa and pastures was sparse while cover in wheat stubble, grain sorghum, and noncultivated areas was abundant. Usage of wheat stubble decreased while use of grain sorghum and noncultivated areas increased. Ten of the 16 broods observed on noncultivated areas were observed in fence rows.

Significant differences in chick usage were found between noncultivated areas and the other four cover types. Usage of alfalfa, pastures, grain sorghum, and wheat stubble did not vary significantly.

Analysis of both brood and chick data revealed no significant differences between time periods, or the cover-time interaction. Analyses of the brood data indicated differences between time periods. Sixteen broods were observed during the evening as compared to 9 and 10 during the morning and midday periods respectively.

CLAY CENTER

During the first sampling period, 20 broods including 130 chicks were observed on the Clay Center study area (Table 2). Analysis of the brood and chick data revealed no significant differences among cover types, time periods, and cover-time interactions. In grain sorghum and noncultivated areas, most chicks were observed during the morning, while all chicks in pastures were observed during the evening.

A total of 42 broods including 218 chicks was observed on transects during the second sampling period (Table 2). Differences in brood use of cover were not significant. There was some evidence that broods utilized wheat stubble more than other cover types, since 20 of the 42 broods were recorded on wheat-stubble plots.

Eighteen broods were observed during the morning period, and 24 broods were observed during the evening period. The difference between time periods was not significant. The cover-time interaction was significant at the 0.10 level. In grain sorghum, most broods (7 of 8) were observed during the morning, and in wheat stubble most broods (14 of 20) were observed during the evening.

There was a significant difference in cover use by chicks. Use of wheat stubble 1 was significantly greater than grain sorghum 1, noncultivated areas, and pastures. Neither the differences between time periods nor the difference among cover-time interactions was significant. However, there were indications that chick use of grain sorghum was greater during the morning, while use of wheat stubble and pasture was greater during the evening.

Analysis of the combined brood data for the first and second sampling periods revealed no significant difference in cover use. Duncan's multiple-range test indicated a difference between wheat stubble 1 and the two lowest ranking cover types, sorghum 1 and pasture.

A significant increase in the number of broods was observed between the first and second sampling periods. During the first period, 20 broods were observed; 42 broods the second period. New broods added to the population accounted for a large portion of the increase; e.g. 15 broods observed were younger than 6 weeks. There was no significant difference in cover use between the two periods.

Analysis of the chick data for the combined periods did show a significant difference in chick utilization of cover at the 0.10 level. Chick utilization of wheat stubble 1 was significantly greater than grain sorghum 1 and pastures.

During the third sampling period, 45 broods including 139 chicks were observed on transects (Table 2). A significant difference was found among cover types, and brood observations in grain sorghum were significantly greater than in alfalfa and pastures.

Table 2. Results: Brood and Chick Sampling, Clay Center Area, 1965.

Sampling Period	Time of Day	Number of Broods and Total Number of Chicks in Each Cover Type							
		Alfalfa	Grain Sorghum 1	Grain Sorghum 2	Noncultivated	Pasture	Wheat Stubble 1	Wheat Stubble 2	Total
1	Morning	1 (9)	1 (1)	1 (15)	3 (24)	—	3 (19)	1 (5)	10 (73)
	Evening	2 (10)	—	2 (4)	1 (8)	3 (24)	2 (11)	—	10 (57)
2	Morning	4 (27)	3 (8)	4 (15)	1 (5)	—	5 (26)	1 (8)	18 (89)
	Evening	4 (20)	—	1 (3)	2 (7)	3 (16)	5 (29)	9 (54)	24 (129)
3	Morning	2 (3)	7 (25)		1 (7)	1 (5)	3 (5)		14 (45)
	Midday	—	6 (16)		5 (13)	1 (2)	2 (3)		14 (34)
	Evening	1 (8)	4 (9)		6 (23)	2 (5)	4 (15)		17 (60)
4	Morning	1 (1)	3 (4)		7 (17)	1 (2)	—		12 (24)
	Midday	1 (8)	8 (16)		4 (5)	2 (8)	—		15 (37)
	Evening	1 (3)	4 (10)		5 (8)	1 (5)	8 (38)		19 (64)

Hay harvest had reduced cover in alfalfa while grazing and dry weather reduced cover in pastures. Cover in wheat stubble, noncultivated areas, and grain sorghum was abundant. Differences in observations between these three cover types were not significant. In addition to there being maximum cover in grain sorghum, most contaminant species of weeds had matured and abundant seed was available.

Differences in chick utilization of cover were significant at the 0.10 level. Chick use of grain sorghum was significantly greater than their use of alfalfa. Differences between the other cover types were not significant.

No significant differences were shown between the three time periods or cover-time interaction with either the brood or chick analysis. That chicks utilized grain sorghums early in the day and remained there through midday was indicated by observations of 25 and 16 chicks respectively during these 2 periods. Only nine chicks were observed in grain sorghum during the evening. On noncultivated areas and wheat stubble, most chicks were observed during the evening.

During the fourth sampling period, 46 broods and 125 birds (adults included) were observed on transects. This was a decrease of 38 birds from the 139 chicks and 24 adults observed during the third sampling period. Average brood size decreased from 3.1 to 2.7.

During the fourth period, a significant difference in cover use by broods was shown. Brood use of noncultivated areas and of grain sorghum was significantly greater than that of alfalfa and pastures. Cover in alfalfa and pastures was sparse while cover in wheat stubble, grain sorghum, and noncultivated areas was abundant. Cover use during the fourth period agreed closely with that for the third period. No significant difference was shown between cover types by analysis of the chick data.

Cover-time interactions showed a significant difference at the 0.10 level. All broods observed in wheat stubble were observed during the evening, and 8 of 15 broods observed in grain sorghum were observed during the midday period. Brood observations in the other cover types were evenly distributed over the three time periods. Overall differences between the three time periods were not significant. No significant differences were shown between time periods or cover-time interaction with the chick analysis.

BROOD USE OF THE STUDY AREAS

Analysis of the brood and chick data showed that observed differences between the two study areas were not significant during any of the four sampling periods. During each sampling period, more broods and chicks were observed on the Clay Center area than the Harvard area. These results were in agreement with data collected from the same two areas over 10 previous years. Nesting studies conducted on the two areas over the past six years showed that more chicks were produced on the Clay Center area than on the Harvard area. Results from a similar brood study conducted in 1964 produced the same differences between the two study areas. Throughout the summer and early fall of 1964, 91 broods including 272 chicks were observed at Clay Center, while only 37 broods including 106 chicks were observed at Harvard.

COVER TYPES

Brood use of alfalfa varied with the amount of cover available. During the summer and fall, nearly all alfalfa was mowed for hay at least three times. Regrowth subsequent to mowing was variable depending on the age and quality of the alfalfa and whether it was irrigated.

During the first sampling period, there was a dinstinct difference in brood use of alfalfa between the two study areas. Total number of broods in alfalfa ranked third at Clay Center, while no broods were observed in alfalfa at Harvard. Just prior to the start of the first sampling period, the second alfalfa cutting had been completed on both areas. Regrowth was faster at Clay Center where a much greater proportion of the crop was irrigated.

The third cutting on both areas was not completed until after the start of the third sampling period. Cover in most fields was thus quite abundant during the second sampling period. Nearly half of all broods (11 of 23) observed in alfalfa were observed during the second sampling period. When viewed relative to the other cover types, there was good agreement between the number of broods observed in alfalfa on the two study areas. However, a greater number of broods were observed at Clay Center where the cover was more abundant.

During the third and fourth sampling periods, fewer broods were observed in alfalfa than in the other four cover types. After the third cutting in early September, the alfalfa attained little growth and cover was sparse.

In grain sorghum, brood utilization increased steadily through the summer and early fall. During the first two sampling periods, neither grain sorghum nor its contaminant weed species had attained full growth or matured. By the start of the third sampling period, must contaminant weed species had matured and the sorghum heads had filled out. Thus grain and weed seeds, which make up a large portion of older chicks' diet, were readily available. Also, the loose, cultivated soil in grain sorghum fields made them prime dusting areas.

Without exception during each of the four sampling periods, more broods utilized grain sorghum at Clay Center than at Harvard. The discrepancy between the two areas might be explained by the difference in corn and grain sorghum acreage between the two areas. At Clay Center, only 1.6 percent of the area was devoted to corn, while at Harvard 12.5 percent of the area was planted in corn. The type of cover provided by corn was very similar to that provided by grain sorghum. However, it was impossible to sample corn because of its great height. Those broods found utilizing grain sorghum at Clay Center may have been using corn at Harvard.

In pastures and native hay, brood utilization was greatest during the first two sampling periods (July 19-September 13). During the third and fourth sampling periods, few broods were observed in these two cover types. During the early portion of the summer, cover in pastures had been enhanced by the heavy spring rains, but dry weather coupled with continued grazing greatly reduced the amount of cover in pastures by the end of August. In relative terms, more broods were observed in pastures at Harvard than at Clay Center. In retrospect, it was apparent that cover was heavier in pastures on the Harvard area. At Harvard, grazing was not as heavy as at Clay Center and much of the pasture ground was located in areas where it received irrigation runoff from adjacent crop land.

Broods utilized native hay until it was mowed in late August. In lowland areas where native hay was not mowed, broods continued to utilize it through the fall.

Although not reaching a peak until the fourth sampling period, brood observations on noncultivated areas were comparatively high throughout all four sampling periods. The lowest number of broods observed on noncultivated areas was during the second sampling period, when the chick population reached its highest density. During all sampling periods, there was good agreement between the results obtained on the two study areas. During the third and fourth sampling periods, use of noncultivated areas ranked second and first respectively on both areas. At Harvard, utilization of noncultivated areas was significantly greater than the other four cover types.

Definite trends were observed in each of the cover types making up the noncultivated cover group. Use of diverted acres gradually increased through the first three sampling periods,

Nine-week-old pheasant chicks in milo.

then dropped off in the fourth sampling period as nearly all diverted acres were plowed or disked. Observations on unused areas were constant during the first two periods and showed gradual increases during the last two periods. Use of roadsides dropped off slightly during the second period, but showed substantial increases the third and fourth periods. Brood observations in fence rows showed steady and substantial increases each sampling period.

Brood use of wheat stubble was most intensive during the first three sampling periods. Since the wheat harvest had been completed just prior to the start of the first sampling period, the only cover available initially was that offered by the stubble. However, it took only a short time for most weeds to attain substantial growth. As a result, cover in wheat stubble fields was tall and dense for the remainder of the summer.

Cover use during the four sampling periods was consistent between study areas. During the first sampling period, brood observations on the two wheat stubble plots ranked first and fifth at Harvard and first and sixth at Clay Center. During the second period, the wheat stubble plots ranked first and second on both study areas. Forty broods (20 on each area) representing 244 chicks were observed in wheat stubble during the second period. Half of all broods observed during the second period were observed in wheat stubble. During the third sampling period, broods observed in wheat stubble ranked first at Harvard and third at Clay Center. Although grain sorghum and noncultivated areas were utilized more intensively than wheat stubble at Clay Center, the differences between the three cover types were not significant. During the fourth sampling period, broods observed in wheat stubble ranked third to noncultivated areas and grain sorghum on both study areas.

TIME OF DAY

Analysis of the time data revealed few significant results when broken down into study areas and sampling periods. When the data for both study areas and the four cover types were combined, definite preferences were shown by broods for the various cover types during certain parts of the day.

In alfalfa, most broods were observed during the evening sampling period. Fewer broods were observed in alfalfa during the morning, and only one brood was observed in alfalfa during midday. Possibly alfalfa was avoided during the morning because of the heavy dew often there at that time. Of those broods observed in alfalfa during the morning, none were observed when there was a dew. The fact that broods were not observed in alfalfa during midday would indicate that it was poor loafing cover.

Observations in grain sorghum were most numerous during the morning and midday sampling periods. This indicated that chicks apparently move into grain sorghum early in the day and remain there until late afternoon. Grain sorghum apparently serves as both a good feeding and loafing cover. The fact that some broods were observed in grain sorghum very late in the evening during September and October suggested that grain sorghum might also be used as a roosting cover. On a few occasions, roosting sign was observed in grain sorghum.

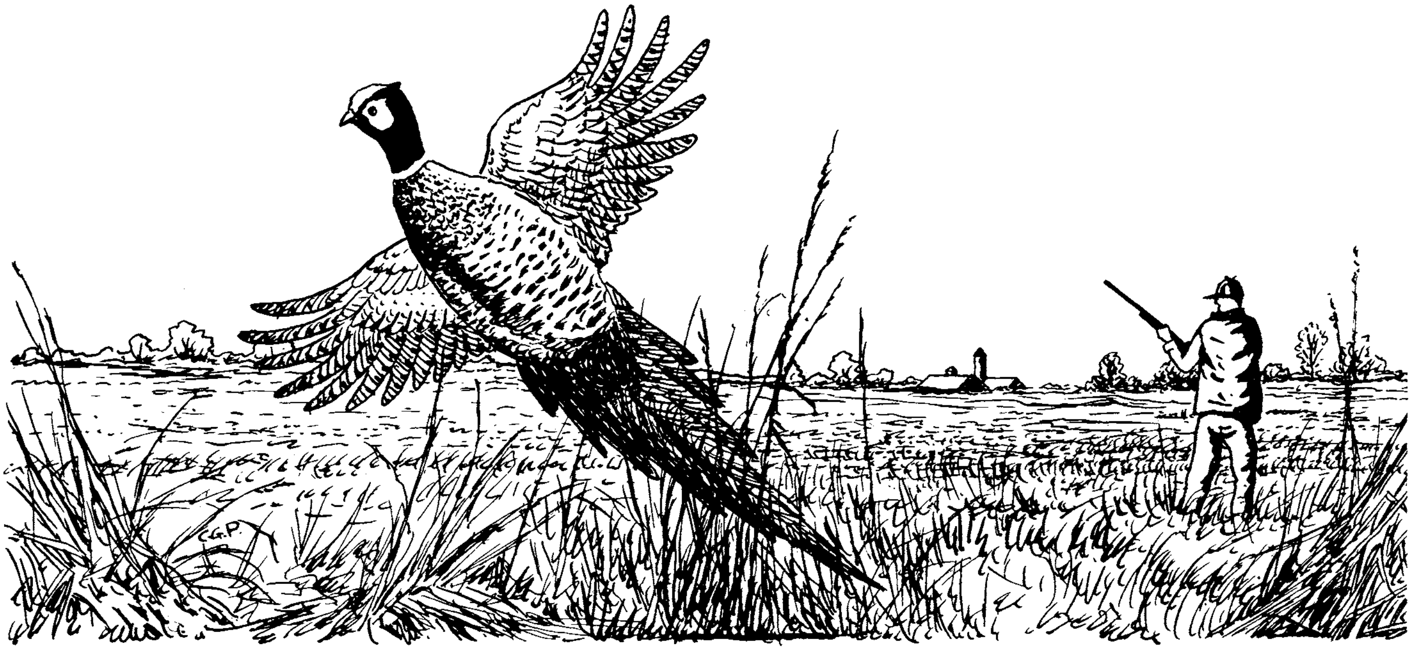
In pastures and native hay, observations were evenly distributed between the morning and evening sampling periods. Fewer broods were observed in pastures during the midday period. This would suggest that pastures might be important as roosting cover, especially during mid-summer when cover in them was heaviest. The importance of native hay as roosting cover was apparent as nearly all broods observed in native hay were observed very late in the evening or very early in the morning.

Observations on noncultivated areas were evenly distributed between the three time periods. When viewed separately, certain time-cover preferences were shown by broods for the four cover types making up the noncultivated cover group. Most brood observations in fence rows were made during the midday period. There was an apparent shift in time-cover usage of roadsides as the summer progressed. During initial sampling, most roadside observations were made during the morning or evening. Later in the summer, more broods were observed in roadsides during the midday period. Roadsides with very heavy weed growth or trees and shrubs received the greatest usage during the latter part of the summer. Usage of diverted acres and unused areas suggested no apparent time patterns as observations were about equal for all time periods.

The most significant cover-time interaction was found in wheat stubble. Of the 89 broods and 489 chicks observed in wheat stubble during the 4 sampling periods, 61 broods representing 367 chicks were observed in wheat stubble during the evening time period. Of the 23 broods observed in wheat stubble during the morning, most were observed shortly after sunrise. Only five broods including nine chicks were observed in wheat stubble during midday. These observations would indicate that wheat stubble was heavily used as a roosting cover.

The very heavy use of wheat stubble as roosting cover provided a partial explanation for the imbalance in observations between morning and evening time periods through most of the summer. The use of wheat stubble as a roosting cover concentrated broods in that cover during the evening. Therefore, sampling yielded inflated results for wheat stubble and the evening sampling period. When wheat stubble observations were subtracted from total observations for the morning and evening periods, the remaining four cover types were about equal. Thus with a given population, equal sampling during the morning and evening provided equal totals for the two periods and lent credibility to the sampling technique used.

6. Harvest



Hunting seasons play an important role in the life history of Nebraska pheasant populations. Statewide surveys have indicated that approximately 60 percent of the cocks in the fall population are harvested by hunters. These rates are similar to the reported proportion of cocks harvested in South Dakota (Trautman, 1968), but well below rates reported for Pelee Island (Stokes, 1954), Ohio (Leedy and Hicks, 1945) and Michigan (Shick, 1952). None of these authors indicated that harvesting a high proportion of the fall cock population was biologically unsound.

Methods

Complete control of the number of hunters using an area would be the "ideal" situation in a pheasant life-history study. In this study, the hunt could not be directly controlled by project personnel because (1) a major portion of the study areas were privately owned and (2) hunters had numerous access routes onto each area along the section line roads which transected the areas. Therefore, control of hunting was placed primarily in the hands of landowners or their agents.

Fiberglass signs (Appendix Figure 1) were placed at one-quarter-mile intervals along all roads in and around the study areas. These signs explained the purpose of the study and instructed the hunter to contact the landowner for permission to hunt. Mimeographed sheets affixed to the signs informed hunters of the name of the farmer in charge of each parcel of land and directions for locating his house.

Prior to the hunting season, each cooperating farmer was given a supply of envelopes (Figure 1) to issue to hunters as a permit to hunt on his land. The first year of the study (1955), each hunter was given an envelope. In subsequent years, one envelope was given to each hunting party. The front of each envelope was printed as a permit to hunt and as a questionnaire for the hunter(s) to report success at the end of the hunt. Hunters were asked to place the right wing and right leg of each pheasant harvested in

PLEASE ANSWER QUESTIONS ON ENVELOPE AND RETURN EVEN IF YOU KILL NO BIRDS.

THIS IS YOUR PERMIT TO HUNT THE.................................FARM.

Remember that you are a guest on private property: show your appreciation by cooperating with the farmer.

Date.................................

Hours hunted........................a.m./p.m. to........................a.m./p.m.

Number in party.................................

Number of pheasants bagged.................................

Number of pheasants hit but not retrieved.................................

Name (Optional)........................ Address........................

☐ Check here if you want bands or tags returned. We will include information about the birds you have killed.

(over)

PHEASANT HUNTERS

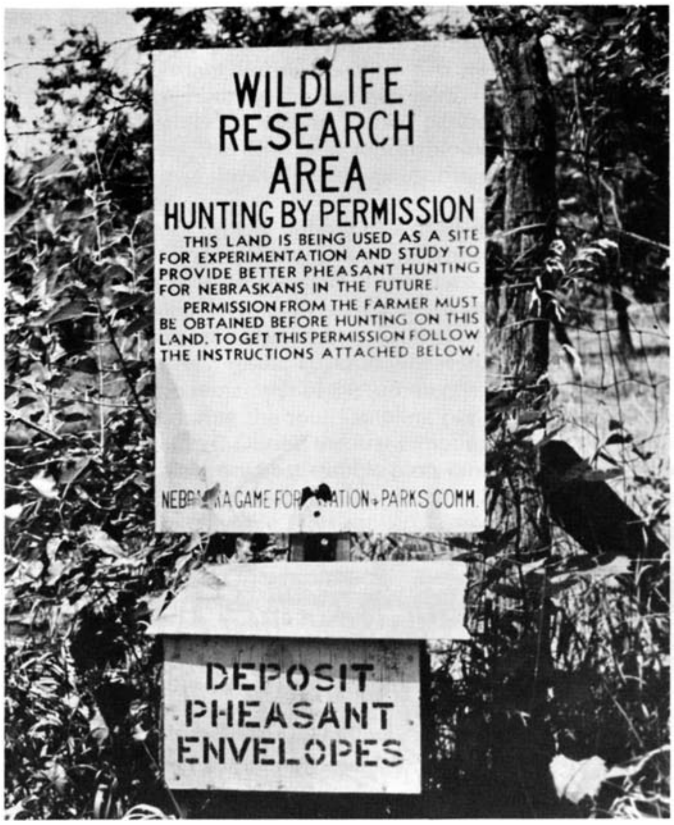
WE NEED WINGS, LEGS, BANDS AND TAGS OF PHEASANTS YOU SHOOT ON OR NEAR THIS AREA.

BY EXAMINING THESE ITEMS WE CAN LEARN WHEN THE BIRDS WERE HATCHED, HOW FAR THEY MOVED AND OTHER VITAL INFORMATION. THIS INFORMATION HELPS US PLAN BETTER PHEASANT MANAGEMENT.

DIRECTIONS

1. Fill in blanks on other side of envelope even if you kill no birds.
2. Cut off RIGHT WING at the first joint: RIGHT LEG at joint below drumstick.
3. Place the wing and leg of each pheasant you kill in this envelope; also include band and/or tag, if present.
4. Drop envelope in silver Game Commission box on section corner.

Figure 1. *Hunter questionnaire envelope (front and back).*



the envelope. Diagrams of how to remove the wing and legs were printed on the reverse side of each envelope (Figure 1). Hunters were also asked to deposit the envelopes in marked boxes located on each section corner.

Biologists cruised the study areas regularly to assist hunters and farmers with any questions they might have, to deliver additional envelopes to farmers needing them, and to pick up envelopes deposited in collection boxes. After the hunting season, each cooperating farmer was visited to pick up envelopes not issued to hunters and to obtain his reaction concerning hunter cooperation during the season.

Results and Discussions

HUNTER EFFORT AND HARVEST

Data collected from hunter-envelope returns on the study areas from 1955 through 1964 are summarized in Appendix Tables 1 and 2. Over the 10-year period, the total hunting effort on the two Clay County areas was practically identical, but the total harvest on the Clay Center area was significantly greater than that on the Harvard area.

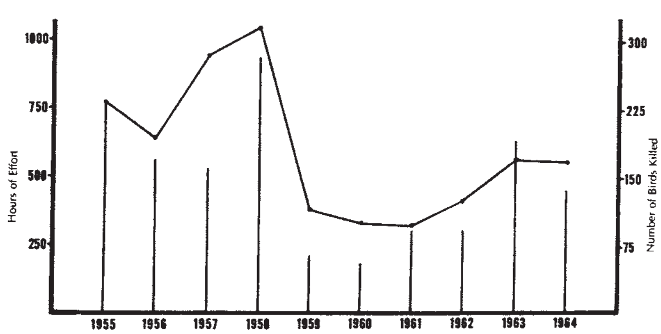


Figure 2. Relationship of hours of effort to number of birds killed, Harvard and Clay Center study areas.

Hunter effort generally followed the availability of birds (Figure 2). In 1958, for example, hunter success was high as indicated by the total number of birds harvested. Effort decreased in 1959 and then remained stable until 1962. An increase in hunter effort was again noted in 1963 and 1964. Data from the Fairmont study area supported the hypothesis that hunter effort is related to availability of pheasants. This study area supported a lower fall pheasant population than the Clay County area and hunter effort and harvest were also significantly lower (Appendix Table 3).

Linear regression analysis indicated that a direct relationship existed between hunting effort (gun hours) and total harvest on both the Harvard and Clay Center study areas (Appendix Figures 2 and 3). However, the amount of effort required to harvest a bird differed between the two areas. An average of 5 hours was required to bag a cock on the Harvard area, while 3½ hours were needed on the Clay Center area during the ten years. More hunting pressure was directed toward the Harvard area during the first five years of study, while a greater amount of gunning pressure was exerted at the Clay Center area during the last four years.

Comparison of crippling rates indicated that no significant difference existed between the Harvard and Clay Center areas (Appendix Figure 4). The percentage of cocks hit but not retrieved on the Harvard area averaged 18.2 for the 10 years, while at Clay Center the crippling loss was tallied at 15.2 percent. A significant relationship was found between the total kill and the number of birds hit but not retrieved on both Clay County areas (Appendix Figure 5). As the total kill increased, a proportionate increase in birds hit but not retrieved occurred. Average crippling rate for both Clay County areas during the 10-year period was 16.5 percent.

EFFECTIVENESS OF THE ENVELOPE SYSTEM

The envelope system used in this study would have been completely effective only if all hunters using the area obtained envelopes and returned them properly completed. Chances of 100 percent cooperation from hunters were remote, since (1) a few hunters trespassed and had no envelope, (2) illegal road hunting occurred along roads which transected the areas, and (3) all hunters having envelopes did not return them. Table 1 summarizes hunter envelope returns from the study areas.

Table 1. Summary of envelope returns from the Harvard, Clay Center and Fairmont study areas.

	Harvard	Clay Center	Total
Envelopes issued	1,010	1,084	2,094
Envelopes returned	450	499	949
Percent returned	44.5	45.8	45.3

Approximately 45 percent of all permit envelopes issued were voluntarily returned by hunters legally using the areas during the course of the study. Returns at Harvard ranged from 24.7 percent to 53.5 percent and averaged 44.6 percent. On the Clay Center area, returns ranged from 28.2 percent to 62.7 percent and averaged 45.2 percent.

Linear correlation analysis of combined data from the Clay County areas indicated that an inverse relationship existed between percentages of envelopes returned and the effort required to bag a cock bird (r = 0.6019). This relationship was significant at the 0.10 percent level and approached significance at the 0.05 percent level. As the amount of effort required to harvest a bird increased, the percentage of envelopes returned decreased. This would indicate that in years when more effort was required on the hunter's part, fewer hunters were successful and, therefore, less inclined to fill out and return their permit envelopes.

ESTIMATED HARVEST

Total harvest could not be estimated directly from envelope returns because of the high variation in the rate of return and biases inherent to any study relying on voluntary response. We felt that the actual harvest of pheasants on the areas was from 10 to 20 percent higher than that reported by cooperating hunters. Therefore, a sliding scale for estimating the harvest was developed.

Hunter effort expressed in terms of total gun hours of effort from the envelope returns was the best indicator of hunting pressure and indirectly a measure of the availability of pheasants on the area. Total gun hours was also shown to be significantly correlated with total birds harvested. Therefore, this parameter (total gun hours) was used as the basis for adjusting harvest data. We assumed that a direct and positive relationship existed between reported hunting pressure and hunting pressure that was not reported because of non-response or illegal hunting. As the reported pressure increased, the rates of trespass and road hunting increased.

Adjusted harvest figures for the Harvard and Clay Center study areas are shown in Appendix Tables 4 and 5.

HUNTER CHARACTERISTICS

To classify hunters using the areas, the following categories were established: (1) Local hunter—a resident of Clay County; (2) Non-local hunter—a resident of Nebraska living outside Clay County; (3) Nonresident—one living outside Nebraska.

Data relating to the hunters' points of origin, party size, and success from 1960 through 1964 were extracted from questionnaire envelopes returned by hunters using the Harvard and Clay Center areas. Thus, hunter trends for the Clay County study areas could be traced.

Hunter Origin and Party Size

Trends in the origin of hunters using the study areas in Clay County were examined. As shown in Table 2, a significant change in hunter composition occurred from 1960 to 1964. Percentage use of the areas by non-local hunters, primarily residents of the Lincoln-Omaha area, hit a high of 86.3 percent during 1960. By 1964, pressure by non-local hunters had declined to a low of 11.6 percent. While the actual number of non-local hunters using the areas did not decline until 1964, they were diluted by increasing numbers of local and nonresident hunters. Local hunters made up only 14 percent of the total in 1960, but by 1964 they constituted more than one-third of all hunters.

Table 2. Source of hunters using the Harvard and Clay Center areas.

Year	No. states represented	From Envelope Return	No. states represented	From Registration
		—Percent Nonresidents—		
1960-61	0	0.0	0	0.0
1961-62	1	5.5	3	19.4
1962-63	2	22.3	1	9.1
1963-64	3	21.1	5	17.6
1964-65	7	51.9	9	42.8
		—Percent Non-locals—		
1960-61		86.3		0.0
1961-62		76.1		67.2
1962-63		52.9		69.7
1963-64		41.9		38.1
1964-65		11.6		20.1
		—Percent Locals—		
1960-61		13.7		0.0
1961-62		18.3		13.4
1962-63		24.8		21.2
1963-64		35.9		44.0
1964-65		36.5		36.4

The distances traveled by non-local hunters using the areas was analyzed by examining hunter envelope returns. The greatest number of hunters using the Clay County areas from 1960-1964 had come from a radius of 100-149 miles, which included the Omaha metropolitan area. The second highest number of hunters came primarily from the Lincoln area or from within 50-99 miles of the study area. The lowest number of non-local hunters came from the 150-mile-plus radius. Over the study period, it became obvious that most hunters were willing to drive at least 50 miles but not more than 150 miles to hunt on the study areas (Figure 3).

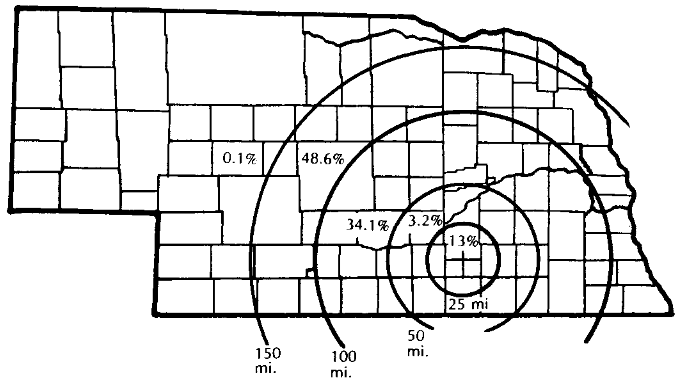


Figure 3. Percentage of hunters related to distance from the study areas

The trend toward increased use of the areas by nonresident hunters contrasts sharply with the pattern of use by non-local hunters (Figure 4). From no use by nonresidents in 1960, a rapid increase was recorded up to 1964, when nonresidents accounted for 52 percent of all hunting effort on the areas. The majority of nonresident hunters in 1961-63 were from Missouri and Oklahoma. In the last year of the study, hunters were recorded from nine different states. However, adjacent states to the south still continued to supply the majority of nonresident hunters.

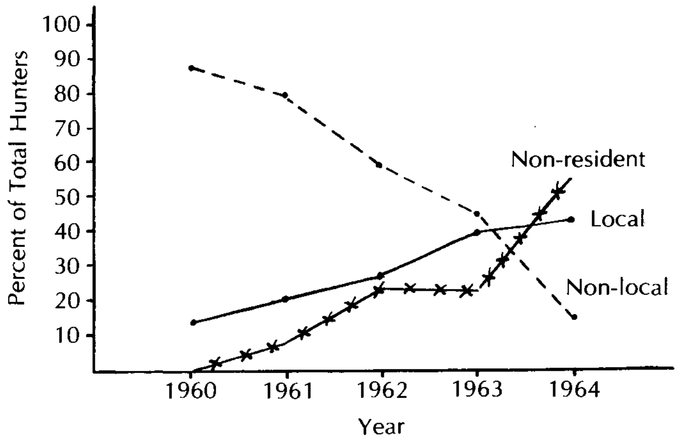


Figure 4. Composition of hunters using the Harvard and Clay Center Areas.

Table 3. Average number of hunters per party using the Harvard and Clay Center Areas.

Year	Local	Non-local	Non-resident
1960	1.8	3.7	—
1961	2.8	4.9	6.0
1962	3.7	4.0	6.7
1963	3.9	4.1	4.0
1964	3.0	3.8	3.5
Mean	3.23	4.06	3.98

The average party size for the three categories of hunters is shown in Table 3. Average size of local hunters' parties increased from less than two in 1960 to three by 1964. Non-local party size remained stable, while nonresident parties decreased from 6.0

to 3.5 hunters. Average sizes of hunting parties for non-local and nonresident were almost identical, 4.1 and 4.0 hunters respectively, and exceeded the party size for local hunters by nearly one man. Applying an unpaired t-test to resident and nonresident data indicated that a significant difference (.05) existed in party size (Appendix Figure 6).

Information available from the 1964-65 hunting season indicated that the nonresident was a more efficient hunter than the resident. Nonresidents required only 4.0 gun hours per bird, while the resident needed 5.9. From partial information on hunter effort in 1964, calucations indicated that the nonresident accounted for about 70 percent of the total kill on both areas. That the nonresident was more cooperative was evident in the envelope return records for 1964. Of envelopes issued to nonresidents during the 1964 season, 82 percent were returned.

Calculated Hunting Pressure on Hen Pheasants

Each season, some hunting pressure was exerted on the hen pheasant population in south-central Nebraska, although hens were protected by regulation. Some hens were shot on the study areas, either accidentally or deliberately by hunters.

It is possible to estimate relative hunting pressure on a species, as well as hen mortality due to hunting, by using fluoroscopy to determine the incidence of lead shot in bodies of game birds that survived at least one hunting season (Elder, 1955, and Wagner *et al.*, 1965).

Dead pheasants found on or near the Harvard, Clay Center, and Fairmont study areas were collected from 1954-1959 and 1961-1962. Carcasses, which were not too badly decomposed, were labeled and frozen for later analysis. Additional pheasants were collected statewide by conservation officers and other personnel from 1954 through 1959 under P-R Project W-15-R. The statewide collections were used for comparison with data from the intensive study areas.

A sample of 184 cock and 238 hen pheasants was collected on or near the study areas, and 40 cocks (21.7 percent) and 23 hens (9.7 percent) carried shot (Table 4). Shot was found in an average of 9.7 percent of the hens, and ranged from 0.0 in 1961-62 to 28.6 in 1956-57. The percentage of cocks carrying shot ranged from 12.5 to 30.4 percent and averaged 21.7 percent.

Linear correlation analysis was used to determine if a significant relationship existed between birds carrying shot and eight other parameters. Total hours of effort was the only parameter significantly correlated with the percentage of hens carrying shot (r = 0.95, P< .05). The percentage of cocks carrying shot was inversely related to the total number of birds hit but not retrieved (r = 0.82, P< .05). Regression lines for these correlations are shown in Appendix Figures 7 and 8.

Table 4. Fluoroscopy Results, Clay County Study Areas.

	Pheasants examined		Number carrying shot		Percent carrying shot	
Year	Cocks	Hens	Cocks	Hens	Cocks	Hens
1954-55	37	40	9	2	24.3	5.0
1955-56	16	29	2	5	12.5	17.2
1956-57	10	14	2	4	20.0	28.6
1957-58	59	71	13	9	22.0	12.7
1958-59	39	63	7	3	17.9	4.8
1959-60	0	0	0	0	–	–
1960-61	0	0	0	0	–	–
1961-62	23	21	7	0	30.4	0.0
Total	184	238	40	23	21.7	9.7

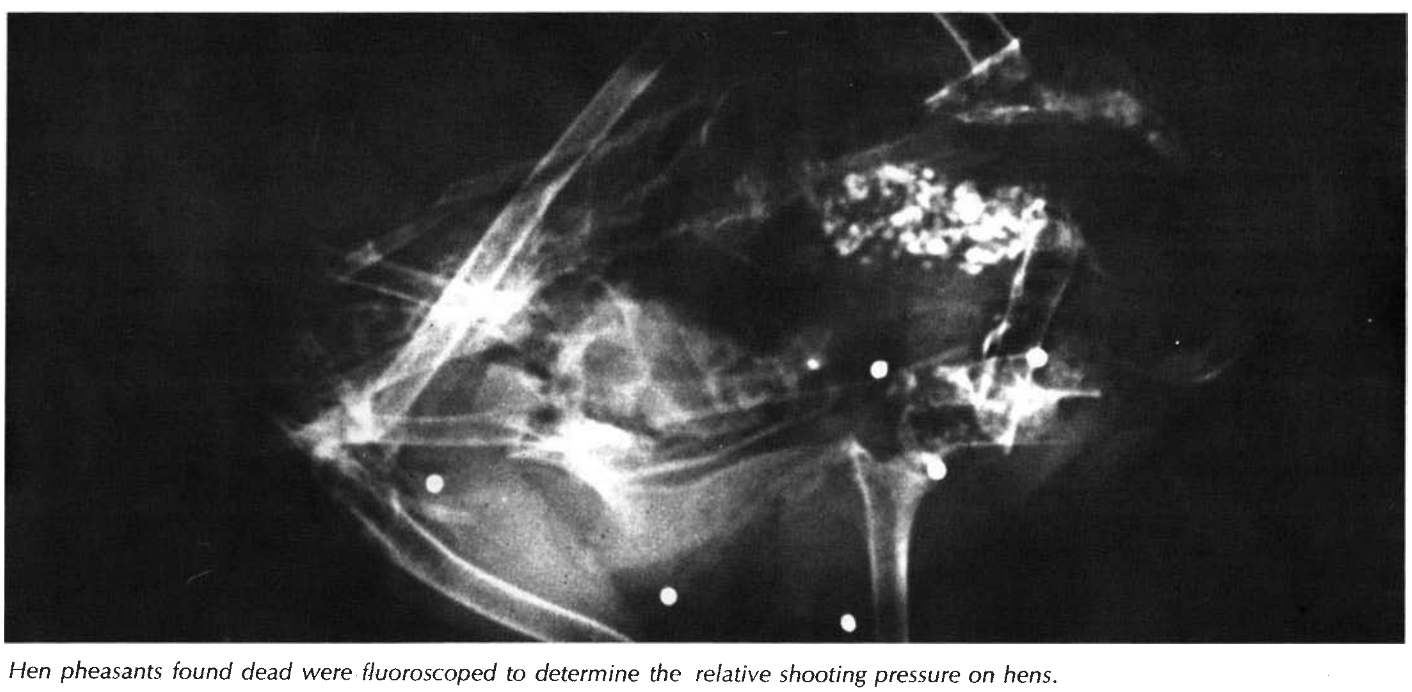
Results of fluoroscopic examination of 579 pheasants (340 cocks and 239 hens) collected statewide under P-R Project W-15-R, are summarized in Table 5. The percentage of these hens carrying shot ranged from 0.0 to 14.3 and averaged 4.2 percent.

A paired t-test was used to compare the incidence of shot in both hens and cocks collected on the study area with those obtained in statewide collections (Appendix Figures 9 and 10). The t-values of 1.14 for hens and 1.45 for cocks indicated no significant difference between birds collected on the study areas and the statewide sample.

A higher percentage of hens tended to carry shot as the number of cocks harvested increased. Also, the number of cocks carrying shot was an indicator of hunting success, since more cocks with shot were found during low-harvest years. As harvest increased, this percentage decreased.

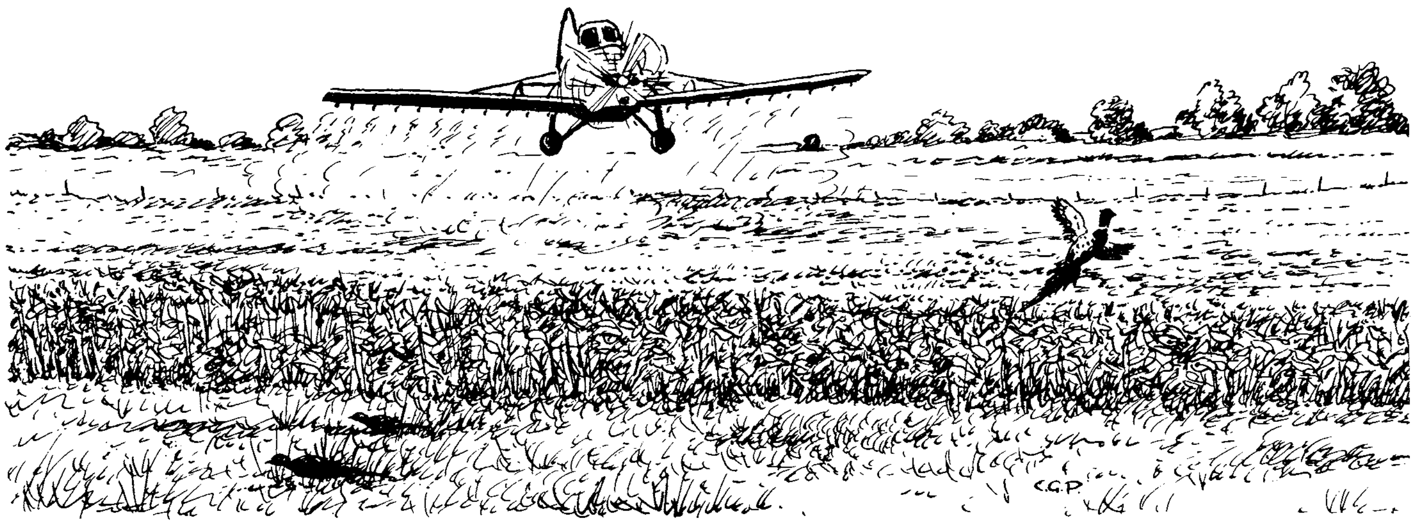
Table 5. Fluoroscopy Results—Statewide Collections (W-15-R)

	Pheasants examined		Number carrying shot		Percent carrying shot	
Year	Cocks	Hens	Cocks	Hens	Cocks	Hens
1954-55	17	21	5	3	29.4	14.3
1955-56	22	9	4	1	18.2	11.1
1956-57	9	5	0	0	0.0	0.0
1957-58	87	68	8	5	9.2	7.4
1958-59	205	136	25	1	12.2	0.7
Total	340	239	42	10	12.4	4.2



Hen pheasants found dead were fluoroscoped to determine the relative shooting pressure on hens.

7. Pesticides and Pheasants



Pesticides and their relationship to pheasant populations were an important aspect of this study, since both study areas were high-use agricultural lands and various types and amounts of pesticides were used over the 10-year period.

To assess the nature and extent of pesticide use on corn acreage, a survey of every landowner or operator on the two study areas was initiated in 1961. Each year through 1964, all pesticide applications made during the growing season were documented, including the total number of acres treated, type of insecticide used, and the rates of application (Table 1).

During the four-year period, an average of 76 percent of the acres planted to corn was treated with some type of pesticide. Primary chemical control efforts were directed at the corn rootworm. Other chemical applications for such pests as grasshoppers in alfalfa did occur, but did not involve large acreages.

Aldrin at a rate of 3 lbs./acre constituted the heaviest application of any chemical. The phosphate ester insecticides including Di-syston, Diazinon, and Thimet were most commonly used during 1962 through 1964.

To review pesticide use prior to 1961, aerial applicators operating in the immediate area were contacted. Generally, from 1952 through 1954, BHC (benzene hexachloride) was used for rootworm control. Since an increase in rate of application failed to control the resistant rootworm variety, heptachlor was commonly used from 1955 through 1957. Aldrin was the preferred chemical from 1958 through 1961. During 1961, use of organo-phosphates became common. Within the accuracy of our survey, no "hard" pesticides were used after 1961.

As corn rootworm developed resistance to chemical treatment, a dramatic shift in row crop acreage occurred during the period from 1954 through 1964. In 1954, 1,415 acres at the Clay Center area (25 percent) was devoted to corn. By 1964, corn planting had dropped to slightly over 3 percent. On the Harvard area, corn acreage decreased from 27 percent to 17 percent during the 10 years.

Table 1. Insecticide use patterns on corn acreage, Clay County, Nebraska, 1952-1964.

Year	Insecticide Used	Application Rate	Acres Treated	% Total Acres
1952-54	BHC	No data available		
1955-57	Heptachlor	No data available		
1958-60	Aldrin	1.5 lbs./A	--	--
1961	Aldrin	1.5 lbs./A	20	2.0
	Aldrin	3.0 lbs./A	115	11.4
	Parathion	3 oz./A	618	61.4
	(No treatment)	--	254	25.2
			1,007	100.0
1962	Diazinon	1.0 lb./A	567	61.6
	Parathion	3.0 oz./A	85	9.2
	(No treatment)	--	268	29.1
			920	99.9
1963	Diazinon	1.0 lbs./A	293	28.8
	Thimet	1.0 lbs./A	348	34.2
	Parathion	2.0 oz./A	93	9.1
	(No treatment)	--	283	27.8
			1,017	99.9
1964	Diazinon	1 lb./A	79	13.7
	Diazinon[1]			
	Di-syston[1]	1 lb./A	415	72.3
	Thimet[1]			
	(No treatment)	--	80	13.9
			574	99.9

[1]Cooperators could not secure adequate supplies of any one insecticide; therefore they used varying combinations and were not certain how many acres were treated with each individual chemical.

In April 1962, 14 hen pheasants collected as a part of a population density study on the Harvard area were sent to the U.S. Bureau of Sport Fisheries and Wildlife Research Laboratory at Denver for pesticide analysis. Standard gas chromatographic methods identified four chlorinated hydrocarbons in fat samples: DDT, DDE, heptachlor epoxide and dieldrin (Table 2).

Table 2. Organo-chlorine insecticide residues in 14 hen pheasants, Harvard Area, 1962.

	DDT	DDE	Heptachlor Epoxide	Dieldrin
Percent containing	78.6	78.6	92.8	78.6
Average load per bird (ppm)	0.31	0.37	0.60	0.17
Range (ppm)	0.1-1.0	0.1-1.7	0.1-1.6	Trace-0.9

While the sample size was small (approximately 7 percent of the hen population), residue levels found generally agreed with pesticide usage on the section where the birds were collected.

Occurrence of DDT and its metabolites in 13 of 14 hens was interesting, since our survey indicated no apparent use of DDT on the area. The degradation product of heptachlor, heptachlor epoxide, was also found in 13 of 14 hens, although its use was discontinued in the late 1950's.

Since aldrin was used for rootworm control, the occurrence of its metabolite, dieldrin, was expected. The average load per bird (11 of 14 hens) of 0.17 ppm was the lowest of all the chlorinated hydrocarbon residues determined. However, dieldrin concentrations did not appear sufficient to adversely affect reproduction when compared to residue levels in penned hens fed dieldrin (Atkins and Linder, 1967; Lamb, *et al.*, 1967).

At the same time body tissues were analyzed, a preliminary check was made on pheasant eggs collected. The Denver laboratory analyzed two, three-egg composites, using standard paper chromatography. DDT and its metabolites were found in both samples with levels ranging from a trace to 0.6 ppm. Results showed:

	DDT	DDE	DDD
Sample 1 (3-egg composite, same nest)	0.2	0.4	Trace
Sample 2 (3-egg composite, same nest)	0.0	0.6	Trace

Additional analysis of several other eggs from the same nests by the Nebraska Agricultural Department Laboratory, using electron capture gas chromatography methods, indicated the presence of lindane (gamma-isomer of BHC) and dieldrin in sufficient concentration to adversely affect reproduction.

Beginning in 1962 and ending in 1964, intact eggs were collected from every abandoned or destroyed nest located during nest searching activities on the two study areas. These eggs were labeled and frozen until residue analysis was completed in 1971. Standard gas chromatographic methods determined organochlorine residues on pooled egg samples from each nest. The five residues found in virtually every sample included DDE; TDE; p,p DDT; heptachlor epoxide, and dieldrin.

Table 3. Dieldrin residues in pheasant eggs, Clay County, Nebraska, 1962-1964.

Study Area	Year	Ave. residue (ppb/egg)	Range (ppb)	Sample size (no. nests)
Clay Center	1962	316.8	16.0-617.6	2
Clay Center	1963	296.7	7.3-2,910.2	14
Clay Center	1964	60.2	0.0-353.8	61
Harvard	1962	319.1	4.1-1,167.9	9
arvard	1963	60.1	4.5-216.8	10
Harvard	1964	241.4	0.0-2,650.0	31

Special emphasis was given dieldrin since this compound has been used as a reference standard (Heath, *et al.*, 1972) and considered a potentially toxic insecticide to pheasants. Dieldrin residues declined on the Clay Center study area from 316 ppb in 1962 to 60 ppb in 1964. However, residues in eggs on the Harvard study area did not indicate any consistent trend (Table 3). In 1962, an average of 319 ppb was found in each egg, 60 ppb in 1963, and an increase in 1964 to 241 ppb on the Harvard area.

It is difficult to interpret how the organo-chlorine insecticides, dieldrin in particular, have influenced pheasant numbers on the study areas. Many changes have affected the areas, in addition to the normal variables of weather, density stress, predation, and suitable habitat. Land-use changes became obvious during the 10-year study period. Agricultural methods intensified with a subsequent reduction in vital habitat components required by pheasants. Concurrently, insecticides that can move into and through biological systems were used on the study areas. It becomes impossible to make valid evaluations of the component effects of each variable. However, we could examine hen mortality rates, since sufficient valid data was available. Certain trends become evident, if it can be assumed that changing mortality rates reflect changes in the biological systems on which the pheasant depends and indicate effects on the bird's physiologic capability to survive. Figures 1 and 2 show the percentage of hen mortality on the Harvard study area from 1956 through 1963 as well as the corn acreage vs. spring populations from 1955 through 1964. Hen mortality gradually increased over the 8-year period. Use of organo-chlorine insecticides could have been responsible, in part, for this trend.

Figure 1. Comparison of hen mortality rates and dieldrin residues in eggs, Harvard Area.

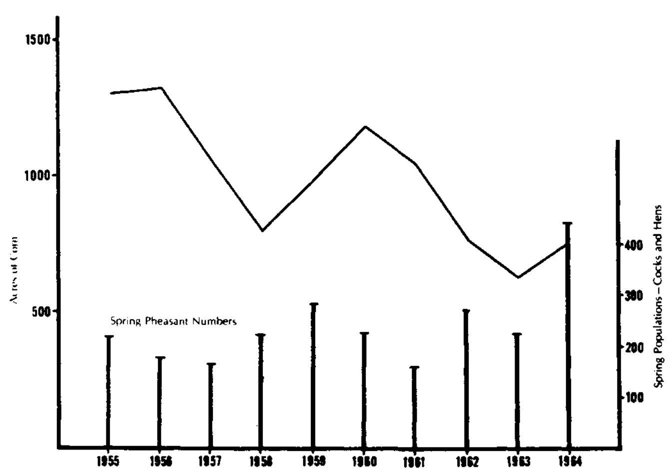


Figure 2. Comparison of spring pheasant numbers and corn acreage, Harvard Area.

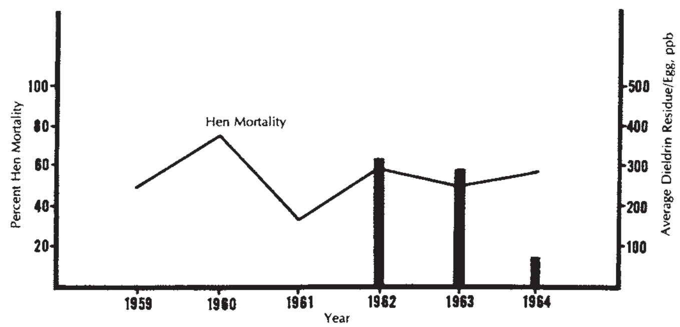


Figure 3. Comparison of hen mortality rates and dieldrin residues in eggs, Clay Center Area.

Data from the Clay Center study did not present a clear picture of hen mortality as it may relate to pesticide use, since only six years of data were available for comparison. The mortality rate was notably high in 1960, the peak year for "hard" pesticide use on the area (Figure 3). During this time, corn acreage declined (Figure 4).

A lack of definitive information prevented valid demonstration of a cause-and-effect relationship between organo-chlorine insecticides, particularly dieldrin and pheasants. However, the data did indicate several pertinent conclusions:

(1) Dieldrin residue levels were high enough in a small percentage of the pheasant eggs analyzed to cause hatching failure or mortality of young;
(2) Dieldrin residues were detected in pheasant eggs during three years of sampling after the last documented use of this insecticide;
(3) Dieldrin residues were found in hen pheasants during the nesting season two years after the discontinuance of aldrin use; and
(4) Hen mortality appeared to increase with increased usage of organo-chlorine insecticides.

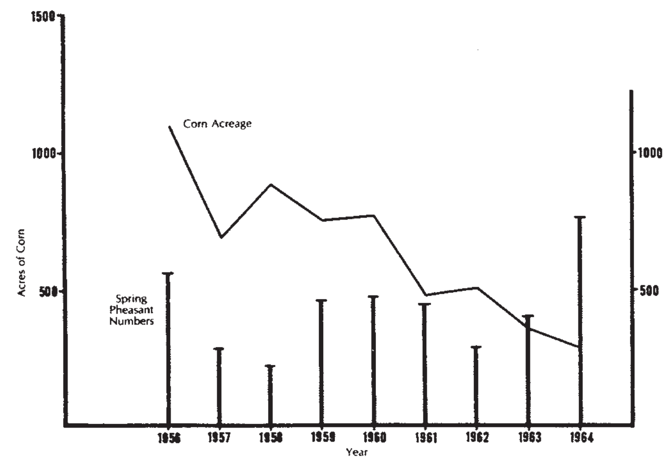


Figure 4. Comparison of spring pheasant numbers and corn acreage, Clay Center Area

A changeover to organophosphate insecticides necessitated studies dealing with effects on juvenile pheasants. Researchers here are preparing to check young birds caged in a field to test effects of parathion.

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Appendix

CHAPTER I

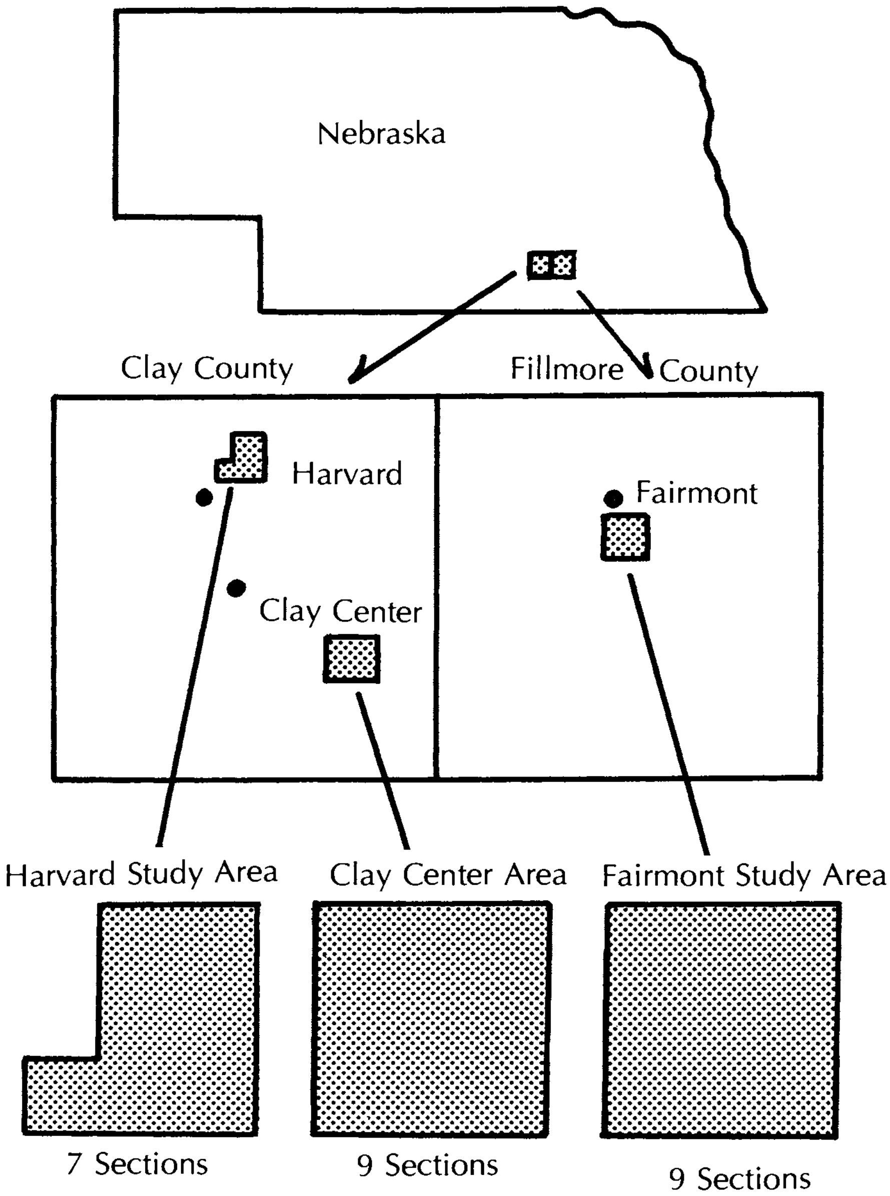


Figure 1. Location of study areas

CHAPTER 2

Table 1. Spring population estimates on the Clay and Fillmore County study areas.

Harvard Area (seven sections)											
Year	**1955**	**1956**	**1957**	**1958**	**1959**	**1960**	**1961**	**1962**	**1963**	**1964**	**1965**
Males	85	48	39	73	59	83	69	101	78	110	80
Females	124	115	124	145	212	134	82	164	139	310	114
Total	209	163	163	218	271	217	151	265	217	420	224
Hens/Cock	1.46	2.39	3.17	1.98	3.59	1.61	1.18	1.62	1.78	2.82	1.80

Clay Center Area (nine sections)											
Year	**1955**	**1956**	**1957**	**1958**	**1959**	**1960**	**1961**	**1962**	**1963**	**1964**	**1965**
Males	159	166	47	60	87	142	126	99	129	182	138
Females	571	414	248	157	378	335	328	188	260	578	339
Total	730	580	295	217	465	477	454	287	389	760	478
Hens/Cock	3.59	2.49	5.28	2.62	4.34	2.35	2.60	1.90	2.01	3.18	2.53

Fairmont Area (nine sections)							
Year	**1955**	**1956**	**1957**	**1958**	**1959**	**1960**	**1961**
Males	31	41	43	45	44	84	64
Females	148	114	149	108	98	109	168
Total	179	155	192	153	142	193	232
Hens/Cock	4.77	2.78	3.47	2.40	2.23	1.30	2.63

Appendix Table 2. Analysis of Variance—Harvard Area.

		Blocks			Treatment Totals xij	
Treatment	1962	1963	1964	1965	Observed	All
Aerial	33	30	38	33	134	134
Ground	53	x=(26)	18	42	113	139
Crowing Count	101	78	110	80	369	369
Block Totals obs.	187	108	166	155	616	
Block Totals all xij	187	134	166	155		642
ΣX^2_{ij}	14,099	7,660	13,868	9,253		

Analysis of Variance

Source of Variation	**df**	**SS**	**MS**	**F**
Blocks	r-1=3	488.33	162.78	
Treatments	t-1=2	9,012.50[1]	4,506.25	21.83**
Error	(r-1) (t-1)-1=5	1,032.17	206.43	
Total	rt-2=10	10,533.00		

[1]Treatment sum of squares biased upwards by 522.67

Appendix Table 3. Analysis of Variance—Clay Center Area.

	Blocks				Treatment Totals	
Treatment	1962	1963	1964	1965	xi	$\Sigma_j x^2_{ij}$
Aerial	56	64	137	39	296	27,522
Ground	44	30	70	35	179	8,961
Crowing Count	99	129	182	135	545	77,791
Block x.j	199	223	389	209	1020	
Totals Σx^2_{ij}	14,873	21,637	56,793	20,971		114,274

Analysis of Variance

Source of Variation	**df**	**SS**	**MS**	**F**
Blocks	t-1=3	8,074	2691.33	
Treatments	5-1=2	17,470	8,735	25.82**
Error	(r-1) (t-1)=6	2,030	338.33	
Total	rt-1=11	27,574		

Appendix Table 4. Correlation of pheasants/100 acres versus percent of land intensively cultivated or grazed.

X	Y	x (x-x)	x²	y (y-y)	y²	xy
8.10	89.0	+3.05	9.30	−4.8	23.04	−14.64
3.97	95.4	−1.08	1.17	+1.6	2.56	− 1.73
3.09	96.9	−1.96	3.84	+3.1	9.61	− 6.08
15.16	281.3	+ .01	14.31	−0.1	35.21	−22.45
$\bar{X}$ 5.05	93.8					

$$r = \frac{\Sigma xy}{\sqrt{\Sigma x^2 \ \Sigma y^2}}$$

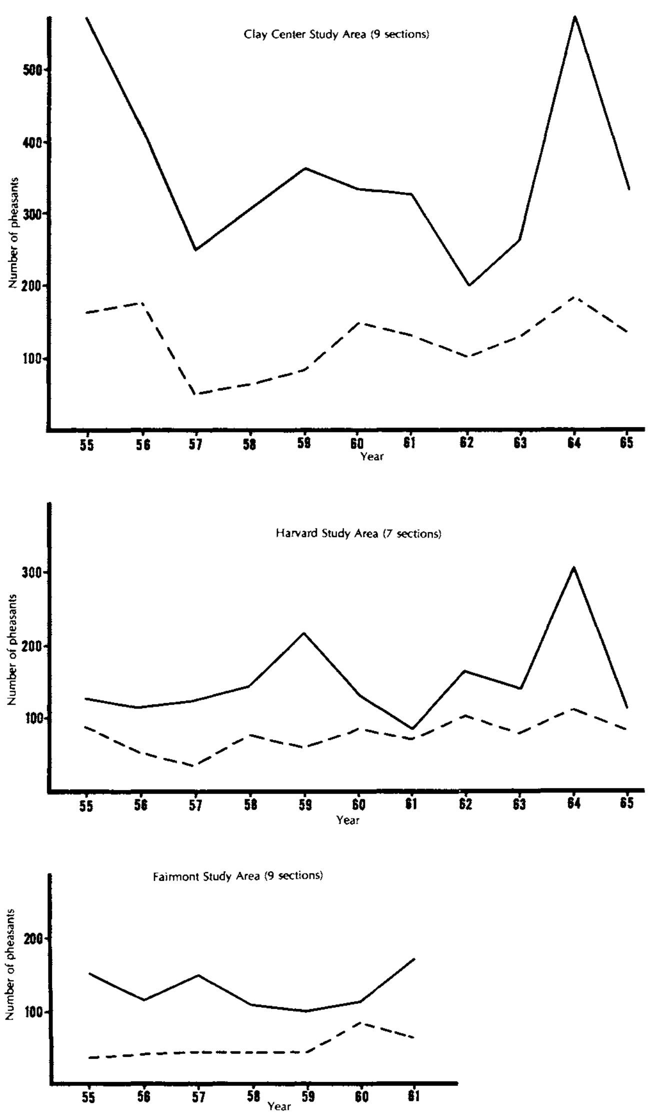
$$= \frac{-22.45}{\sqrt{14.31 \times 35.21}}$$

$$= \frac{22.45}{\sqrt{503.8551}}$$

$$r = -1.00$$

Appendix Table 5. Percent and cummulative percent of pheasants observed during 15-minute time intervals after sunrise, 1962-1964.

Time Past Sunrise-Min.	Percent of Total	Cummulative Percent
1- 15	0.400	0.400
16- 30	3.656	4.056
31- 45	7.311	11.367
46- 60	12.068	23.435
61- 75	14.922	38.357
76- 90	16.324	54.681
91-105	17.376	72.057
106-120	10.466	82.523
121-135	6.710	89.233
136-150	4.757	93.990
151-165	2.704	96.694
166-180	1.652	98.346
181-195	.951	99.297
196-310	.701	99.998



Appendix Figure 1. Spring population estimates, Clay and Fillmore County areas.

CHAPTER 3

Appendix Table 1. Average Nesting Cover, Harvard study area, (7 sections)

Cover Type	Acres	Percent Total Land Area
Wheat	1200.9	26.81
Alfalfa	150.4	3.36
Hay and Pasture	373.5	8.34
Unused	18.9	.42
Fencerow	10.9	.24
Roadside	64.1	1.43
Conserving Acres	8.3	0.18
TOTAL		40.78

Appendix Table 2. Average Nesting Cover, Clay Center study area, (9 sections)

Cover Type	Acres	Percent Total Land Area
Wheat	1270.43	22.06
Alfalfa	150.72	2.62
Hay and Pasture	565.48	9.82
Unused	252.32	4.38
Fencerow	8.27	0.14
Roadside	77.71	1.35
Conserving Acres	10.70	0.19
TOTAL		40.56

Appendix Table 3. Location of nests found on sample plots on the Clay Center study area, 1959-1964.

	Number of Nests by Cover Type							
Year	Roadsides	Wheat	Alfalfa	Unused	Pasture And Hay	Fencerow	Conserving Acres	Total
1959	38	12	49	*	12	1	–	112
1960	35	11	23	1	6	0	–	76
1961	32	26	13	3	15	0	7	96
1962	22	14	8	11	22	0	–	77
1963	27	24	12	28	8	0	–	99
1964	22	47	51[1]	36	25	0	4	185
TOTAL	176	134	156	79	88	1	11	645
Percent of Total	27.3	20.8	24.2	12.2	13.6	0.2	1.7	100

*Not sampled rainbasins were full of water and lacked vegetation.
[1]Includes 36 nests in alfalfa which was not mowed until after July 1.

Appendix Table 4. Location of nests found on sample plots on the Harvard study area, 1956 through 1964.

	Number of Nests by Cover Type							
Year	**Roadsides**	**Wheat**	**Alfalfa**	**Unused**	**Pasture And Hay**	**Fencerow**	**Conserving Acres**	**Total**
1956	27	11	4	3	0	2	—	47
1957	21	6	22	2	0	1	—	52
1958	9	5	26	4	0	2	—	46
1959	17	20	45	3	14	3	—	102
1960	12	11	10	0	2	4	—	39
1961	11	16	10	1	4	1	—	43
1962	6	12	12	4	5	2	—	41
1963	13	20	20	0	4	0	—	59
1964	16	43	5	0	11	2	—	78
TOTAL	132	146	154	17	40	17	1	507
Percent of Total	26.0	28.8	30.3	3.4	7.9	3.4	0.2	0.2

Appendix Table 5. Location of pheasant nests found on sample plots, pooled data for the Harvard and Clay Center study areas, 1956-1964[1]

	Number of Nests by Cover Type							
Year	**Roadsides**	**Wheat**	**Alfalfa**	**Unused**	**Pasture And Hay**	**Fencerow**	**Conserving Acres**	**Total**
1956	27	11	4	3	0	2	—	47
1957	21	6	22	2	0	1	—	52
1958	9	5	26	4	0	2	—	46
1959	55	32	94	3	26	4	—	214
1960	47	22	33	1	8	4	—	115
1961	43	42	23	4	19	1	—	139
1962	28	26	20	15	27	2	—	118
1963	40	46	32	28	12	0	—	158
1964	38	90	56	36	36	2	5	263
TOTAL	308	280	310	96	128	18	12	1152
Percent of Total	26.7	24.3	26.9	8.3	11.1	1.6	1.0	100

[1] *Nesting studies were conducted for nine years on the Harvard Study Area and for 6 years on the Clay Center Study Area.*

Appendix Table 6. Percent occurrence of plant species associated with pheasant nests on the Clay County, Nebraska, study areas.

Plant Species	**Mean Percent Occurrence**
Alfalfa (Medicago sativa)	28.06
Wheat (Triticum aestivum)	16.99
Western Wheatgrass (Agropyron smithii)	13.26
Cheat (Bromus spp.)	11.43
Bluegrass (Poa spp.)	10.11
Smooth Brome (Bromus inermis)	9.33
Fireweed (Kochia scoparia)	6.85
Sedge (Carex spp.)	3.27
Smartweed (Polygonum spp.)	2.88
Rose (Rosa arkansana)	1.89
Common Milkweed (Ascleplias syriaca)	1.23
Prairie Cordgrass (Spartina pectinata)	.90
Tall Dropseed (Sporobolus asper)	.90
Prickly Lettuce (Lactuca scariola)	.82
Ragweed (Ambrosia psilostachva)	.82
Sunflower (Helianthus spp.)	.82
Foxtail (Setaria spp.)	.78
Bindweed (Convolvulus spp.)	.72
Slenderrush (Juncus tenuis)	.68
Sweet Clover (Melilotus spp.)	.59
Aster (Aster spp.)	.57
Lambsquarters (Chenopodium album)	.56
Unidentified	.56
Dock (Rumex spp.)	.52
Scribner Panicum (Panicum scribnerianum)	.49
Oats (Avena sativa)	.48
Blue-Joint (Calamagrostis canadensis)	.45
Reed Canarygrass (Phalaris arundinacea)	.45
Big Bluestem (Andropogon gerardi)	.38
Switchgrass (Panicum virgatum)	.34
Plains Coreopsis (Coreopsis tinctoria)	.33
Goatsbeard (Tragopogon pratensis)	.28
Catnip (Nepeta cataria)	.27
Cottonwood (Populus spp.)	.26
Wild Barley (Hordeum jubatum)	.24
Speargrass (Stipa spp.)	.22

Plant Species	**Mean Percent Occurrence**
Groundcherry (Physalia heterophylla)	.22
Ash (Fraxinus pennsylvanica)	.21
Giant Ragweed (Ambrosia trifida)	.21
Pepper Grass (Lepidium virginicum)	.21
Pennycress (Thlaspi arvensis)	.18
Squirreltail (Sitanion hystrix)	.16
Buffalograss (Buchloe dactyloides)	.14
Pigweed (Amaranthus retroflexus)	.14
Dandelion (Taraxacum officinale)	.13
Cattail (Typha spp.)	.11
Milo (Sorghum spp.)	.11
Witchgrass (Panicum capillare)	.11
Little Bluestem (Andropogon scoparius)	.10
Wild Hemp (Cannabis sativa)	.10
Bullrush (Scirpus americanus)	.09
Ironweed (Vernonia spp.)	.09
Russian Knapweed (Centaurea repens)	.09
Canada Thistle (Cirsium arvense)	.08
Osage Orange (Maclura pomifera)	.08
Buffalo Bur (Solanum rostratum)	.07
Goldenrod (Solidago spp.)	.07
Intermediate Wheatgrass (Agropyron intermedium)	.07
Milo Stubble (Sorghum spp.)	.07
Western Snowberry (Symphoricarpos occidentalis)	.07
Sage (Artemisia spp.)	.06
Scurfpea (Psoralea spp.)	.06
Side-Oats Grama (Bouteloua curtipendula)	.05
Dotted Gayfeather (Liatris punctata)	.04
Leafy Spurge (Euphorbia esula)	.04
Virginia Creeper (Parthenocissus quinquefolia)	.04
Bedstraw (Galium aparine)	.03
Foxtail Barley (Hordeum jubatum)	.03
Prickly Pear (Opuntia humifusia)	.03
Wooly Verbena (Verbena stricta)	.03
Box Elder (Acer negundo)	.02
Leadplant (Amorpha canescens)	.02

Appendix Table 7. Placement of Pheasant Nests in Experimental Alfalfa Fields

Nest Placement in feet from nearest edge	Number of Nest	Cumulative Number of Nests	Cumulative Percent Occurrence
0- 10	1	1	2.94
11- 20	5	6	17.64
21- 30	5	11	32.35
31- 40	5	17	47.06
41- 50	2	18	52.94
51- 60	3	21	61.76
61- 70	1	22	64.71
71- 80	0	22	64.71
81- 90	1	23	67.65
91-100	2	25	73.53
101-110	1	26	76.47
111-120	2	28	82.35
121-130	1	29	85.29
131-140	2	31	91.18
141-150	3	34	100.00

Appendix Table 8. Placement of Pheasant Nests in Alfalfa Fields, Harvard and Clay Center Study Areas, 1956-1964.

Nest Placement in feet from nearest edge	Number of Nests	Cumulative Number of Nests	Cumulative Percent Occurrence
0- 10	26	26	10.4
11- 20	48	74	29.6
21- 30	23	97	38.8
31- 40	21	118	47.2
41- 50	15	133	53.2
51- 60	23	156	62.4
61- 70	13	169	67.6
71- 80	13	182	72.8
81- 90	9	191	76.4
91-100	5	196	78.4
101-110	5	201	80.4
111-120	11	212	84.8
121-130	–	–	–
131-140	1	213	85.2
141-150	9	222	88.8
151-300+	28	250	100.0

Appendix Figure 1. PLOT RECORD

Area:

Plot No.:

Plot Dimensions: N-S ________ yds. E-W ________ yds.

Location: Section ________ Quarter Section ________

Cover Type:

FIRST VISIT

Date: Nest Found:

Remarks ________________

SECOND VISIT

Date: Nests Found:

Remarks ________________

THIRD VISIT

Date: Nests Found:

Remarks ________________

Appendix Figure 2. NEST RECORD

Area ________ Date ________

Cover Type ________ Plot No. ________ Nest No. ________

Location of nests in roadsides Road  Fence

Location within plot ________________

Nest cover ________ Height of cover ________

Nest concealment ________________

State of incubation when found ________ No. of eggs ____

Hen present? ________________

VISITS TO THE NEST

Date

Number of eggs:

in nest

Outside

Broken

Total Eggs

FINAL VISIT

Date ________

Successful nests:

Eggs hatched ________

Eggs infertile ________

Eggs with dead embryos ________

Eggs destroyed ________

Undetermined ________

Hatching date ________

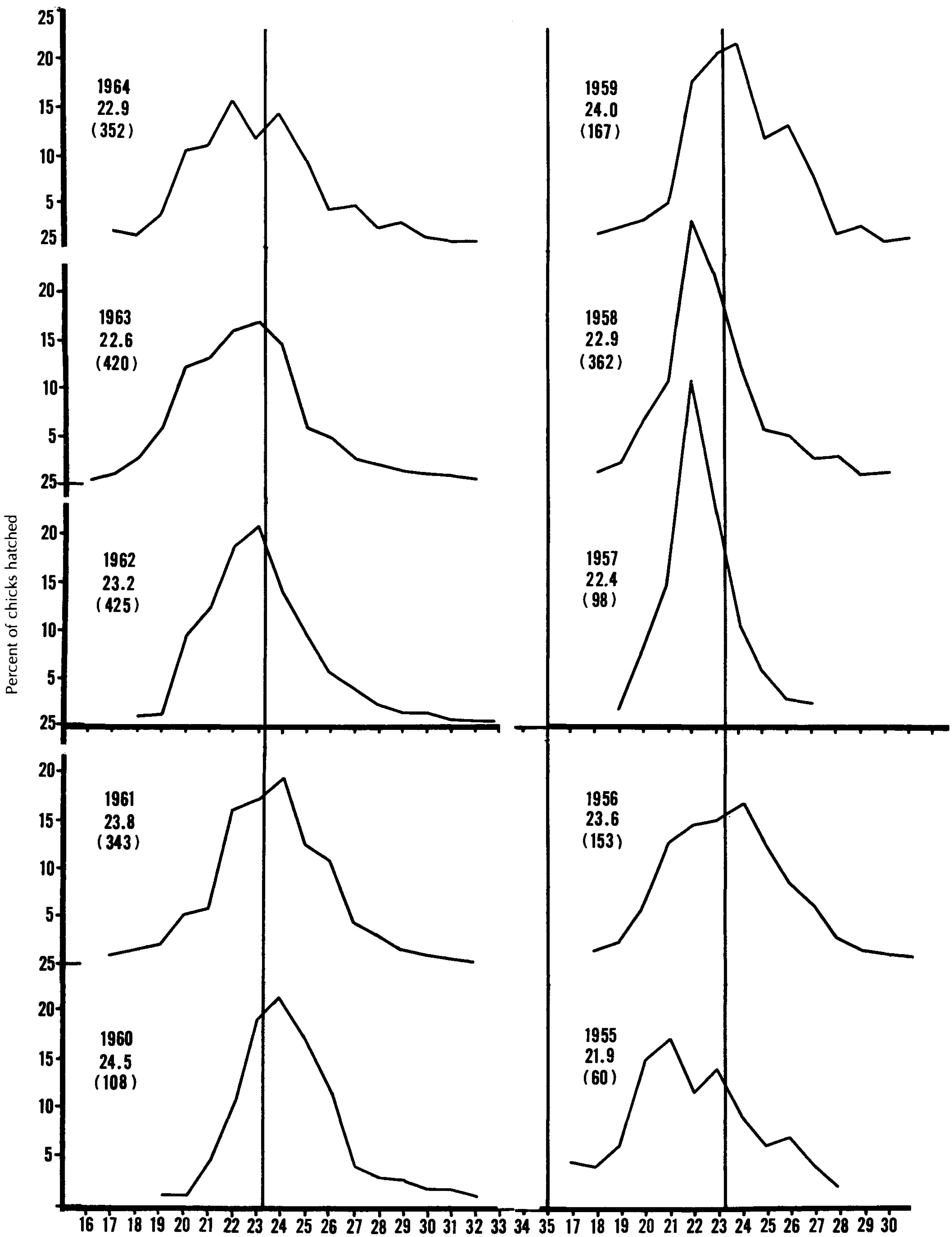
Hatching date calc. ________

Known ________

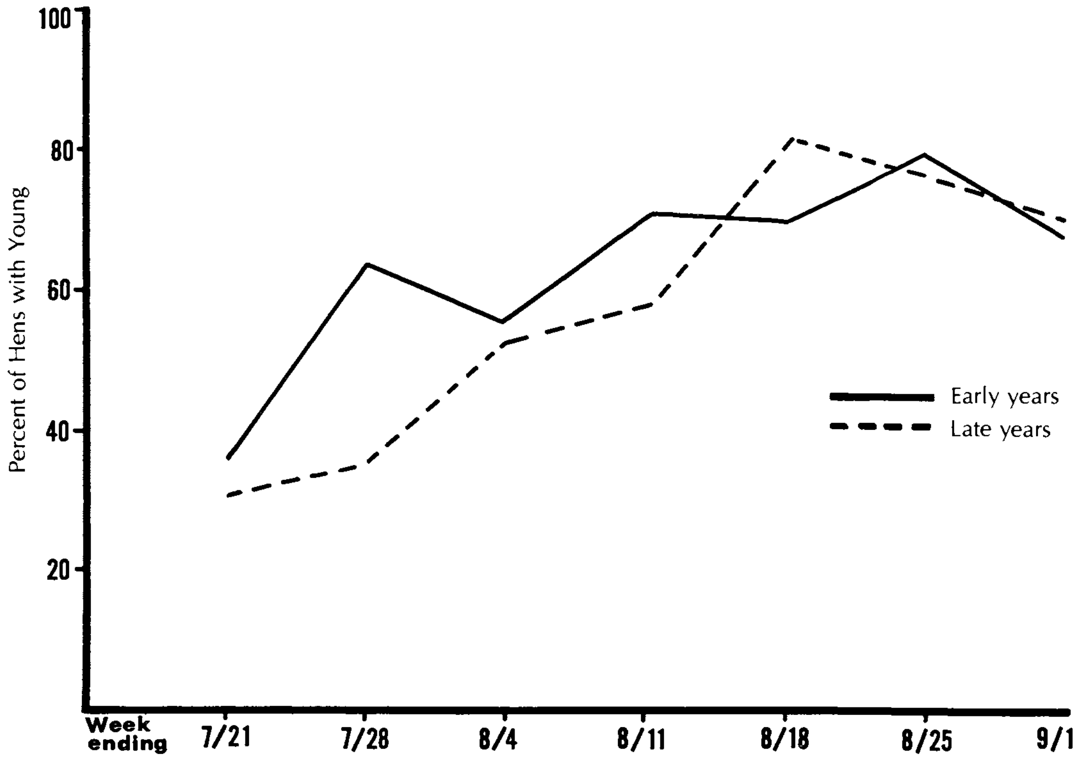
Unsuccessful nests:

Cause of breakup ________

Hen killed? ________



Appendix Figure 3. Hatching distribution for Harvard and Clay Center areas, 1955-64



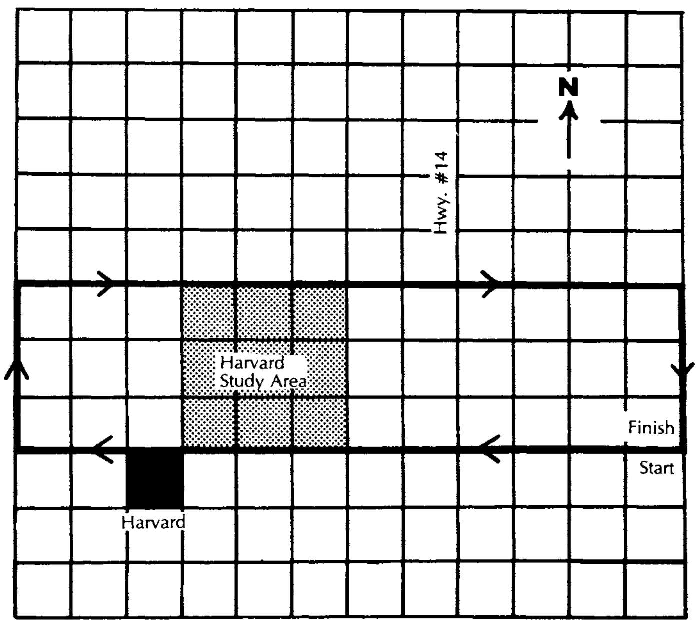
Appendix Figure 4. Percent of hens with young by weekly time intervals (early vs. late hatching years) computed by 3-point moving averages

CHAPTER 4

Appendix Table 1. Frequency distribution of flushed broods by age group[1]

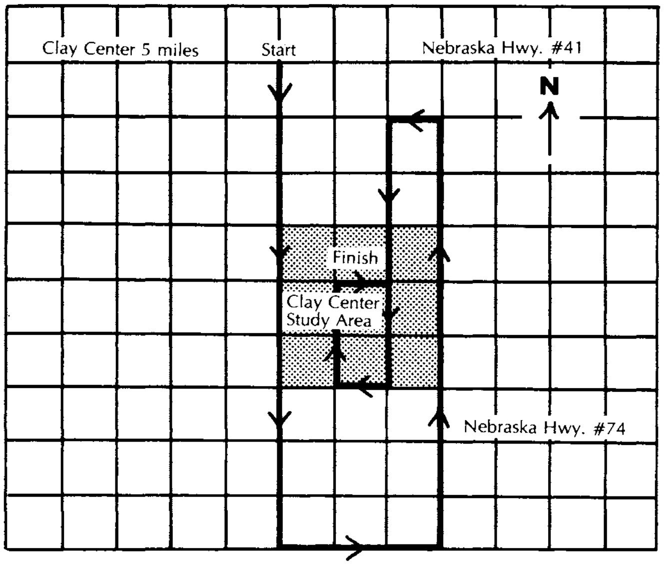
Age in Weeks	Number of periods	Percent of total	Average brood size
1	5	0.3	3.2
2	18	1.0	5.2
3	59	3.3	5.2
4	112	6.2	5.2
5	149	8.2	5.1
6	203	11.2	5.9
7	274	15.2	5.6
8	288	15.9	5.6
9	178	9.8	5.3
10	151	8.4	5.4
11	103	5.7	5.8
12	91	5.0	4.5
13	81	4.5	5.2
14	60	3.3	5.5
15	30	1.7	4.7
16	4	0.6	2.2
17	1	0.1	1.0
	1,807	98.4[2]	5.4

[1]*Includes only broods from the Harvard and Clay Center study areas where the term flushed is synonymous with complete counts for purpose of analysis.*
[2]*Percent does not total 100 because of rounding errors.*



Appendix Figure 1. Brood route, Harvard study area.

Appendix Figure 2. Brood route, Clay Center study area.



Appendix Figure 3

GAME TECHNICIAN'S RECORD OF PHEASANT BROODS

Date________ (Month) (Day) (Year) Temperature: Start______Finish____
County________ Wind Velocity: Start______Finish____
Time: Start____Finish____ Amount of Clouds: Start____Finish____
Dew: None____Lt.____ Odometer: Start______Finish____
Mod.____Heavy____ Length of Route________
Observer________

Obs. No.	No. Observed				Brood Flushed		Age of Young	Tally No. of: Cotton-tails			Jacks	Fox Squirrels	Remarks
	Ad. Cocks	Ad. Hens	Yng.	?	Yes	No		Yng.	Ad.	?			

Figure 4. Sample calculation: Testing for difference in young per adult female ratios from brood route and hunting season data (Harvard Area) using paired t-test.

Year	x_{ij}[1] Brood Route and nesting studies	x_{2j} Hunting Season	x_{ij} x_{2j} D	D^2
1956	3.00	3.11	−0.11	0.012
1957	5.96	1.55	5.41	29.268
1958	4.85	7.98	−3.13	9.797
1959	3.95	2.04	1.91	3.648
1960	3.57	4.42	−0.85	0.722
1961	3.26	2.48	0.78	0.608
1962	3.74	3.80	−0.06	0.004
1963	3.43	3.81	−0.38	0.144

[1] $x_{ij} = \dfrac{\text{\# successful nests X ave. brood size 6-10 wks.}}{\text{total females in population after mortality}}$

Ho: $x_{ij} = x_{2j}$

$\Sigma D = 3.57$

$SS = \Sigma D^2 - \dfrac{(\Sigma D)^2}{n} = 42.61$

$\bar{d} = .446$

$D^2 = 44.20$

$SD^2 = \dfrac{SS}{n-1} = 6.09$

$CT = \dfrac{(\Sigma D)^2}{n} = 1.59$

$S\bar{d} = \sqrt{\dfrac{SD^2}{n}} = .872$

$t_{calc} = \dfrac{(\bar{d} - 0)}{S\bar{d}} = .5115$ NS

t_{tab} @ .05 with 7 d.f. = 2.365

Therefore, Ho accepted. No significant difference exists between young per adult female indices from hunting season and brood route data.

Appendix Figure 5. Sample calculation: Testing for difference in young per adult female ratios from hunting season and brood route data (Clay Center Area) using paired t-test.

Year	xij^1 Brood Route Yng/Ad female	x_2j Hunting Season Yng/Ad female	$xij-x_2j$ D	D^2
1959	3.08	1.63	+1.45	2.10
1960	4.42	5.00	−0.58	0.34
1961	2.33	3.84	−1.51	2.28
1962	2.92	1.68	+1.24	1.54
1963	3.18	4.30	−1.12	1.25

[1] $xij = \frac{\#\text{ successful nests X ave. brood size 6-10 wks.}}{\text{total females in population after mortality}}$

Ho: $xij = x_2j$

$\Sigma D = .52$

$\bar{d} = .104$

$\Sigma D^2 = 7.51$

$CT = \frac{(\Sigma D)^2}{n} = .05$

$SS = \Sigma D^2 - \frac{(\Sigma D)^2}{n} = 7.46$

$S_{D^2} = \frac{SS}{n-1} = 1.86$

$S_D = S_{D^2} = 1.36$

$S_{\bar{d}} = \frac{S_{D^2}}{n} = .61$

$t_{calc} = \frac{(\bar{d}-0)}{S\bar{d}} = \frac{.104}{.61} = .17$ NS

t_{tab} @ .05 with 4 d.f. = 2.571

Therefore, Ho accepted. No significant difference exists between young per adult hen indices from hunting season data and brood route data.

Juvenile Growth and Development

METHODS

Nightlighting of pheasants in grain stubble fields and hay meadows was the live-trapping method used to capture pheasants on the study areas.

Trapped birds were sexed, aged, and weighed at the time of capture. Birds were weighed to the nearest ounce after each field had been completely traversed. Weights were converted to grams to facilitate analysis.

Birds were assigned to weekly age by bursal probe and on the basis of progress of wing molt (Trautman, 1950). Chicks under five weeks of age were difficult to trap and sex, and limited numbers were examined. Therefore, growth rate data is limited to birds over five weeks of age.

SAMPLING PROBLEMS

Two major problems are present in this data: (1) sample size and (2) the validity of aging techniques. Sample size was affected by the recurring problem of periodic changes in personnel on the study and the associated changes in emphasis on certain phases of the study. In some age classes, the number of chicks trapped was limited to one bird.

Aging techniques used during this study were based on age criteria from pen-reared birds. A major assumption of this technique was that wild pheasants develop at the same rate as pen-reared birds. Work on Pelee Island suggests that a difference exists between wild and pen-reared birds (Stokes, 1954). We have no data to determine if a difference exists in Nebraska birds or the degree of variation. Therefore, we recognize this as a possible source of error in our growth curves and present this data as indication of growth trends in Nebraska.

PHEASANT GROWTH RATES

Juvenile pheasant weights are presented as mean weights per week of age in Table 1. Figures 1 and 2 represent the growth curve for cocks and hens based on this data. Both sexes exhibited a rapid growth curve from 6 weeks to about 13 or 14 weeks of age, at which times the growth rate fell off until adult weights were reached.

Weight differences between individual birds within each class were highly variable. In addition, the range of weights within an age class often overlapped with the range of weights in adjoining age classes. Weekly increments in pheasant weights were also variable (Table 1).

The variability in weights associated with individual birds, birds in different age classes and in weekly weight increments was associated with (1) actual differences and (2) apparent differences due to sampling. While our data did not lend itself to statistical analysis by standard methods, it did provide a trend of growth patterns. These growth patterns appeared quite similar to those of Kirkpatrick (1944), Stokes 1954, Westerkov (1957), and Wight (1945).

Table 1. Weekly weight gain of juvenile cock and hen pheasants.

Age in Weeks	—Weekly Weight Gain (in grams)—	
	Male	Female
6	55.36	—
7	78.87	87.97
8	129.15	73.67
9	107.47	69.08
10	82.94	39.04
11	82.77	73.23
12	85.31	126.82
13	108.53	43.81
14	36.43	61.90
15	65.73	—
Total weight gain:	5-15 wks.	6-16 wks.
	832.58	594.62

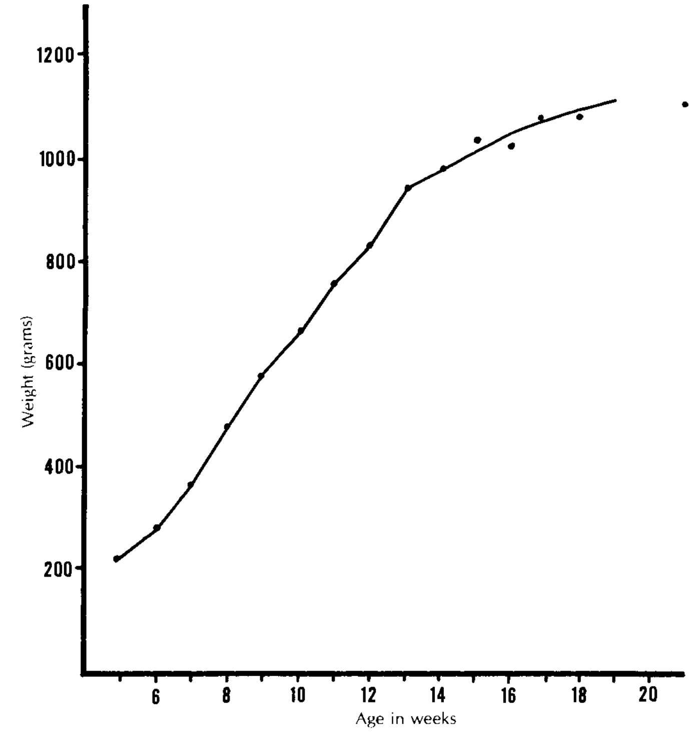


Figure 1. Weekly growth rate of male pheasants

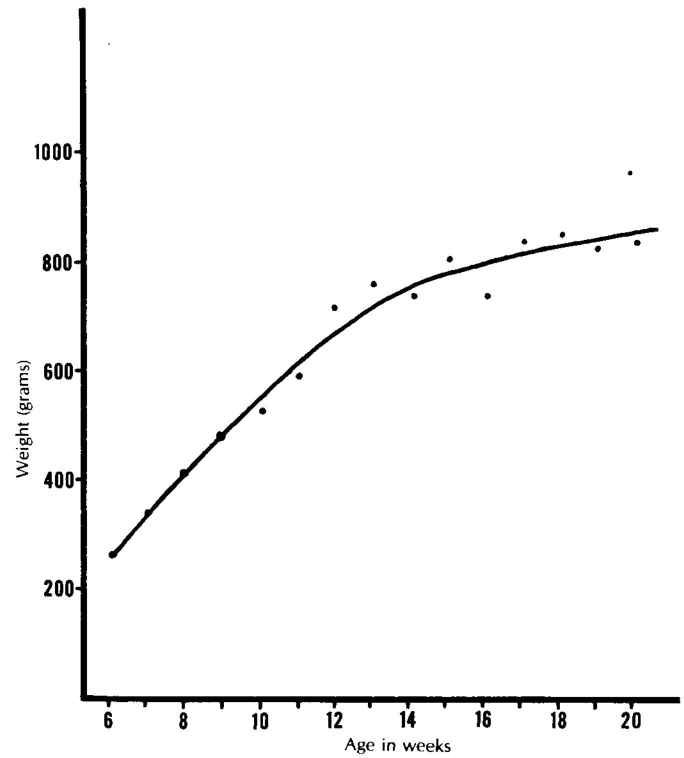


Figure. 2. Weekly growth rate of female pheasants

CHAPTER 5

Supplemental Tables

Appendix Table A. Analysis of Variance Summary for Harvard Study Area.

Source of Variation	Degrees of Freedom	Broods		Chicks	
		Mean Square	F-ratio	Mean Square	F-ratio
Sample Period 1					
Total	83				
Cover	6	0.107233	2.552	1.299399	2.550
Time	1	0.142683	3.395	0.916110	n.s.
Cover-Time	6	0.027759	n.s.	0.473675	n.s.
Residual	70	0.042022		0.509511	
Sample Period 2					
Total	83				
Cover	6	0.169619	n.s.	2.320694	2.043
Time	1	0.106864	n.s.	1.021025	n.s.
Cover-Time	6	0.108458	n.s.	1.580876	n.s.
Residual	70	0.116163		1.135711	
Sample Periods 1 and 2					
Total	167				
Cover	6	0.221411	2.7994	2.864366	3.4821
Period	1	0.508343	6.4272	3.456370	4.2017
Cover-Period	6	0.055440	n.s.	0.755727	n.s.
Time	1	0.248256	3.1388	1.935713	2.3531
Cover-Time	6	0.099848	n.s.	1.509110	1.8345
Period-Time	1	0.001292	n.s.	0.001421	n.s.
Cover-Period-Time	6	0.036369	n.s.	0.545441	n.s.
Residual	140	0.079093		0.822611	
Sample Period 3					
Total	59.				
Cover	4	0.003719	2.946	0.031251	3.109
Time	2	0.000128	n.s.	0.006083	n.s.
Cover-Time	8	0.002672	2.117	0.014898	n.s.
Residual	45	0.001262		0.010050	
Sample Period 4					
Total	59				
Cover	4	0.005550	7.157	0.025904	8.264
Time	2	0.001646	n.s.	0.006314	n.s.
Cover-Time	8	0.000325	n.s.	0.002824	n.s.
Residual	45	0.000775		0.003919	

Appendix Table B. Results of Duncan's Multiple-range Test, Harvard, 1965.

Sampling Period			Rank 1	2	3	4	5	6	7
1	Broods	Cover Type	A	GS_2	W_2	GS_1	N	P	W_1
		LSR X S_x	0.7071	0.7071	0.7502	0.7934	0.8662	0.9228	0.9228
	Chicks	Cover Type	A	GS_2	W_2	GS_1	N	P	W_1
		LSR X S_x	0.7071	0.7071	0.8764	0.97339	1.0857	1.4526	1.5142
2	Broods	Cover Type	GS_1	GS_2	A	P	N	W_2	W_1
		LSR X S_x	0.7934	0.7934	0.8365	0.9228	0.9632	1.0360	1.0945
	Chicks	Cover Type	GS_1	GS_2	N	A	P	W_2	W_1
		LSR X S_x	0.8472	1.0293	1.0569	1.1721	1.4334	1.6766	2.1090
1 & 2	Broods	Cover Type	GS_2	A	GS_1	W_2	N	P	W_1
		LSR X S_x	0.7502	0.7718	0.7934	0.8931	0.8945	0.9430	1.0086
	Chicks	Cover Type	GS_2	GS_1	A	N	W_2	P	W_1
		LSR X S_x	0.8685	0.9106	0.9396	1.0713	1.2765	1.4430	1.8116
3	Broods	Cover Type	A	P	GS	N	W		
		LSR X S_x	0.07502	0.07933	0.08903	0.10272	0.11789		
	Chicks	Cover Type	A	P	GS	N	W		
		SLR X S_x	0.07798	0.08472	0.10846	0.13004	0.20473		
4	Broods	Cover Type	A	P	W	GS	N		
		LSR X S_x	0.07933	0.08365	0.09335	0.10523	0.13302		
	Chicks	Cover Type	A	P	GS	W	N		
		LSR X S_x	0.08472	0.08662	0.11567	0.12100	0.19916		

Appendix Table C. Analysis of Variance Summary for Clay Center study area.

Source of Variation	Degrees of Freedom	Broods Mean Square	Broods F-ratio	Chicks Mean Square	Chicks F-ratio
Sample Period 1					
Total	83				
Cover	6	0.043564	n.s.	0.742262	n.s.
Time	1	0.001802	n.s.	0.205672	n.s.
Cover-Time	6	0.048083	n.s.	0.540537	n.s.
Residual	70	0.067238		0.887035	
Sample Period 2					
Total	83				
Cover	6	0.167796	n.s.	2.276699	2.216
Time	1	0.100478	n.s.	1.162570	n.s.
Cover-Time	6	0.207513	1.851	1.585917	n.s.
Residual	70	0.112082		1.029463	
Sample Period 1 and 2					
Total	167				
Cover	6	0.126991	n.s.	1.818486	1.8977
Period	1	0.559724	6.2427	3.620322	4.7781
Cover-Period	6	0.084370	n.s.	1.200475	n.s.
Time	1	0.037683	n.s.	0.195133	n.s.
Cover-Time	6	0.126993	n.s.	1.193342	n.s.
Period-Time	1	0.064597	n.s.	1.173108	n.s.
Cover-Period-Time	6	0.128603	n.s.	0.933112	n.s.
Residual	140	0.089660		0.958249	
Sample Period 3					
Total	59				
Cover	4	0.004591	2.772	0.017500	2.056
Time	2	0.000275	n.s.	0.004922	n.s.
Cover-Time	8	0.001142	n.s.	0.005995	n.s.
Residual	45	0.001645		0.008510	
Sample Period 4					
Total	59				
Cover	4	0.005259	3.213	0.007608	n.s.
Time	2	0.001485	n.s.	0.008070	n.s.
Cover-Time	8	0.003059	1.869	0.011943	n.s.
Residual	45	0.001636		0.008481	

Appendix Table D. Results of Duncan's Multiple-range Test, Clay Center, 1965.

Sampling Period			Rank 1	2	3	4	5	6	7
1	Broods	Cover Type	GS_1	W_2	P	GS_2	A	N	W_1
		LSR X S_x	0.7502	0.7502	0.8041	0.8231	0.8365	0.8796	0.9093
	Chicks	Cover Type	GS_1	W_2	P	GS_2	A	N	W_1
		LSR X S_x	0.7502	0.8436	1.0607	1.0941	1.1713	1.3906	1.4033
2	Broods	Cover Type	P	N	GS_1	GS_2	A	W_2	W_1
		LSR X S_x	0.8231	0.8365	0.8365	0.8903	1.0119	1.0569	1.1060
	Chicks	Cover Type	GS_1	N	P	GS_2	A	W_2	W_1
		LSR X S_x	0.9596	1.0530	1.0607	1.1555	1.6845	1.8538	2.0019
1 & 2	Broods	Cover Type	GS_1	P	GS_2	N	W_2	A	W_1
		LSR X S_x	0.7939	0.8136	0.8567	0.8581	0.9036	0.9242	1.0077
	Chicks	Cover Type	GS_1	P	GS_2	N	W_2	A	W_1
		LSR X S_x	0.8549	1.0607	1.1248	1.2218	1.3487	1.4279	1.7026
3	Broods	Cover Type	A	P	W	N	GS		
		LSR X S_x	0.08230	0.08797	0.10550	0.11297	0.13083		
	Chicks	Cover Type	A	P	W	N	GS		
		LSR X S_x	0.09880	0.10862	0.13818	0.16523	0.19012		
4	Broods	Cover Type	A	P	W	GS	N		
		LSR X S_x	0.08365	0.08662	0.10008	0.12592	0.12732		
	Chicks	Cover Type	A	P	W	N	GS		
		LSR X S_x	0.10312	0.11003	0.12778	0.15405	0.15888		

CHAPTER 6

Appendix Table 1. Summary of hunting season data, Harvard Area, 1955 through 1964.

	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	Mean
Envelopes Issued	267[1]	78	116	100	97	59	47	59	101	86	101
Envelopes Returned	129	33	61	33	24	21	19	31	54	45	45
Percent Returned	48.3	42.3	52.6	33.0	24.7	35.4	40.4	52.5	53.5	52.3	44.6
Gun hours effort	399.6	315.9	693.6	463.4	246.0	217.5	75.9	180.5	276.1	232.0	310.1
Cocks bagged	81	90	80	107	31	28	24	43	81	55	62
Gun hours/cock	4.9	3.5	8.7	4.3	7.9	7.8	3.2	4.2	3.4	4.2	5.0
Young	57	71	57	69	24	23	16	34	61	54	46.6
Adult	24	19	23	33	7	5	8	9	18	1	14.7
Total bagged	81	90	80	107[2]	31	28	24	43	81[2]	55	62.0[2]
Young: Adult	2.4	3.7	2.5	2.1	3.4	4.6	2.0	3.8	3.4	54.0	3.1
Shot but not Retrieved	16	22	13	24	7	4	3	9	23	17	13.8
Total birds shot	97	112	93	131	38	32	27	52	104	72	75.8
Percent HBRN[3] (crippled)	16.5	19.6	14.0	18.3	18.4	12.5	11.1	17.3	22.1	23.6	18.2

[1]Each hunter received an envelope, thereafter each party received only one envelope.
[2]Includes birds of unknown age.
[3]Hit but not retrieved.

Appendix Table 2. Summary of hunting season data, Clay Center Area, 1955 through 1964.

	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	Mean
Envelopes Issued	302[1]	138	70	124	85	78	75	56	89	67	108
Envelopes Returned	129	56	33	63	24	32	36	30	54	42	50
Percent Returned	42.7	40.6	46.1	51.0	28.2	41.0	48.0	53.5	60.1	62.7	45.2
Gun hours effort	347.2	369.6	289.8	652.3	152.5	132.5	265.5	239.9	314.5	344.5	310.8
Cocks bagged	136	84	86	189	34	28	72	47	122	86	88.4
Gun hours/cock	2.8	4.4	3.4	3.4	4.5	4.7	3.7	5.1	2.6	4.0	3.5
Young	94	62	74	130	21	24	60	29	99	78	67.1
Adult	42	22	12	43	6	4	12	18	23	3	18.5
Total bagged	136	84	86	189[2]	34[2]	28	72	47	122	86[2]	88.4[2]
Young: Adult	2.2	3.6	6.2	3.4	3.5	6	5.0	1.6	4.3	26.0	3.6
Shot but not Retrieved	20	10	17	34	14	9	6	11	25	13	15.9
Total Birds Shot	156	94	103	223	48	37	78	58	147	99	104.3
Percent HBNR[3] (crippled)	12.8	10.6	16.5	15.2	29.2	24.3	7.7	19.0	17.0	13.1	15.2

[1]Each *hunter* received an envelope, thereafter each *party* received only one envelope.
[2]Includes birds of unknown age.
[3]Hit but not retrieved.

Appendix Table 3. Summary of hunting season data, Fairmont Area, 1955 through 1962.

	1955	1956	1957	1958	1959	1960	1961	1962	Mean
Envelopes Issued	140	52	40	64	50	53	46	25	59
Envelopes Returned	74	25	17	33	21	34	29	14	25
Percent Returned	52.9	48.0	42.5	52.0	42.0	64.2	63.0	56.0	52.0
Gun hours effort	261.8	197.2	162.4	205.3	59.5	149.9	164.3	50.7	156.4
Cocks bagged	44	58	37	55	14	36	59	16	39.9
Gun hours/cock	6.1	3.4	4.4	3.7	4.2	4.2	2.8	3.2	3.9
Young	27	48	29	39	8	28	48	6	29.1
Adult	17	10	8	15	2	8	11	10	10.1
Total bagged	44	58	37	55[1]	14[1]	36	59	16	39.9[1]
Young: Adult	1.6	4.8	3.6	2.6	4.0	3.5	4.4	0.6	2.9
Shot but not Retrieved	27	21	10	24	5	18	9	5	14.9
Total Birds Shot	71	79	47	79	19	54	68	21	54.8

[1]Includes birds of unknown age.

Table 4. Adjusted harvest and birds hit but not retrieved (HBNR), Harvard study area.

Year	Gun Hours	Reported Harvest	Correction Factor (%)	Adjusted No. Birds	Adjusted Harvest	HBNR	Adjusted HBNR	Total Birds Shot (Reported)	Total Birds Shot (Adjusted)
1956	315.9	90	14	13	103	22	25	112	128
1957	693.6	80[1]	20	16	96	13	16	93	112
1958	463.4	107	19	20	127	24	29	131	156
1959	246.0	31	12	4	35	7	8	38	43
1960	217.5	28	11	3	31	4	4	32	35
1961	75.9	24	10	2	26	3	3	27	29
1962	180.5	43	10	4	47	9	10	52	57
1963	276.1	81	13	10	91	23	26	104	117
1964	232.0	55	12	7	62	17	19	72	81

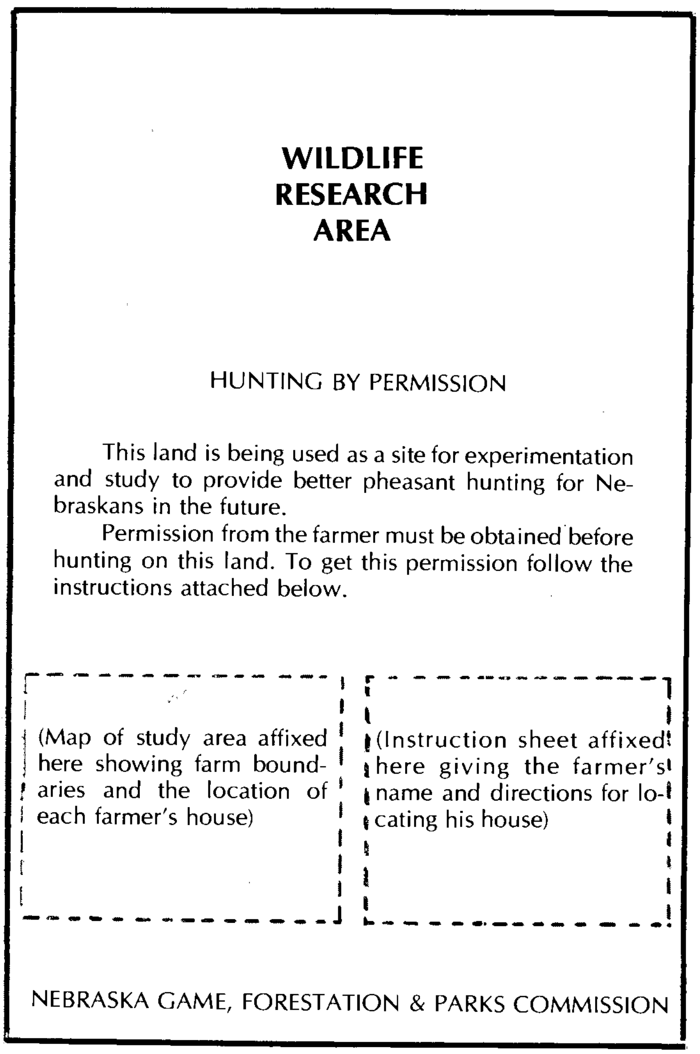
[1]191 game farm birds were also harvested on the Harvard area during 1966. These birds are not included in the above analysis.

Table 5. Adjusted harvest and birds hit but not retrieved (HBNR), Clay Center study area.

Year	Gun Hours	Reported Harvest	Correction Factor (%)	Adjusted No. Birds	Adjusted Harvest	HBNR	Adjusted HBNR	Total Birds Shot (Reported)	Total Birds Shot (Adjusted)
1956	369.6	84	16	13	97	10	12	94	109
1957	289.8	86	14	12	98	17	19	103	117
1958	652.3	189	20	38	227	34	41	223	268
1959	152.5	34	10	3	37	14	15	48	52
1960	132.5	28	10	3	31	9	10	37	41
1961	265.5	72	13	9	81	6	7	78	88
1962	239.9	47	12	6	53	11	12	58	65
1963	314.5	122	15	18	140	25	29	147	169
1964	344.5	86	15	13	99	13	15	99	114

Appendix Table 6. Pheasant seasons in Clay County, Nebraska.

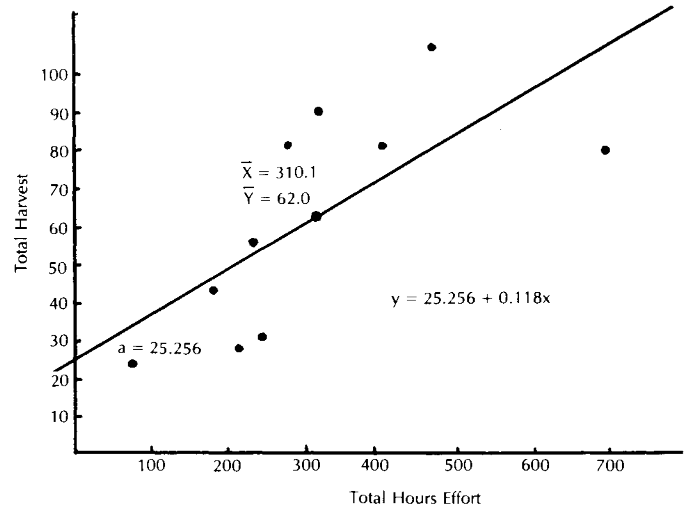
Year	Season length (days)	Shooting Hours	Bag Limit	Possession Limit
1955	23	Sunrise to sunset	3	
1955	23	Noon to sunset	3	3
1956	22	Sunrise to sunset	3	6
1957	29	Sunrise to sunset	3	6
1958	44	Sunrise to sunset	3	9
1959	65	Sunrise to sunset	3	9
1960	79	Sunrise to sunset	3	9
1961	71	Sunrise to sunset	2	8
1962	86	Sunrise to sunset	4	16
1963	93	Sunrise to sunset	4	20
1964	93	Sunrise to sunset	4	20



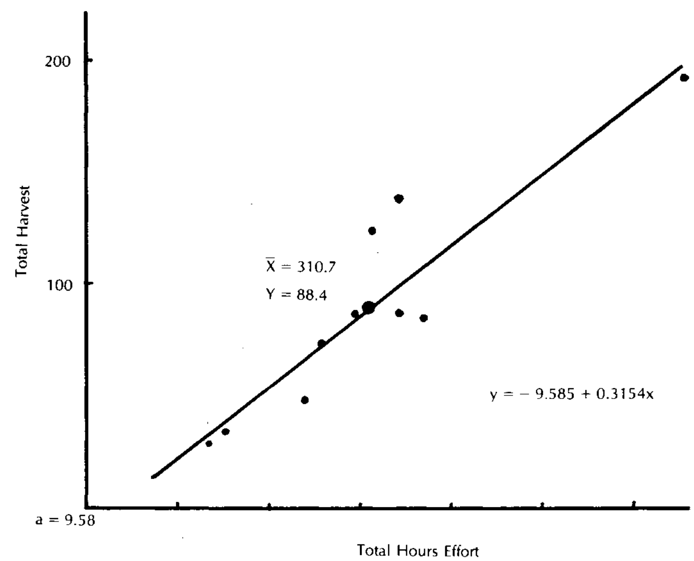
Appendix Figure 1. Sign used to post study areas

Sign specifications:
- Measurements—16 x 30 inches
- Material—Fiberglass
- Colors—Black lettering on white background

Map of Study Area and instruction sheet were pasted to the face of the sign.



Appendix Figure 2. Regression of gun hours on total harvest, Harvard Area.



Appendix Figure 3. Regression of gun hours effort—Total harvest, Clay Center.

Appendix Figure 4. Sample calculation: Testing for difference in crippling rates on the study areas (Paired t-test).

Year	P_c (Harvard) % HBNR	P_a (Clay Ct.) % HBNR	(P_c-P_a) D	D^2
1955	16.5	12.8	3.7	13.69
1956	19.6	10.6	9.0	81.00
1957	14.0	16.5	− 2.5	6.25
1958	18.3	15.2	3.1	9.61
1959	18.4	29.2	−10.8	116.64
1960	12.5	24.3	−11.8	139.24
1961	11.1	7.7	3.4	11.56
1962	17.3	19.0	− 1.7	2.89
1963	22.1	17.0	5.1	26.01
1964	23.6	13.1	10.5	110.25
			8.0	517.14

Ho: $P_c = P_a$

$$\bar{D} = \Sigma(P_c-P_a)/n = 8.0/10 = 0.80$$

$$S_D^2 = \frac{\Sigma D^2 - (\Sigma D)^2/n}{n-1} = \frac{517.14 - (8)^2/10}{9} = 56.749$$

$$t_{calc} = \frac{\bar{D}-0}{S_{\bar{D}}} = 0.80/2.38 = 0.336$$

$$S_{\bar{D}}^2 = \frac{S_D^2}{n} = 56.749/10 = 5.6749$$

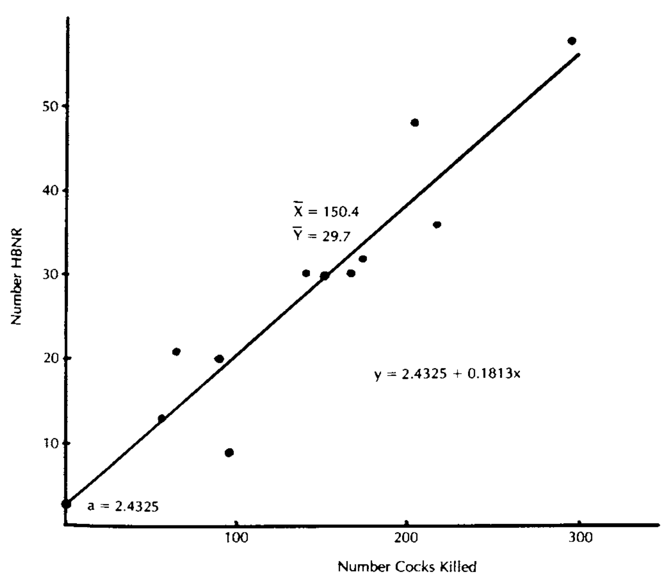
$$S_{\bar{D}} = \sqrt{5.6749} = 2.38$$

t_{tab} @ .05 w/ 9 d.f. = 2.262

Therefore, Ho accepted. No significant difference exists between crippling rates.

Note: Comparison of two methods (Paired and Unpaired t) indicated that the paired t was the more precise test for the above date.

Appendix Figure 5. Regression of total harvest on number of "Hit but not retrieved" birds.



Appendix Figure 6. Sample calculation: Testing for difference between resident and nonresident party size (Unpaired t-test).

Year	Resident X	Resident X_i^2	Non-resident Y	Non-resident Y_i^2
1960	1.8	3.24	—	—
1961	2.8	7.84	6.0	36.00
1962	3.7	13.69	6.7	44.89
1963	3.9	15.21	4.0	16.00
1964	3.0	9.00	3.5	12.25
	15.2	48.98	20.2	109.14

Ho: $\bar{X} = \bar{Y}$

$$\bar{X} = \Sigma X/n = 15.2/5 = 3.04$$

$$S_X^2 = \frac{\Sigma X_i^2 - (\Sigma X_i)^2/n}{n-1} = \frac{48.98 - (15.2)^2/5}{4} = 0.943$$

$$S_{\bar{X}}^2 = S_X^2/n = 0.943/5 = 0.1886$$

$$\bar{Y} = \Sigma Y/n = 20.2/4 = 5.50$$

$$S_Y^2 = \frac{\Sigma Y_i^2 - (\Sigma Y_i)^2/n}{n-1} = \frac{109.14 - (20.2)^2/4}{3} = 2.71$$

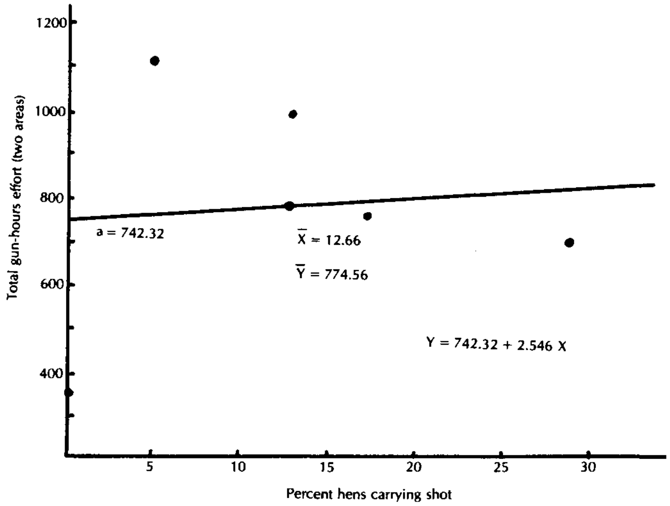
$$S_{\bar{Y}}^2 = S_Y^2/n = 2.71/4 = 0.6775$$

The pooled estimate of S^2 is then:

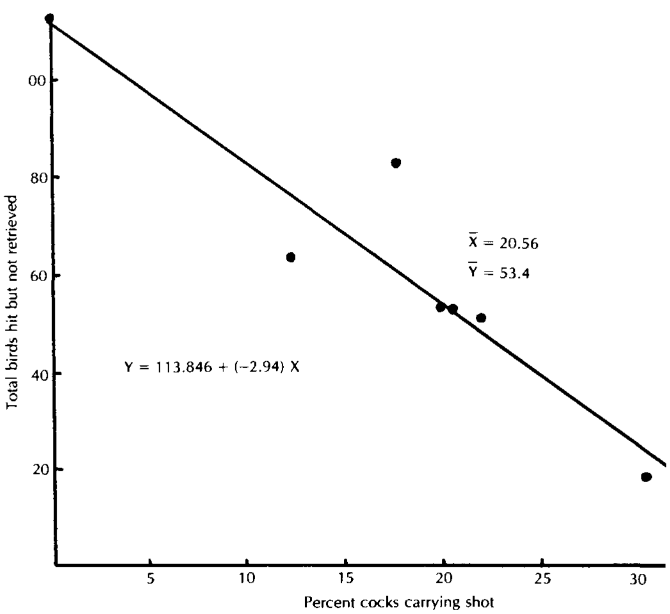
$$S^2\text{ (pooled)} = \frac{(n-1)S^2_X + (n_2-1)S^2_Y}{(n_1-1)+(n_2-1)} = \frac{4(0.943) + 3(2.71)}{7} = 1.700$$

$$t_{calc} = \frac{\bar{X} - \bar{Y}}{\sqrt{S_X^2/n_1 + S_Y^2/n_2}} = \frac{3.04-5.50}{\sqrt{\frac{1.700}{5} + \frac{1.700}{4}}} = 2.81$$

Therefore, Ho is rejected. A significant difference in party size exists.



Appendix Figure 7. Regression of percent hens carrying shot on total gun-hours effort (Harvard and Clay Center Areas).



Appendix Figure 8. Regression of percent cocks carrying shot on total birds hit but not retrieved (three study areas).

Figure 9. Testing for difference between area and statewide fluoroscopy results (Paired t), hens.

Year	P_c (area %)	P_a (statewide %)	(P_a-P_a) D	D^2
1954-55	5.0	14.3	9.3	86.5
1955-56	17.2	11.1	6.1	37.2
1956-57	28.6	0.0	28.6	818.0
1957-58	12.7	7.4	5.3	28.1
1958-59	4.8	0.7	4.1	16.8
			34.8	986.6

Ho: $P_c = P_a$

$\bar{D} = \Sigma (P_c - P_a)/n$

$= 34.8/5$

$= 6.96$

$S_{D^2} = \dfrac{\Sigma D^2 - (\Sigma D)^2/n}{n-1}$

$= \dfrac{986.6 - 242.0}{4}$

$= 744.6/4 = 186.15$

$S_{\bar{D}^2} = S_{D^2}/n$

$= 186.15/5$

$= 37.23$

$S_{\bar{D}} = \sqrt{S_{\bar{D}^2}}$

$= \sqrt{37.23}$

$= 6.102$

$t_{calc} = \bar{D} - 0/S_{\bar{D}}$

$= 6.96/6.102$

$= 1.14$

t_{tab} @ .05 with 4 d.f. = 2.776

@ .01 with 4 d.f. = 4.604

Figure 10. Testing for difference between area and statewide fluoroscopy results (Paired T), cocks.

Year	P_c (area %)	P_a (statewide %)	(P_c-P_a) D	D^2
1954-55	24.3	29.4	−5.1	26.0
1955-56	12.5	18.2	− .7	0.5
1956-57	20.0	0.0	20.0	400.0
1957-58	22.0	9.2	12.8	163.8
1958-59	17.9	12.2	5.7	32.5
			32.7	622.8

Ho: $P_c = P_a$

$\bar{D} = \Sigma(P_c - P_a)/n$

$= 32.7/5$

$= 6.54$

$S_{D^2} = \dfrac{\Sigma D^2 - (\Sigma D)^2/n}{n-1}$

$= \dfrac{622.8 - 213.9}{4}$

$= 408.9/4$

$= 102.2$

$S_{\bar{D}^2} = S_{D^2}/n$

$= 102.2/5$

$= 20.44$

$S_{\bar{D}} = \sqrt{S_{\bar{D}^2}}$

$= \sqrt{20.44}$

$= 4.52$

$t_{calc} = \bar{D} - 0/S\bar{D}$

$= 6.54/4.52$

$= 1.45$

t_{tab} @ .05 with 4 d.f. = 2.776

@ .01 with 4 d.f. = 4.604