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Raymond L. Linder
Nebraska Game, Forestation and Parks Commission

David L. Lyon
Nebraska Game, Forestation and Parks Commission

C. Phillip Agee
Nebraska Game, Forestation and Parks Commission

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AN ANALYSIS OF PHEASANT NESTING IN SOUTH-CENTRAL NEBRASKA[1]

RAYMOND L. LINDER, DAVID L. LYON, AND C. PHILLIP AGEE
Nebraska Game, Forestation and Parks Commission, Lincoln, Nebraska

The ring-necked pheasant (*Phasianus colchicus*) constitutes the most important species of upland game bird in Nebraska. According to Mohler (1960), Nebraska's population is the result of a relatively small introduction; probably not more than 500 pairs were brought into the state between the years 1915 and 1925—the period of initial establishment. Through natural increase and dispersal, aided by a program of trapping and transplanting, a population estimated to be more than one million was reached by 1930 (Swenk, 1930). The statewide population continued an upward trend until the early '40's and then began to decline. Coincident with these changes, there occurred apparent shifts of centers of population from one part of the state to another. It is presumed that these "shifts" consisted of differential changes in the population levels in various regions of the state.

Nebraska, similar to many other states, inaugurated programs intended to increase or stabilize populations. While these efforts did not accomplish the desired results, they attested to the need for factual information upon which management programs might be founded. To be effective, any program of management must be directed at the limiting factor which prevails in the locality.

The primary prerequisite to such a program is a thorough knowledge of the life history of the species to be managed and its ecology in that particular environment. In 1954, an intensive research project was begun for the purpose of gathering such information. This study, entitled "The Life History and Ecology of the Ring-necked Pheasant" (Pittman-Robertson Project W-28-R), is now in its sixth year and is designated to continue until 1964. In this study, we are attempting to examine each segment of the life history and to relate it to environmental influences. One segment being given particular attention is reproduction, for extensive data have suggested that this has been closely related to population fluctuations. It is the purpose of this paper to describe work accomplished to date relative to nesting and to relate this to changes in the population.

The authors are indebted to Dr. J. Henry Sather, former Project Leader, who initiated the research project, to Mr. Max Hamilton and Mr. James A. Norman, biologists who contributed substantially to the

[1]Work conducted under Pittman-Robertson Project W-28-R, "Life History and Ecology of the Ring-necked Pheasant."

study and to the administrators of the Nebraska Game, Forestation and Parks Commission who furnished necessary support to the program. Thanks are also due the many farmer-cooperators who have permitted the use of their farms in this and other parts of the pheasant research program.

DESCRIPTION OF AREA

The Harvard study area occupies seven sections in the northern part of Clay County (elevation 1,800 feet), a region of gently undulating uplands slightly modified by stream erosion. Soil types in this area are largely 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 in these soil types ranging from 5.4 to 8.3 (Roberts and Gemmell, 1927). Soil technicians regard calcium levels to be adequate for all crops except legumes on the most acid sites.

The climate of Clay County is characterized by long, moderately hot summers and cold, dry winters. Mean monthly temperatures range from 25.2° F. in January to 78.9° F. in July. Mean annual precipitation is 22.52 inches, 43 percent of which falls during May, June and July (U. S. Department of Commerce—Weather Bureau, 1957). The average growing season is 155 days long (Roberts and Gemmell, *op. cit.*).

Approximately 95 percent of the study area was intensively cultivated or grazed. Of the total acreage, row crops (corn and grain sorghum) occupied about 45 percent; winter wheat, 25 percent; pasture, nine percent and alfalfa, three percent. Winter barley, oats, sweet clover and native hay were grown on the study area, but only infrequently and usually in small parcels. There was little change in land use during the course of the nesting study, except during 1956 and 1957 when emphasis was temporarily shifted from corn to grain sorghum due to drought. At no time on the area was there land in the Soil Bank program.

Roadsides, fencerows and odd areas occupied less than two percent of the total acreage. The widths of roadsides ranged from five to thirty feet and averaged approximately twenty feet. Width of cover in fencerows, however, was more restricted, ranging from zero to eight feet with an average of only three to four feet. Odd areas were comprised largely of farmsteads and railroad right-of-ways which had been abandoned and had reverted to mixed weedy grasses and forbs.

In general, facilities for deep-well irrigation increased during the course of the nesting study. The acreage under irrigation increased

from 14 percent of the study area in 1955 to 23 percent in 1957. This activity was curtailed somewhat in 1958 and 1959 with improved rainfall. Crops irrigated included corn, grain sorghum, alfalfa and wheat. However, each year, corn and sorghum comprised more than 90 percent of the total acres irrigated.

STUDY DESIGN

The primary objective of the nest study was to analyze nesting as a factor in population changes and to evaluate some of the environmental factors which influenced the success of nesting. This involved determining the relative importance of various cover types in production and the role of various agents affecting nesting success.

To facilitate an evaluation of nesting, a method of sampling similar to that of Stokes (1954) was used. By this method, production from each cover type was calculated, using data from a thorough search of a sample of each type.

The rate of sampling was adjusted to the anticipated density of nests in each cover type. Sampling rates, chosen as representative of those during the study, were:

Alfalfa	1 acre out of 6
Roadsides	1 acre out of 6
Fencerows	1 acre out of 6
Odd areas	1 acre out of 6
Pastures	1 acre out of 6
Wheat	1 acre out of 16

Row crops, small-grain stubble and seriously overgrazed pasture were not sampled since normal farming operations and phenology precluded any significant production from these types. Row crops and overgrazed pastures did not offer nesting cover during the nesting season, and stubble was plowed in the spring before chicks had hatched.

The investigations were conducted on a seven-square-mile study area, except the first year when only four sections were sampled. To facilitate comparison, the findings for that year have been projected to seven square miles.

In 1955, plots were selected by placing a grid with numbered squares over the map of each parcel of land of a single cover type. Then, by selecting numbers at random, plots (usually one acre in size) were placed on the maps to correspond with the numbered squares. The number of plots in each parcel depended on the assigned rate of sampling and the size of the unit of cover. This pro-

cedure was found to be time consuming, due largely to the difficulty of locating these plots in the field. In subsequent years, transects were used instead of the plots. Each transect was laid out to extend the length of the field; its width was adjusted to cover the desired area (usually one acre). The position of each transect in the field was established by random drawing. Each roadside and fencerow, being of generally linear shape, was divided into six equal segments and one was selected randomly as the plot.

It was necessary to deviate from the predetermined transects only when sampling wheat in 1958 and 1959. The height and density of the ripening wheat those years made it inadvisable to complete the search of plots as planned. An alternate procedure was adopted whereby tractor-drawn combies were followed and the strip free of cut straw was searched as a transect.

Plots were searched once within the period May 15 to June 15 and again between June 15 and July 15 by two permanent personnel with the help of two student assistants. No efforts were made to calculate production from nests established later than July 15. However, brood studies conducted each year indicated at least 97 percent of the chicks to have come from nests established before the completion of the study.

For this study, a form containing one or more eggs was considered to be a nest. All information concerning the nest and eggs was recorded on mimeographed forms. Nests, except those that were destroyed before they were found, were revisited regularly, the observer being careful not to disturb the hen if she was present.

The number of nests found on plots in each cover type was projected according to the rate of sampling to determine the total number of nests in that type. This figure, multiplied by the average number of eggs in all nests found, gave the calculated number of eggs in each type. Production of chicks was calculated by multiplying the percent of eggs successful in each type by the calculated number of eggs in that cover type.

The breeding populations of hens on the area were determined from aerial and ground counts made during January and February and sex ratio counts obtained by flushing birds from concentrations during late winter storms. Only resident wild hens were present on the area during the study except in 1956 when 250 pen-reared hens were released at the beginning of the nesting season.

In order to evaluate efficiency of searching sample plots, 32 dummy nests were secretly placed on plots in various cover types in 1958. Thirty or 94 percent of these were found by the searchers. Further evidence of efficiency is found in the fact that during the five years

only two nests found during the second search had been missed in the first search.

As a part of the records, notes were kept regarding possible influence of the investigators upon nesting success. During the course of the study, only 29 hens were flushed from the nests, and of these, 20 returned. Two nests were accidentally destroyed by the searchers.

RESULTS

The breeding population of pheasants on the study area averaged 29 birds per section. This is relatively low compared with the population levels cited in other nesting studies: breeding populations of 50 to 125 birds per section in north-central Iowa (Baskett, 1947), 78 birds per section in Pennsylvania (Randall, 1940), and 608 nesting hens per section on Pelee Island, Ontario (Stokes, 1954).

The average number of resident hens on the seven-section study area was 144, with a range of 115 to 212 (Table 1). The sex ratio averaged 42 cocks per 100 hens, the extremes being 29 in 1959 and 67 in 1955.

During the five years, 622 nests were found on the study area. Two hundred sixty of these were on plots and served as a base from which the total number of nests in the various cover types were calculated. The greatest numbers of nests were in wheat which contained 38.4 percent, alfalfa which had 27.5 percent and roadsides which had 23.6 percent of the nests (Table 2).

Fencerows, odd areas and pastures were of little importance for nesting on the study area; only 10.5 percent of the nests occurred in these cover types. Except in 1959, pastures were not used for nesting, reflecting the sparse cover conditions brought about by low precipitation and overgrazing.

Based upon the several nesting studies reported in the literature, there is little uniformity in the use of a given cover type for nesting in the different parts of the pheasant range and in the rates of success of those nests. For instance, in hayfields the percent of nests varied

TABLE 1. SPRING POPULATIONS OF HENS AND RESULTANT PRODUCTION

	Year					
	1955	1956	1957	1958	1959	Average
Spring population of hens.....	124	365*	124	145	212	144
Nests:						
Found on plots.....	23	47	41	46	103	52
Total found	151	109	68	174	120	124
On study area (calculated)..	264	400	267	383	768	416
Eggs:						
On study area (calculated)..	2,510	2,997	2,428	3,141	5,392	3,294
Percent successful	13.1	13.6	19.9	20.6	11.4	15.1
Chicks produced (calculated)....	329	407	483	648	614	496

*Includes 115 wild resident hens and 250 pen-reared hens.

TABLE 2. NESTING AND PRODUCTION BY YEAR AND BY COVER TYPE

	1955	1956	1957	1958	1959	Average
Number of nests in:						(Percent of all nests)
Alfalfa	34	32	74	156	276	27.5
Wheat	112	176	105	137	270	38.4
Roadsides	96	162	77	54	102	23.6
Pastures	0	0	0	0	84	4.0
Fencerows	22	12	4	12	18	3.3
Odd areas	0	18	7	24	18	3.2
All types	264	400	267	383	768	100.0
Percent success of nests in:						
Alfalfa	0.0	0.0	4.7	3.8	4.3	3.8
Wheat	27.2	9.1	16.6	40.0	20.0	24.8
Roadsides	13.7	22.2	45.4	22.2	11.8	19.3
Pastures	0.0	0.0	0.0	0.0	7.1	7.1
Fencerows	0.0	0.0	0.0	0.0	0.0	0.0
Odd areas	0.0	0.0	0.0	25.0	0.0	5.0
All types	16.2	12.9	21.1	20.6	10.9	15.1
Number of chicks produced in:						
Alfalfa	0	0	29	61	74	33
Wheat	238	146	141	448	385	271
Roadsides	92	261	313	88	104	172
Pastures	0	0	0	0	51	10
Fencerows	0	0	0	0	0	0
Odd areas	0	0	0	51	0	10
Total	329	407	483	648	614	496

from 81.8 percent (Wight, 1949), to 61.6 percent (Leedy and Dustman, 1947), to 4.4 percent (Stokes, 1954), and success of nests from 4.8 percent (Klonglan, 1955), to 45.5 percent (Eklund, 1942).

In the present study, it was found that through the five years, nests were established in the various cover types as follows:

Roadsides — One nest per each 0.6 acres
Fencerows — One nest per each 0.8 acres
Alfalfa — One nest per each 1.3 acres
Odd Areas — One nest per each 1.4 acres
Wheat — One nest per each 6.7 acres
Pastures — One nest per each 13.0 acres

The proportion of nests in each cover type except alfalfa remained fairly constant each year. During the dry years of 1955 and 1956 when the growth of alfalfa was retarded, density of nests in this cover type was low.

Of the total nests established, 37.2 percent were destroyed by farming operations, including 22.2 percent by alfalfa-mowing operations. Alfalfa mowing also resulted in the death or injury of 98 hens. This represented 14 percent of the spring populations of hens during the five years.

Predators destroyed 25.7 percent of the nests. Mammals were of

greatest importance, destroying 23.1 percent, while birds took 1.7 percent, and undetermined predators, 0.9 percent. Mammals thought to be most important in destruction of nests were the striped skunk *(M. mephitis)*, little spotted skunk *(Spilogale interruptus)*, opossum (*Didelphis virginiana*), badger (*Taxidea taxus*) and feral house cat *(Felis domesticus)*.

Further loss of nests was attributed to abandonment, which accounted for 12.1 percent of the total number; flooding, which destroyed 1.7 percent; and undetermined causes, which took 8.4 percent.

Most other studies have also shown mowing and predation the principal factors in nest destruction. However, Stokes (1954) found abandonment to be of greater importance than either of these.

The over-all success of nests was lower than most of those reported in other studies. Reports vary from 17.3 percent (Klonglan, 1955) to 51.7 percent (Knott, *et. al.*, 1943). Other writers indicate the rate of success of nests to be 23 and 36 percent (Baskett, 1947), 23.1 percent (Hamerstrom, 1936), 41.8 percent (Westerskov, 1956) and 44.8 percent (Eklund, 1942). In the present study, of all nests established over the five-year period, 15.1 percent produced young. Success was greatest in 1957, when 21.1 percent hatched, and lowest in 1959 when 10.9 percent hatched (Table 2). Success of nests was highest in wheat where 24.8 percent were successful (range: 9.1 to 40.0 percent) and in roadsides where 19.3 percent succeeded (range: 11.8 to 45.4 percent). Rates of success were much lower in other cover types: 7.1 percent in pasture, 5.0 percent in odd areas, 3.8 percent in alfalfa and 0.0 percent in fencerows.

The number of eggs found in all nests averaged 8.0 and ranged from 7.0 eggs per nest in 1959 to 9.5 in 1955. The average number of eggs in incubated nests for the five years was 9.9 with a range from 8.0 in 1959 to 12.1 in 1957. A total of 314 nests was ultimately successful. Of the 781 eggs in 72 of these, 77 percent hatched, 13 percent contained dead embryos, seven percent showed no development and three percent were unclassified. At least 90 percent of these were fertile, based on the presence of an embryo.

Approximately 90 percent of the chicks were produced in wheat and roadsides (Table 2). Even though nest densities were low in wheat, about 55 percent of all the chicks were produced there, reflecting the large area devoted to this crop and the large portion of the nests which succeeded. Roadsides, while comprising less than 1.5 percent of the total acreage, accounted for about 35 percent of all chicks produced, reflecting the high density of nests and rate of success. While densities of nests in alfalfa were high, few chicks were produced there since most of the nests were destroyed. Fence-

rows and odd areas were unimportant in the production of chicks because of the small acreages devoted to these types and the high loss of nests to predators. During the first four years of the nesting study, no chicks were produced in pastures. However, in 1959, following rains which tended to relieve the over-grazed condition, about eight percent of the chicks were produced in this cover type.

Many investigators have found small-grain fields to be of importance in the production of chicks. As in the present study, Randall (1940) in Pennsylvania found that a large part of the pheasant crop was produced in wheat. During a three-year period in north-central Iowa, Baskett (1947) found that approximately 33 percent of the successful nests were in small grains, and of these, 94 percent were in oats. On the same study area, Klonglan (1955) found 32 percent of the successful nests were in small grains, all of which were in oats. Similarly, Robertson (1958) reported broods produced in oats "may have contributed substantially to total production" in Illinois' pheasant range.

As in the present study, Klonglan *(op. cit.)* in Iowa found roadsides important in the production of chicks. He reported that 29 percent of the successful nests were in this cover type. In eastern Michigan, Shick (1952) reported that the majority of the production of chicks occurred in roadsides and ditchbanks. Also, on Pelee Island (Stokes, 1954), from 43 to 56 percent of the chicks were produced in "Scrub I," which classification apparently included roadsides.

The ranges in the percent of hens successful and the number of chicks per hen recorded in the present study are comparable to similar information as calculated from studies in north-central Iowa (Baskett, 1947 and Klonglan, 1955) and Pennsylvania (Randall, 1940). However, on Pelee Island (Stokes, 1954), the percent of hens successful and the number of chicks per hen were much higher. Similarly, Errington and Hamerstrom (1937) indicated "from 70 to 80 percent of the hens finally succeed in bringing off broods".

Based upon the five-year study reported here, in a hypothetical "average year" 144 hens were present in the breeding population. They established an average of 2.9 nests (23 eggs) each and 63 (44 percent) of the hens succeeded in producing young. The average hatch was 7.8 chicks, making a total of 496 young produced. Based upon the entire population of hens, 3.4 chicks were produced per each hen (Table 3).

DISCUSSION

From examination of the literature, it is evident that much information has been gathered relative to the success of observed nests

TABLE 3. NESTING AND HATCHING ON THE STUDY AREA—1955-1959 INCLUSIVE

Year	Spring population of hens	Number of nests			Percent of hens successful	Number of chicks		
		Per hen	Total	Successful		Total	Per successful hen	Per hen
1955	124	2.1	264	43	34	329	7.7	2.7
1956	115[1]	3.5	400	52	45	407	7.8	3.5
1957	124	2.1	267	56	45	483	8.6	3.9
1958	145	2.7	383	79	54	648	8.2	4.5
1959	212	3.6	768	84	40	614	7.3	2.9
Average	144	2.9	416	63	44	496	7.8	3.4

[1]Excluding 250 game-farm hens.

and the use of various cover types for nesting. However, no studies have dealt with chick production in relation to the spring populations over a period of years. In the present study, because data were obtained over a five-year period and the number of hens in the spring population was known each year, we have attempted to fill a few gaps necessary for a more nearly thorough understanding of productivity and population changes of the pheasant.

USE OF COVER TYPES

In this area, a large part of the total production occurred in winter wheat even though nest densities were low. Since few nests were lost to predation and to harvesting operations, nesting success was high. Of the nests established in wheat, most had hatched before combining operations began which was usually in the first half of July. Furthermore, hens which still were incubating usually returned to the nests after harvesting was completed. Destruction of nests by predators was relatively low, suggesting that the large wheat fields were less intensively explored by mammals than were other cover types which occurred in smaller acreages. This is probably due to the large size of the fields and also to the fields' being plowed each year, not permitting mammals to establish permanent dens.

Roadsides comprised less than 1.5 percent of the total acreage of the study area, but during the five years 23.6 percent of the tota nests were established there. One of the reasons roadsides assumed this importance was the presence of cover remaining from the previous year which was available for early nesting. The use of roadsides for nesting, however, varied from year to year, depending upon changes in the quantity and quality of this residual cover. These changes were not synchronized with changes in most other cover types for early cover in roadsides was greatest following dry years. In dry years, fireweed (*Kochia* sp.) became abundant and during the fall and winter was blown into roadside ditches. This additional

cover resulted in greater density of nests as well as higher rate of success of those nests. The increased success was not thought to have resulted from improved concealment but from the fireweeds' serving as a deterrent to mammalian predators that normally used roadsides as travel lanes.

Although few chicks were produced in alfalfa, because of the large number of nests established there it was considered one of the most important cover types for nesting. However, as a result of the variations in growth of alfalfa during the five years, the number of nests there fluctuated disproportionately in relation to the total number in all cover types. In 1955 and 1956, both dry years, only 10 percent of the total nests were in alfalfa, while in 1957, 1958 and 1959, years of normal or above normal precipitation, 36 percent of the nests were established there. In the former instance only permanent cover in roadsides, fencerows and odd areas was available early in the season, but in the latter, alfalfa developed quickly and constituted additional early nesting cover. The earlier growth of alfalfa was not, however, followed by earlier mowing; hence, it was useable for a longer period. The result was a higher proportion of nests in alfalfa during wet years and an increase in the percent of nests successful in this cover type.

During nest searching, we were impressed by the small number of chicks killed in alfalfa by mowers. As indicated earlier, few chicks were hatched in alfalfa, and of additional importance is the observation that other cover types, especially wheat, provided preferred roosting and loafing cover as well as an adequate food supply. Consequently, chicks produced in alfalfa probably left soon after hatching and thus escaped the mower.

Odd areas, fencerows and pastures were not important in production; most nests were destroyed by mammalian predators. All three cover types offered sites for permanent dens, and fencerows, where all nests were destroyed, were used as travel lanes as well. Also, in pastures, trampling of nests by livestock created still another hazard.

RENESTING

The ability of hen pheasants to renest is well known, but the extent to which this occurs has probably been underestimated. In this study, we found not only extensive renesting, but also considerable variation between years in the tendency of hens to renest. It is interesting to note that the number of nests established per hen increased as the population was rising. (This is similar to the findings of Kozicky and Hendrickson (1951) who reported the greatest number of "observed"

nests per hen on the Winnebago Research Area in Iowa occurred "during the greatest observed spring density for the five-year period".) In 1955 and 1957, the numbers of hens and of nests per hen were the lowest recorded. In 1958, as the population began to rise, there was a corresponding increase in the number of nests per hen, and in 1959, when the population of hens was highest, the greatest number of nests per hen was recorded. This comparison was made for only four years' data. A correlation for 1956 was not possible due to the presence of pen-reared hens.

If we consider that the number of nestings is indicative of the effort exerted by the hen, the above observation appears to be contradictory to the principle of inversity (Errington, 1945). It seems more plausible, however, that the two are entirely compatible. Even though the number of nests per hen increased as the population increased, the average number of eggs per nest declined, and the total *number of eggs* laid by each hen each year remained surprisingly constant. This suggests that the larger number of nests reflected a greater incidence of voluntary abandonments or "false starts" (similar to randomly dropped eggs), which the hen made no attempt to incubate. Hence, it appears that in years of higher population there was more *nesting effort,* about equal *laying effort* and less *incubation effort.*

Whatever the interpretation above, it is apparent that there are weaknesses inherent in any study which relies upon success of nests alone to evaluate production. Since it appears that nesting effort may show considerable variation between years, one must consider nest success in association with spring populations and the number of nests established per hen.

PRODUCTION AND POPULATION LEVELS

During the five years, the primary factor responsible for variations in the rate of production of chicks was the percent of hens bringing off broods and not variation in clutch size and fertility and hatchability of eggs. In 1955, 34 percent of the hens were successful, resulting in production at the rate of 2.7 chicks per each hen in the spring population while in 1958, 54 percent of the hens were successful and the production index was 4.5 chicks per hen. This relationship was consistent throughout the five years, indicating that the percent of hens bringing off broods was the variant directly related to the resultant level of production (Figure 1). However, a secondary factor, the average number of chicks hatched from each successful nest (chicks per successful hen), also influenced production, but the magnitude of the fluctuations in this factor was small. In 1957, the year in which the number of chicks per successful hen deviated

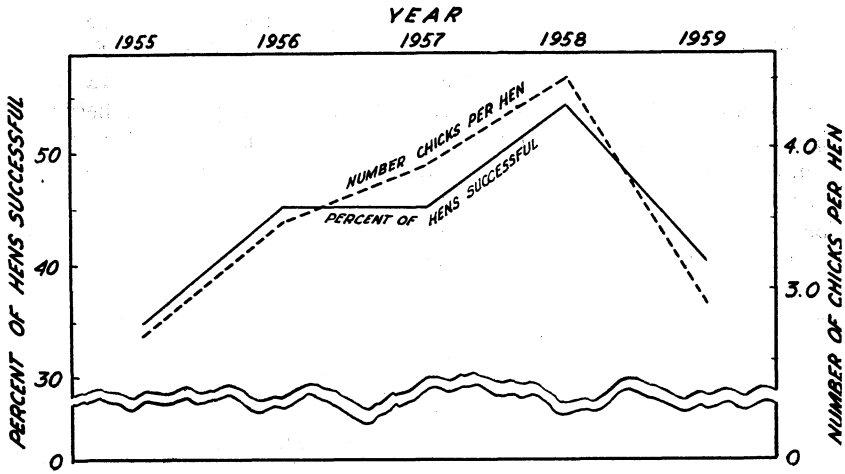

Figure 1. Correlation between percent of hens successful and rate of production.

furthest from the average, only 11.4 percent more chicks were produced per hen than in 1956, even though the percent of hens successful was the same each year (Table 3).

From information gathered during this study, it is evident that chick production was the factor determining changes in the following year's spring population. This correlation is shown in Figure 2. Since there is close correlation between these two factors, annual mortality was evidently quite constant from year to year. In view of this, it is interesting to note that in years when fewer than 3.0 chicks were produced per hen, the following spring's population of hens declined and when the number of chicks produced exceeded 3.0, an increase followed. Evidently, about 3.0 birds for each hen in the breeding population is necessary in order to maintain a constant population level. This correlation was observed also on another study area (Clay Center) about nine miles away. There also, the threshhold was 3.0 chicks per hen. It is interesting to note that the density of birds there was approximately twice that on the present study area. Therefore, since 3.0 chicks was the threshhold on both areas, it is evident that the rate of production was not the factor responsible for the lower population on the Harvard study area.

In 1956, even though the 250 pen-reared hens released on the study area increased the population of hens by about 200 percent over the 1955 hen population, the production of chicks was only 25 percent greater. The fact that these additional hens raised total production very little might be explained in two ways: (1) The pen-reared birds

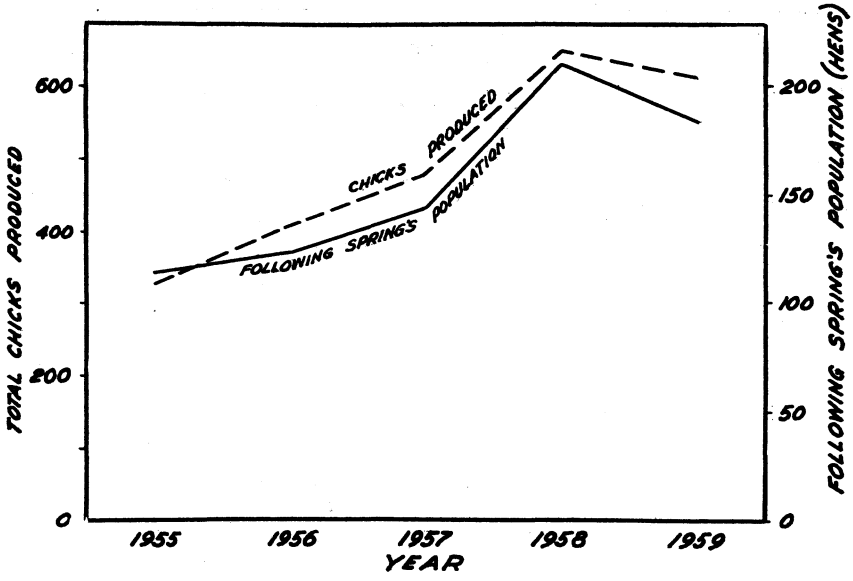

Figure 2. Relationship of number of chicks produced to following spring's population of hens.

were not capable of reproduction under "wild" conditions (2) The quality of the environment during the nesting season proved to be a limiting factor, and determined the upper limit of production regardless of the level of the breeding population. The first seems doubtful since the number of nests established that year exceeded the number for the previous year by 51 percent, suggesting that nests of pen-reared birds supplemented substantially those established by wild resident hens. The second seems more plausible since, despite the increase in the number of nests established, the level of production was approximately that expected from the wild resident hens (Figure 3).

This explanation appears to apply for 1956 and for the other four years as well. It was especially striking in 1959 (Figure 3). In that year a 46-percent increase in the population of hens resulted in a 101-percent increase in the number of nests established; the number of nests successful, however, increased only six percent.

This phenomenon appeared to operate on the Clay Center area as well, but there the number of nests that were successful was approximately twice that on the Harvard area. Rates of production and mortality were about the same on both areas, and thus the populations fluctuated simultaneously but at different levels.

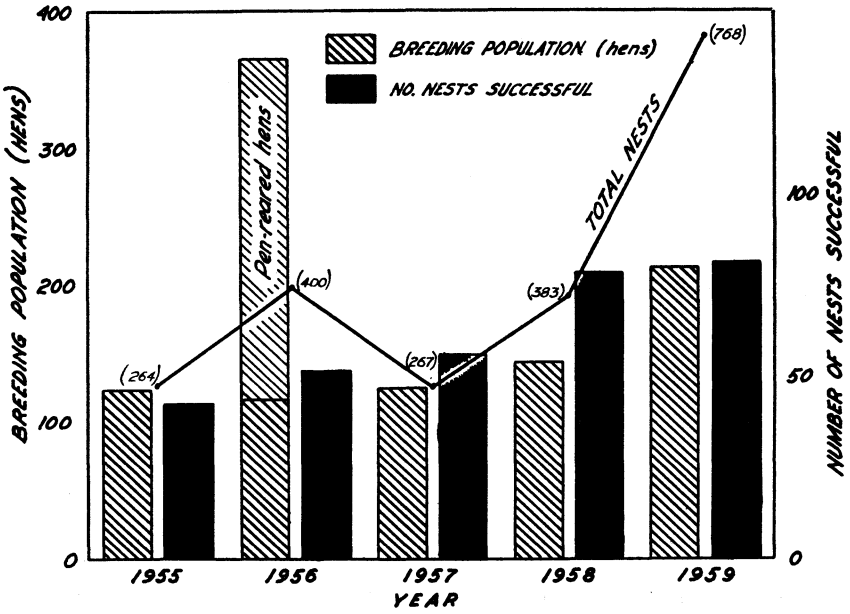

Figure 3. Relationship between number of breeding hens and number of nests successful.

In the light of this interpretation, the quality of nesting environment determines the *number* of nests which will be successful in a given year; this regulates total production which in turn determines the following year's breeding population. In each of the five years, a surplus of hens was present in the breeding population.

SUMMARY AND CONCLUSIONS

A nesting study was conducted on the Harvard Study area in south-central Nebraska from 1955-1959. Objectives were to evaluate the importance of various cover types in the production of chicks and the role of chick production in relation to changes in population.

The average breeding population of hens was 144, as determined from aerial and ground counts.

During the five years, 622 nests were found, 260 of them on sample plots. The number of nests on plots was projected to determine the total number established in each cover type.

Information was presented and discussed concerning success of nests, density of nests, and production of chicks in each cover type.

Nearly 90 percent of the nests on the area were located in wheat, roadsides, and alfalfa; about 90 percent of the total production of chicks came from nests in wheat and roadsides.

In a hypothetical "average year" 144 hens established an average of 2.9 nests each. Sixty-three (44 percent) of the hens produced young, and 7.8 chicks hatched from each successful nest. An average of 496 chicks or 3.4 chicks per hen (based upon the entire breeding population) was produced each year.

Extensive renesting occurred on the study area. Of more interest, however, was the greater incidence in renesting during years of population increase. Some aspects of this phenomenon in relation to the principle of inversity, were discussed.

The percent of hens successful in producing young was the factor most closely related to the fluctuations in the rate of production of chicks from year to year.

Throughout the study, each year's breeding population correlated closely with the preceding year's production and the average number of chicks produced for each hen seemed to offer a key to predicting increases or decreases in the following springs' populations. A production index of 3.0 young per hen seemed to represent a threshhold; when this figure was not attained, the following spring's population declined and when exceeded, the breeding population increased.

Based upon the data gathered, the quality of the nesting environment appeared to determine the *number* of nests which would be successful in a given year; this regulated production which in turn determined the level of the following year's breeding population. In each of the five years, a surplus of hens was apparently present in the breeding population.

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DISCUSSION

MR. THOMAS A. SCHRADER [Falls Church, Va.]: I am curious, and I would like to ask both of these men the same question. I don't know the percentage of the crop land which has been placed in the soil bank in the county in Nebraska in which these studies were made, but in Brookings County, if my memory serves me correctly, something in the neighborhood of 8 per cent of the crop land was in the conservation reserve in 1959. Did you not make any surveys in soil bank land, or are they included in one of these categories?

MR. TRAUTMAN: The first studies from the soil bank were in the year of 1958. That was a 37-acre field. This year in 1959 there were approximately, I would say, 120 acres, but that, of course, was the first year. Actually, it was just the establishment of oats or the small grain crop with the seeding of the more or less perennial vegetation, but that 37-acre field was the only conservation reserve lands on the area.

I might add, since you obviously are interested in the Soil Bank, Tom, this other survey involved a study of 21 fields of each. The average for the entire acreage was 2.5 nests per acre, which compares to the ordinary alfalfa of the two years. That is, 1958 and 1959 1.3 and 1.6 nests per acre, so it obviously is attractive.

The only difficulty was that we had some that we didn't know the exact age of. That, of course, is very important in conservation reserve land.

MR. LINDER: On our study area during the five years we had no soil bank land on the seven sections.

DR. GEORGE A. PETRIDES: [East Lansing, Mich.]: This isn't a question. It struck me as the last paper was read that the turnover rates in the pheasant population is 75 per cent on the average, and this directly parallels the population turnover study results which Dr. Rinebole and his students found in the arboretum at Madison. This may be evidence which these gentlemen wish to use if the 75 per cent figure is to be considered a critical level.

DISCUSSION LEADER DUSTMAN: In view of the pheasant scare which we had in many parts of the Midwest, I thought there would be many questions asked regarding the high rate of production in the area and the general decrease in the pheasant population this past season. I wonder if Mr. Trautman would care to comment on the high rate of production on his study area?

MR. TRAUTMAN: The production, of course, as we found out after the work was done and the reports were in, indicated rather spotty reproduction throughout the state. There was very good correlation between our hay and crop production and our area of poor reproduction within the state.

The particular area that we were in of course, was not in this particular pro-

duction slump. That followed through from Nebraska upwards through the southeastern part of the state and up along the eastern. I don't know to what extent western Minnesota felt it, but there was a good correlation between drought and the agricultural deficiency with poor reproduction.

We need additional information on that, but for this particular area, to answer Dusty's question, the August brood counts were just slightly up, about 9 per cent, and the subsequent age range that was in the hunter bag was at least normal to possibly slightly above that which generally we consider a normal range.

We did get area information under relatively poor conditions, and the February count in 1959 was 141 birds per square mile on a part of this area that I counted under relatively poor conditions. We had greater harvest, so I believe we anticipate we have about the same status of population, about the same level as we had last year.

MR. LINDER: I thought I might as well tell you what the Nebraska pheasant population was while I am up here. Production this past year, chicks per hen was about average for the past ten years, considerably lower than 1958, but we had a substantial increase in the breeding population state-wide last spring in some regions of the state, the southwestern part as much as about 100 per cent increase, and so this fall we had more birds than in 1958; production was down sharply from 1958, but it was about average for the past ten years. 1958 was an exceptionally good year for reproduction.

MR. TRAUTMAN: Excuse me for interrupting, but I did want to point out one thing. We had two different sampling systems in effect, and the efficiency of the 50x1000 acre plots, the location of nests and so forth was greater, possibly the percentage as differences were slightly, in spite of that. The 5-acre plots were more cumbersome. It took a greater detail, greater efforts to locate and find all the nests. Possibly some nests were missed in those larger sample plots of the previous year.

MR. LES BERNER [Game and Fish, Pierre, S.D.]: Mr. Linder, didn't you say you had a surplus of hens each year? Why don't you put a hen in the bag?

MR. LINDER: I didn't say we had a surplus of hens each year. I said "for the 5 years of study." We probably do each year. Why don't we have one in the bag? I think we should. I know a lot of people won't agree with me. It's just a matter of trying to regulate as far as I am concerned.

MR. CHARLES V. BOHART [Lincoln, Nebr.]: I would like to ask in relation to the studies made, are either of the gentlemen in a position to make a recommendation as to the species of grasses and perhaps some other plants that might be used in developing better roadside or field plantings, perhaps in soil bank land, to make better nesting?

MR. LINDER: To me the most important thing probably for roadside or anywhere else is to carry over cover from the previous year. Our roadsides as they stand probably would be hard to improve because they are not mowed. They are burned once in a while, often enough to keep them in a constant fluctuation of cover, but most of them are in forbs or revert to native grasses. Western wheat grass is fairly important.

The residual cover from the previous year is the important thing, and the same thing would hold true in an area where there is high nest loss from mowing. Cover from the previous year is available earlier than the alfalfa. If possible, leave cover from the previous year, be it a grass that stands through the winter such as Western wheat grass or, better yet, fire weed.