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Nesting Ecology of the Ring-necked Pheasant in Eastern South Dakota

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NESTING ECOLOGY OF THE RING-NECKED PHEASANT IN EASTERN SOUTH DAKOTA

By

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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Abstract

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Nesting of the ring-necked pheasant (Phasianus colchicus) was studied in 1973 and 1974 on 90 randomly chosen 4.05-ha plots in the Lake Sinai Township of south-western Brookings County. Nest initiation and hatching peaks over the 2-year period occurred from 1-15 May and 16-30 June, respectively. Average density of nests was 0.3 per hectare in 1973 and 0.2 in 1974. Average clutch size for combined years was 8.6 for all nests and 10.8 for nests where clutches hatched. Clutch sizes declined as the nesting season progressed. Fertility of eggs in nests where clutches hatched was 96 percent.

Hatching success varied between years with 21 percent of 111 clutches in nests hatching in 1973 and 28 percent of 75 clutches in nests hatching in 1974. Fifty percent of the nests in 1973 and 65 percent in 1974 were destroyed while 28 percent and 7 percent of the nests were abandoned in 1973 and 1974, respectively.

Highest densities of nests per hectare for cover types as averaged over both years were found in tame hay, 2.19,

and roadside, 2.13, while lowest nest densities occurred in pasture, 0.12; flax, 0.13; and small grain, 0.14. Highest hatching success for clutches in nests in the various cover types as averaged over both years occurred in flax, 100 percent, and shelterbelt, 50 percent. Lowest hatching success occurred in alfalfa, 8 percent, and fencerow and pasture, each with 7 percent. Approximately 34 percent of the total nests with hatched clutches was found in idle farmland while roadside and small grains each contained 14 percent.

Chi square analysis showed no significant relationship between nest success and cover conditions, amount of dead vegetation at nest sites, height of vegetation, physiognomy of the nest, or shape of the plot.

Two major causes of nest failure during the 1973 and 1974 nesting seasons were predation and agricultural machinery. Rate of predation was difficult to estimate since many nests destroyed by predators may have been inactive or abandoned when destroyed. Mammals were associated with 51 percent of all nest failures on sample plots during the study period. Thirty-five percent of the clutches in nests destroyed by mammals showed evidence of incubation while the remaining percentage associated with mammalian predation included abandoned nests, active nests in the pre-incubation period, and nests of unknown category.

Losses to machinery on sample plots in harvested crops accounted for 17 percent of all unsuccessful nests each year. Agricultural machinery was a major cause of nest loss in alfalfa as mowing occurred just prior to peak hatching each year. Sixty-nine percent of all nests located in fields of alfalfa but not included within the sample plots during 1973 and 1974 were destroyed by mowing. Losses to machinery in small grains and flax were considerably lower due to later dates of harvesting.

TABLE OF CONTENTS

LIST OF TABLES

Table | Page

LIST OF FIGURES

INTRODUCTION

Ring-necked pheasant (*Phasianus colchicus*) populations in South Dakota have fluctuated considerably since their establishment. Factors such as weather, cover quality, predation, and farming practices may affect pheasant population levels. However, availability of dense nesting cover is the greatest single factor favoring increased pheasant populations (Dustman 1950, Linder et al. 1960, MacMullan 1961, Baxter and Wolfe 1973).

The most recent major increase in pheasant populations occurred during the Soil Bank program in the late 1950's and early 60's when large areas of cropland were retired under long term contracts. This program provided undisturbed, grassy-herbaceous cover ideal for nesting (Frank and Woehler 1969). Pheasant populations approximately doubled in South Dakota during the Soil Bank program, reaching a peak fall population estimated at 11 million birds in 1961 (Dahlgren 1967). In contrast, pheasant populations dropped rapidly with annual declines of 49 and 27 percent occurring between 1963-65 when the Soil Bank program expired (Dahlgren 1967).

The Cropland Adjustment Program (CAP) and Diverted Acres practice, initiated by the Department of Agriculture in the 1960's, provided some replacement of dense nesting cover after the Soil Bank program expired. However, the areas in CAP and Diverted Acres were considerably reduced when compared with the Soil Bank program, and annual contracts on Diverted Acres provided little incentive for establishment of quality nesting cover (Baxter and Wolfe 1973). Contracts for retired cropland under CAP and Diverted Acres are currently expiring. No new Federal cropland retirement programs are being established to replace the lost cover. In addition, constantly increasing effort to increase crop yields and many changing agricultural practices result in destruction of available nesting and winter cover (MacMullan 1961).

The objectives of this study were to determine (1) the distribution and density of pheasant nests in relation to available cover types, (2) the relationship of cover types and cover characteristics to nesting success, and (3) the major causes of nest failure. Trautman (1960) previously conducted studies on pheasant nesting in western Brookings County during the Soil Bank program. Kimball (1948) conducted nesting studies in South Dakota during 1946 and 1947 as part of an overall project to evaluate yearly fluctuations of pheasant populations in the Dakotas.

STUDY AREA

Nesting studies were conducted in east-central South Dakota during 1973 and 1974 in the southwestern portion of Brookings County. The study area, Lake Sinai Township (Township 109 N, Range 52 W), contains 9,324 ha and is bounded by Lake County on the south and Kingsbury County on the west.

East-central South Dakota has a continental-type climate with cold winters and warm to hot summers. January is the coldest month with mean daily high and low temperatures of -4.9 C and -16.8 C while July is the warmest month with mean daily high and low temperatures of 29.2 C and 14.7 C. Average annual precipitation is 51.25 cm, of which 80 percent falls during the growing season (1 April to 1 September). Average dates for the first and last frost on the study area are 21 September and 17 May. Annual snowfall averages 60 cm and is often accompanied by strong winds causing moderate to severe drifting in sheltered areas (Spuhler et al. 1971).

Topography of the study area is gently undulating to undulating, interspersed with poorly drained soils and marshes. Major divisions in relief are due to Pleistocene glaciation which deposited an average of 12 m of glacial drift and outwash across the state east of the Missouri River (Flint 1955). Lake Sinai Township is positioned in the south-central part of the Coteau des Prairies, a major physical land division (Westin et al. 1967). This highland area slopes gently to the south and west between the Minnesota-Red River Lowland and the James River Lowland divisions on the northwest and west, respectively. Elevations vary from 600 m in the north to 480 m in the south. Elevation at Sinai is 525 m. Drainage flows southward via the Big Sioux River whose tributaries enter from the east (Flint 1955).

Soils, classified as the Chernozem group and Mid and Tall Grass subgroup, formed under tall and mixed grasses in a temperate to cool subhumid climate (Westin et al. 1967). Chernozem soils have a dark black surface horizon rich in organic matter grading into lighter material with a final horizon of accumulated carbonate material.

Native vegetation of Lake Sinai Township consisted of both mid and tall grass prairie. Native tall grass prairie species included big bluestem (*Andropogon gerardii*)[1], sand dropseed (*Sporobolus cryptandrus*), switchgrass (*Panicum virgatum*), and a variety of upland and lowland forbs. Native mid-grass species included needle and thread (*Stipa comata*), green needlegrass (*Stipa viridula*), western wheatgrass (*Agropyron smithii*), slender wheatgrass (*Agropyron*

1. Scientific nomenclature from Johnson and Nichols (1970).

trachycaulum), blue grama (Bouteloua gracilis), and prairie junegrass (Koeleria cristata) (Westin et al. 1967).

Agriculture provides the major source of income on the study area with corn, oats, wheat, flax, soybeans, and alfalfa comprising the major crops. Eighty-two percent of the study area was in cropland, 8.5 percent in pasture land, and 9.5 percent in miscellaneous lands (roads, shelterbelts, idle farmlands, lakes, building sites, etc.) during 1973 and 1974 as reported by the Agricultural Stabilization and Conservation Service of the U.S. Department of Agriculture in 1975 (Agricultural Stabilization and Conservation Service, U.S. Department of Agriculture, Brookings, S.D., Unpublished data). An average of 1.1 percent of the area was retired under the Cropland Adjustment Program (CAP) and Diverted Acres program of the U.S. Department of Agriculture during 1973 and 1974.

METHODS AND PROCEDURES

Selection of the Sample

Each section of Lake Sinai Township was traced from aerial photographs on a 20.3 cm^2 grid. Sections were equally divided into four quarter sections representing 64.75 ha each, and each quarter section was subdivided into sixteen 4.05-ha plots. Fencerows, roads, farmsites, shelterbelts, marshes, and other topographic features were included in the tracing for reference in plot location. Plots were numbered and 90 were selected using a random numbers table. Selected plots represented a 3.9 percent sample of the 9,324 ha in Lake Sinai Township.

All plots were cover mapped, and hectares of the various land uses were calculated for each year (Table 1). Cover considered suitable for nesting was categorized as fencerow, roadside, idle farmland, marsh, shelterbelt, small grains, alfalfa, flax, pasture, and tame hay.

Field Studies

Three to four-men field crews searched each 4.05-ha plot for nests twice during the nesting season in 1973 and 1974. The first search occurred approximately from 15 May to 1 July and the second from 2 July to 23 August in both years. All plots were systematically searched by field crews walking abreast in overlapping transects and using sticks

Table 1. Hectares and percentage (in parentheses) of land use types on sample plots, 1973-74.

Land use type	Number of hectares 1973	1974	Average
Residual Cover	88.66 (24.4)	74.70 (20.5)	81.68 (22.4)
Marsh	35.50 (9.8)	32.38 (8.9)	33.94 (9.3)
Idle farmland	31.33 (8.6)	19.37 (5.3)	25.35 (6.9)
Shelterbelt	9.09 (2.5)	9.03 (2.5)	9.06 (2.5)
Fencerow	6.44 (1.8)	7.05 (1.9)	6.75 (1.9)
Roadside	6.30 (1.7)	6.87 (1.9)	6.58 (1.8)
Crops	156.04 (42.9)	164.40 (45.1)	160.22 (44.0)
Corn	81.16 (22.3)	80.36 (22.0)	80.76 (22.2)
Oats	41.98 (11.5)	40.68 (11.2)	41.33 (11.3)
Flax	14.06 (3.9)	24.23 (6.6)	19.14 (5.3)
Wheat	11.97 (3.3)	18.74 (5.2)	15.36 (4.2)
Barley	3.89 (1.1)	0.39 (0.1)	2.14 (0.6)
Stubble	2.22 (0.6)	0.00	1.11 (0.3)
Sorghum	0.76 (0.2)	0.00	0.38 (0.1)
Hayfields	38.68 (10.6)	34.73 (9.5)	36.71 (10.1)
Alfalfa	35.73 (9.8)	29.83 (8.2)	32.78 (9.0)
Tame hay	2.93 (0.8)	4.85 (1.3)	3.89 (1.1)
Clover	0.02	0.06	0.04
Miscellaneous	80.48 (22.1)	90.78 (24.9)	85.64 (23.5)
Pasture	58.95 (16.2)	64.86 (17.8)	61.91 (17.0)
Lake Sinai	14.68 (4.0)	14.73 (4.0)	14.70 (4.0)
Roads	3.55 (1.0)	3.58 (1.0)	3.57 (0.9)
Fallow	1.61 (0.4)	4.11 (1.1)	2.86 (0.8)
Residential	0.88 (0.2)	0.44 (0.1)	0.67 (0.2)
Farmyard	0.62 (0.2)	2.22 (0.6)	1.42 (0.4)
Creeks	0.19 (0.1)	0.17 (0.1)	0.18 (0.1)
Feedlots	0.00	0.67 (0.2)	0.33 (0.1)
Total	363.86	364.62	364.25

to part the vegetation. Nests accidently found while walking to or from study plots were used in computing nest initiation and hatching curves, clutch sizes, egg fertility, and parameters of nest site vegetation.

Small grains, flax, tame hay (Bromus inermis), and alfalfa were searched to determine nest fate following mowing, windrowing, or combining. Alfalfa was searched only after the first cutting in late June as the second growth was comparatively sparse in both years and probably attracted few hens (Baskett 1947). Extra rows in small grains, flax, tame hay, and alfalfa were searched to compensate for area covered by windrows. Supplemental fields of small grains, flax, and alfalfa aside from sample plots were searched to obtain a more accurate assessment of agricultural operations on nesting. Corn was not searched as periodic cultivation precluded nesting.

Information on location, plot characteristics, clutch size, incubation stage, cover characteristics, nest fate, and hen fate was recorded for all nests on field record forms or cover maps and later transferred to unisort cards for analysis. Indexes of nesting cover preference and hatching success were calculated for each cover type in 1973 and 1974 using the technique of C. P. Agee (Pheasant Seminar, South Dakota Chapter of Wildlife Society, November 22, 1968, Brookings, Unpublished proceedings) as an indication of cover type selectivity by nesting hens and hatching success of clutches in cover types where nesting occurred.

A "form" containing one or more eggs was considered a nest (Linder et al. 1960). Incubation stages were determined by floating an egg in water (Westerskov 1950) or in the case of abandoned or destroyed nests, embryonic examination (Fant 1957, Opsahl and Labisky 1958). Active nests were periodically visited and nesting chronology recorded. Date of hatching was estimated for each active nest. Active nests which were not abandoned or destroyed during the incubation period were visited after the projected hatch date. Revisited nests were not approached closer than 1.5 m to avoid disturbing the hen and surrounding cover.

Dates of nest initiation were calculated by multiplying the number of eggs in a nest by the average laying rate of 1.3 days per egg (Wright and Otte 1962), adding days of incubation, and back-calculating. Hatching dates were estimated from nests of known incubation stages and records of nest chronology.

Fates of terminated nests were determined from sign in the vicinity of the nest. Nests with neatly capped eggs, stacked egg shells, small loose chips, or loose and parched egg shell membranes were considered hatched. Nests with crushed or pierced eggs showing no evidence of hatching were considered destroyed by predators. Some of the destroyed nests may have been abandoned prior to destruction. Attempts were made to determine the specific predator species responsible for nest destruction by examining remains at the nest (Darrow 1938, Rearden 1951, Duebbert 1970). Predators could not be identified in most cases.

Spring populations of breeding hens were estimated each year from triangulation counts of crowing cocks and winter sex ratios (Stokes 1954). Thirty-six quarter sections, randomly chosen from each of the 36 sections, were sampled to estimate cock populations. Winter sex ratios were obtained from roadside counts conducted in southwestern Brookings County in both years by Vergil Hoekman (Conservation officer, South Dakota Department of Game, Fish, and Parks, Brookings, Unpublished data) and by ourselves in the study area in 1974. Counts were conducted when snow cover on the ground was 75 percent or more. Data were combined from both sources in 1974. Sex ratios were based on a sample size of 1200 in 1973 and 293 in 1974. The percentage of breeding hens in the spring population which was successful in hatching clutches and the percentage of hens with broods in August, observed from summer brood counts, was estimated as two parameters to examine the percentage of hens successful in hatching clutches.

RESULTS AND DISCUSSION

Chronology of Nesting

The date of earliest nest initiation in this study was 26 April 1974. The hen selected a roadside as the site. Nesting in the pheasant range begins in early April and is preceded by random egg dropping in March (Baskett 1947). Wright and Otte (1962) in central Iowa and Frank and Woehler (1969) in southern Wisconsin observed early nesting in late April while Sandfort (1948) in Colorado and Dustman (1950) in Ohio discovered nests initiated between 1-7 April.

Thirty-two percent of nests with dates of known initiation in 1973 and 41 percent dated in 1974 were initiated between 1-15 May (Fig. 1). Baskett (1947) in northcentral Iowa, Wight (1949) in Pennsylvania, and Erickson et al. (1951) in Minnesota found peaks of nest initiation occurring from 1-15 May while Allen (1941) in Michigan, Sandfort (1952) in Colorado, and Wright and Otte (1962) in central Iowa report peaks between 16-31 May. Klonglan (1955) in Iowa found peak nest initiation from 1-15 June. Late or renesting hens in the northcentral or eastern United States usually do not nest after July (Wight 1949, Dustman 1950, Erickson et al. 1951, Wright and Otte 1962). However, Baskett (1947) in northcentral Iowa found one nest in early August and Hamerstrom (1936) in northwest Iowa reported one on

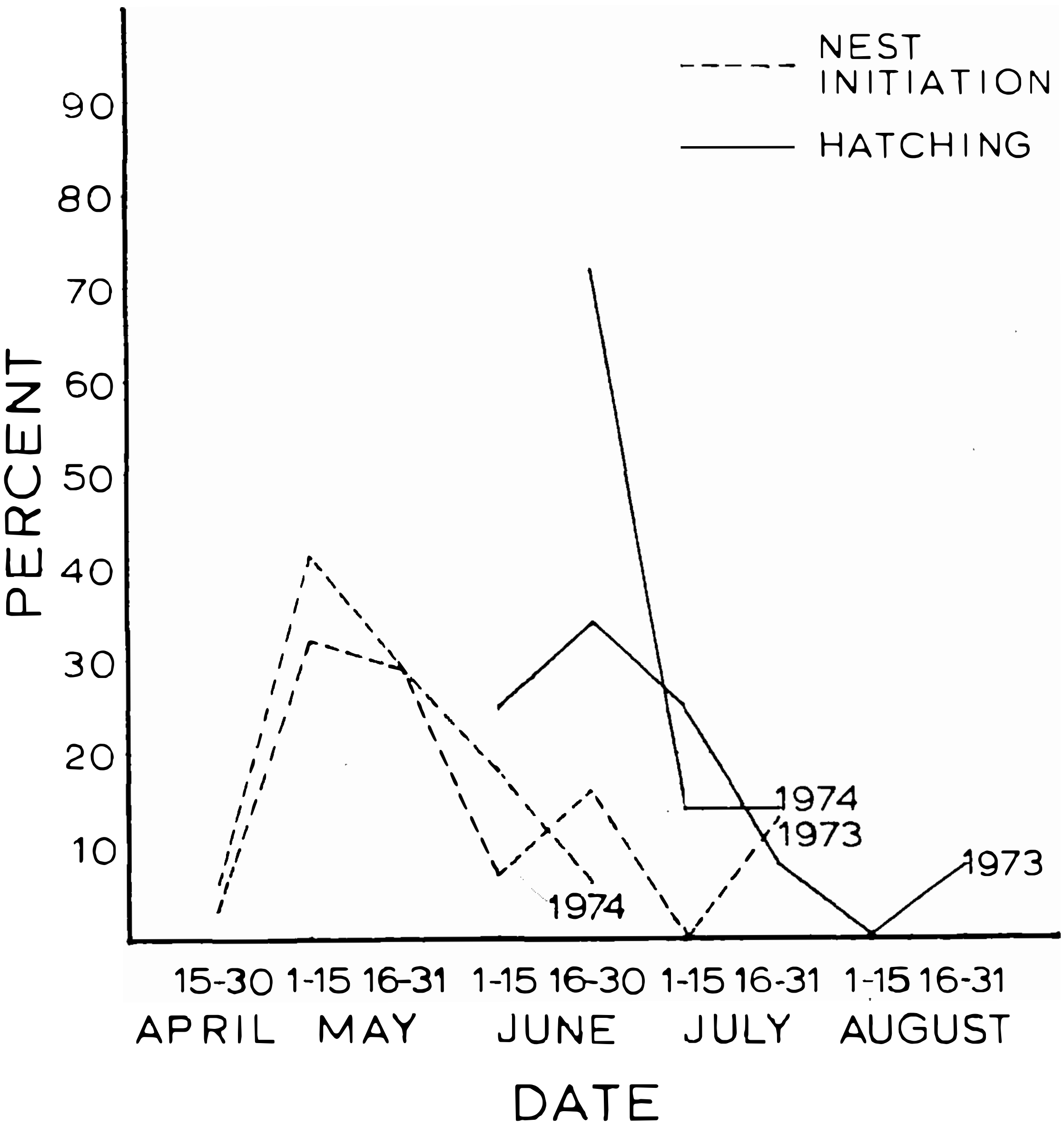

Fig. 1. Initiation and peak of hatching of nests with known dates of initiation, 1973-74. Thirty-one nests in 1973 and 17 nests in 1974 comprised the sample for initiation curves. Eleven nests in 1973 and 7 nests in 1974 comprised the sample for hatching curves.

4 September. In this study only 13 percent of the nests with known initiation dates in 1973 and none in 1974 were started after 30 June. The latest recorded date of nest initiation was 27 July 1973.

Numbers of nests with known dates of initiation within the various cover types are shown in Table 2. Several investigators reported preference for residual cover among early nesting hens until new vegetative growth became sufficiently dense for nesting (Klonglan 1955, Linder et al. 1960, Trautman 1960, Gates 1964, Bartmann 1969, Frank and Woehler 1969). Late nesting in small grains is probably the result of renesting hens whose first attempts failed in alfalfa or residual cover (Wight 1949). These trends were not readily apparent in this study, perhaps due to the low numbers of nests with known initiation dates. Very few nests in harvested grains and alfalfa could be backdated due to destruction by farming equipment.

The peak of hatching in 1973 and 1974 occurred between 16-30 June when 34 percent and 71 percent of nests with clutches of known hatching dates were hatched, respectively (Fig. 1). The earliest known date of hatching was 6 June 1973 in roadside while the latest hatching date was 21 August 1973 in idle farmland. Other investigators reported peak of hatching to vary from late May through mid-July. Baskett (1947) in northcentral Iowa, Sandfort (1948) in

Table 2. Number of nests with known dates of initiation in eight cover types, 1973-74.

	Date of initiation						
Cover type	April 15-30	May 1-15	May 16-31	June 1-15	June 16-30	July 1-15	July 16-31
Idle farmland		8	5	2			1
Shelterbelt		2					
Tame hay	1	1	2		1		
Fencerow		2	2				
Pasture		3					
Roadside	1		3	1	2		2
Alfalfa[a]		1	1	2	2		
Small grains			1		1		1

[a]Searched only after the first cutting due to sparseness of second growth in both years.

Colorado, and Wright and Otte (1962) in central Iowa recorded hatching peaks from 15-30 June. Kimball (1948) in South Dakota found peak hatching between 29 June and 5 July, Stokes (1954) on Pelee Island recorded peak hatching 20-26 June, and Fischer (1956) in southwestern North Dakota reported hatching peaks in mid-July.

Estimated Nesting Parameters

Densities of hens in spring were estimated to be 18.4 per square kilometer in 1973 and 19.4 in 1974 (Table 3). Density of nests on sample plots was 0.3 nests per hectare in 1973 and 0.2 in 1974. Trautman (1960) in eastern South Dakota found 2.08 nests per hectare in 1958 and 2.25 in 1959 among cover types where nesting occurred.

Estimated nests per hen were 1.63 in 1973 and 1.03 in 1974. Linder et al. (1960) in Nebraska reported nests per hen to vary from 2.1 in 1955 and 1957 to 3.6 in 1959 with an average of 2.9. Kozicky and Hendrickson (1951) in Iowa and Linder et al. (1960) in Nebraska found the highest number of nests per hen in years with a correspondingly high density of hens in spring. However, Linder et al. (1960) stated that nests per hen or nesting effort may vary considerably between years despite densities of hens in spring. Densities of hens in spring on my study area were similar for both years although nests per hen varied from

Table 3. Densities of crowing cocks in the spring, winter sex ratios, densities of hens in the spring, overall densities of nests, nests per hen, percentage of hens successful in hatching clutches in spring, and percentage of hens with broods in August, 1973-74.

Year	Crowing cocks per Km^2	Winter sex ratio	Hens per Km^2 in spring	Nests per hectare	Nests per hen	Percentage of successful hens in the spring[a]	Percentage of hens in August with broods
1973	8.2	44.6	18.4	0.30	1.63	33.7	61.7
1974	6.1	31.4	19.4	0.20	1.03	28.8	67.7
Mean	7.1	38.0	18.7	0.25	1.34	31.7	64.3

[a]Calculated by dividing the number of nests found on sample plots per year by the number of nests per hen, then dividing the number of nests with hatched clutches by the previous quotient (Linder et al. 1960).

1.63 in 1973 to 1.03 in 1974.

Size of clutches varied from 1 to 30 in 1973 and 1 to 16 in 1974 with means of 8.5 and 8.7, respectively (Table 4). Trautman (1960) found mean clutch sizes of 8.3 in 1958 and 8.0 in 1959 for all nests in eastern South Dakota. Other reported clutch sizes include means of 11.2 in northwest Iowa (Hamerstrom 1936), 11.8 on Pelee Island (Stokes 1954), 9.9 in Iowa (Klonglan 1955), and 8.0 in Nebraska (Linder et al. 1960). Nests with hatched clutches contained the largest average clutch size with 10.7 in 1973 and 10.8 in 1974 while clutch sizes in abandoned and destroyed nests were considerably smaller.

Average clutch sizes of hatched and destroyed or abandoned nests where incubation occurred declined as the nesting season progressed. Average clutch sizes of nests with incubated clutches initiated in the same month during 1973 and 1974 combined were April, 16.5 (2 nests); May, 11.4 (22 nests); June, 8.2 (6 nests); and July, 6.7 (3 nests). This phenomenon is commonly observed and has been related to decreased egg laying vigor as reported by Hamerstrom (1936), Leedy and Hicks (1945), Sandfort (1948), Dustman (1950), Seubert (1952), Stokes (1954), and Fischer (1956).

The percentage of eggs that hatched in nests with successful clutches was 90.0 in 1973 and 95.6 in 1974 (Table 5). Trautman (1960) in South Dakota reported rates

Table 4. Range, mean, and mode of clutch sizes for all, hatched, abandoned, and destroyed nests, 1973-74.

		1973	1974
All nests	Range	1-30	1-16
	Mean	8.5	8.7
	Mode	6.0	7.0
Nests with hatched clutches	Range	6-25	7-16
	Mean	10.7	10.8
	Mode	9.0	8.0
Abandoned nests	Range	1-30	1-14
	Mean	7.9	8.0
	Mode	6.0	No mode
Nests destroyed by predators	Range	1-17	1-13
	Mean	7.2	7.4
	Mode	6.0	7.0
Nests destroyed by machine	Range	3-10	3-11
	Mean	6.2	7.5
	Mode	5.0	8.0

Table 5. Summary of fates of eggs in hatched clutches, 1973-74.[a]

Year	Total clutches	Total eggs	Percent					
			Hatched	Non term	Destroyed	Abandoned	Addled	Infertile[b]
1973	25	268	89.9	3.3	0.4	0.4	0.0	6.0
1974	19	188	95.6	1.7	0.0	0.5	0.5	1.7
Average			92.3	2.6	0.2	0.5	0.2	4.2

[a]Four hatched clutches in 1974 not included due to incomplete data.
[b]All classes except infertile had some degree of embryonic development.

of hatching success of 86 percent in 1958 and 87 percent in 1959. The number of eggs hatched is lower than average clutch size due to infertility, partial predation, and embryo death (Lyon 1952). Nonterm eggs accounted for the majority of fertile, unsuccessful eggs in hatched clutches, comprising 3.3 percent in 1973 and 1.7 percent in 1974. Overall average egg fertility in hatched clutches during 1973 and 1974 was 95.8 percent. Egg fertility of hatched clutches was higher in 1974, 98.3 percent, than 1973, 94 percent. Other authors reported egg fertility between 90-95 percent (Hamerstrom 1936, Kimball 1948, Dustman 1950, Klonglan 1955, Fischer 1956).

The percentage of breeding hens in the spring population which were successful in hatching clutches and the percentage of hens with broods in August are shown in Table 3 as two different parameters to compare the percentage of hens successful in hatching clutches. Approximately 33.7 percent of the hens on sample plots in the spring were successful in hatching clutches in 1973 and 28.8 percent in 1974. Trautman (1960) in eastern South Dakota during the Soil Bank program estimated that 88 percent of the hens in the spring of 1959 were successful in hatching clutches, based on projected totals of hens and nests with hatched clutches on his study area. Linder et al. (1960) in Nebraska reported 44 percent of the hens in spring were successful in hatching clutches during the period 1955-59.

Broods were observed with 61.7 percent of the hens in August during 1973 and 67.7 percent in 1974. Hen mortality over summer and a tendency to observe hens with broods more frequently than lone hens may inflate the actual percentage of hens with broods in August. Other investigators reporting on the percentage of hens with broods in August were Randall (1940) in Pennsylvania, 55 percent; Kozicky and Hendrickson (1951) in Iowa, 80.3 percent; Stokes (1954) on Pelee Island, 83-91 percent; and Fischer (1956) in North Dakota, 81.1 percent.

Twenty-three (20.7 percent) of 111 clutches in nests on sample plots in 1973 and 21 (28 percent) of 75 clutches in 1974 were hatched (Table 6). The overall percentage of hatched clutches in nests reported by other authors varied from 4.1 in southwestern North Dakota (Carlson 1953) to 47 on Pelee Island (Stokes 1954). In eastern South Dakota, Trautman (1960) discovered 20 percent of the clutches in nests were hatched in 1958 and 24.3 percent in 1959. Baskett (1947) reported hatched clutches in 36 percent of the nests in northcentral Iowa, Kimball (1948) in South Dakota, 12 percent; Klonglan (1955) in Iowa, 17 percent; Fischer (1956) in southwestern North Dakota, 12.8 percent; Linder et al. (1960) in Nebraska, 15.1 percent; and Wright and Otte (1962) in central Iowa, 25 percent.

Table 6. Summary of the number and percentage (in parentheses) of nests with clutches hatched, abandoned, destroyed, or of unknown fate on sample plots, 1973-74.

Year	Fates of clutches				Total nests
	Hatched	Abandoned	Destroyed	Unknown[a]	
1973	23 (20.7)	31 (27.9)	55 (49.6)	2 (1.8)	111
1974	21 (28.0)	5 (6.7)	49 (65.3)	0	75
Total	44 (23.7)	36 (19.4)	104 (55.9)	2 (1.0)	186

[a]One clutch in small grain was crushed by a swather wheel while the other clutch in shelterbelt was weathered and smashed making determination of fate (hatched or destroyed) impossible.

Nest abandonment (eggs found intact) on sample plots was considerably higher in 1973 at 27.9 percent of all nests than in 1974 at 6.7 percent (Table 6). Higher nest abandonment in 1973 over 1974 could explain the greater number of nests per hen in 1973 as compared with 1974 (Table 3). Kozicky and Hendrickson (1951) in Iowa and Linder et al. (1960) in Nebraska reported a high number of nests per hen in years with a correspondingly high density of hens in spring. However, in my study densities of hens in spring were similar for both years. Linder et al. (1960) noted that the number of nests per hen may vary considerably between years despite densities of hens in spring. Carlson (1953) in North Dakota found 19.5 percent of all nests abandoned while Linder et al. (1960) in Nebraska reported 12.1 percent of all nests during 1955-59 abandoned.

The greatest percentage of clutches in nests on sample plots in 1973 and 1974 was destroyed (Table 6). Other authors reporting percentages of nest destruction include Dustman (1950) in Ohio, 63.1 percent in 1946 and 43.1 percent in 1947; Carlson (1953) in North Dakota, 76.4 percent; Fischer (1956) in southwestern North Dakota, 85.7 percent; and Linder et al. (1960) in Nebraska, 73 percent.

Cover Types and Nest Preference

Analysis of variance indicated a significant difference

($P < .05$) in density of nests among cover types in 1973 and 1974. Duncan's new multiple range test ($P < .05$) (Steel and Torrie 1960:107) isolated tame hay and roadside as the major source of variation in nest density. Tame hay contained highest density of nests per ha in 1973 and 1974 at 3.10 and 1.63 nests per hectare, respectively (Table 7), while comprising the lowest percentage of cover among cover types containing nests. Trautman (1960) found that fencerow contained the highest nest densities at 28.7 nests per hectare in 1958 and 32.1 in 1959, while comprising only 0.4 percent of the total cover each year. Trautman (1960) found relatively moderate to low nest densities in tame hay.

With the exception of tame hay, residual cover types outranked all other cover types in nest densities for 1973 and 1974 (Table 7). Trautman (1960) reported that roadsides ranked second in nest densities with 4.6 nests per hectare in 1958 and 6.9 in 1959. Linder et al. (1960) in Nebraska observed 23.6 percent of all nests in roadside areas which accounted for less than 1.5 percent of the total study area. Others report similar preference for residual cover types (Baskett 1947, Carlson 1953, Fischer 1956, Wright and Otte 1962, Gates 1964, Bartmann 1969, Joselyn and Tate 1972).

Alfalfa contained an average of 12.9 percent of the total nests with density of nests at 0.31 per hectare in

Table 7. Hectares of land use, number of nests, density of nests, and percentage of nests on sample plots, 1973-74.

Cover type	Hectares searched		Number of nests		Nests per hectare[a]			Percent nests		
	1973	1974	1973	1974	1973	1974	1973 and 1974	1973	1974	1973 and 1974
Pasture	58.95	64.86	14	1	0.24	0.02	0.12	12.6	1.3	8.1
Small grain	58.60	59.81	12	5	0.20	0.08	0.14	10.8	6.7	9.1
Alfalfa	35.73	29.83	11	13	0.31	0.44	0.37	9.9	17.3	12.9
Idle farmland	31.33	19.37	36	20	1.15	1.03	1.10	32.5	26.6	30.1
Flax	14.06	24.23	0	5	0.00	0.21	0.13	0.0	6.7	2.7
Shelterbelt	9.09	9.03	3	6	0.33	0.67	0.49	2.7	8.0	4.8
Fencerow	6.44	7.05	7	8	1.09	1.13	1.11	6.3	10.7	8.1
Roadside	6.30	6.87	19	9	3.02	1.30	2.13	17.1	12.0	15.1
Tame hay	2.93	4.85	9	8	3.10	1.63	2.19	8.1	10.7	9.1
Total or average	223.43	225.90	111	75	0.50	0.33	0.41	100.0	100.0	100.0

[a]Excluding non-nesting areas such as roads, corn, buildings, etc.

1973 and 0.44 in 1974 (Table 7) while comprising an average of 9 percent of the study area (Table 1). Density of nests in supplemental fields of alfalfa compares closely with sample plot densities at 0.27 nests per hectare in 1973 and 0.34 in 1974 (Table 8). Trautman (1960) reported 3.2 nests per hectare in alfalfa in 1958 and 3.9 in 1959. Linder et al. (1960) in Nebraska found 27.5 percent of all nests in alfalfa which comprised 3 percent of the study area. Fifty-three percent of all nests in central Iowa were in alfalfa, which comprised 27.1 percent of the study area (Wright and Otte 1962). Baskett (1947) in northcentral Iowa, Wight (1949) in Pennsylvania, Dustman (1950) in Ohio, and Sandfort (1952) in Colorado report preference for establishment of nests in alfalfa.

Density of nests is usually lower and hatching success higher in small grains as compared to other nesting cover types (Fischer 1956, Trautman 1960, Gates 1964). Lowest densities of nests in 1973 and 1974 were found in flax, small grains, and pasture; probably due to insufficient nesting cover in late April, May, and early June (Klonglan 1955, Bartmann 1969, Frank and Woehler 1969). Nests per hectare in flax and small grains on sample plots was 0 and 0.20 nests in 1973 and 0.21 and 0.08 in 1974, respectively (Table 7). Density of nests in supplemental fields of small grains was 0.24 nests per hectare in 1973 and 1974. Flax

Table 8. Nesting densities and fates of nests in supplemental fields of alfalfa, flax, and small grains, 1973-74.

Year	Crop	Hectares searched	Total nests	Nests per hectare	Percent hatched	Percent abandoned or destroyed before mowing	Percent destroyed by machine
1973	Alfalfa	91.87	25	0.27	16	28	56
	Flax	11.48	0	0.00	0	0	0
	Small grains	58.80	14	0.24	43	50	7
1974	Alfalfa[a]	53.14	18	0.34	6	6	88
	Flax	18.95	2	0.11	100	0	0
	Small grains	81.75	20[b]	0.24	42	42	16
1973 and 1974	Alfalfa	145.01	43	0.30	12	19	69
	Flax	30.43	2	0.07	100	0	0
	Small grains	140.55	34[b]	0.24	42	46	12

[a]Excluding one atypical alfalfa field in which mowing was not completed until the first week in July, providing an unusually high hatching success with eight of 15 clutches successful. The field contained 18.2 hectares.
[b]Includes one nest of unknown fate.

contained 0.11 nests per hectare in 1974 (Table 8). There were no nests in supplemental fields of flax in 1973. Trautman (1960) reported density of nests in flax and small grains as 0.35 and 0.67 nests per hectare in 1958 and 1.01 and 1.40 in 1959, respectively. Low densities of nests in small grains result in a lower percentage of total nests when compared with all other nesting cover (Baskett 1947, Wight 1949, Fischer 1956, Trautman 1960, Wright and Otte 1962). However, Linder et al. (1960) in Nebraska found 38.4 percent of all nests in wheat, which comprised 25 percent of the study area.

Density of nests in pasture is directly related to the condition of nesting cover and nesting cover depends on grazing pressure (Lyon 1952). Pastures where grazing is delayed until early to mid summer often contain suitable cover for hens to nest (Lyon 1952). In this study density of nests in pastures was 0.24 nests per hectare in 1973 and 0.02 in 1974 (Table 7). Early season cattle grazing, often at an intensive level, considerably reduced available nesting cover in pastures. Grazing on pasture cover was particularly heavy during the drought conditions of 1974. Linder et al. (1960) in Nebraska found no nests in pasture from 1955-58, and believed that sparse cover conditions brought about by low precipitation and overgrazing was the cause. Trautman (1960) in South Dakota reported 0.57 nests per hectare in grazed pastures in 1958 and 0.91 in 1959.

Tame hay and roadside were preferred by nesting hens above all other cover types, exhibiting nesting cover preference indexes of 10.1 each in 1973 and 8.2 and 6.7 in 1974, respectively (Table 9). Other cover types with high indices were idle farmland, fencerow, and shelterbelt. Small grains, pasture, and flax were less preferred types of nesting cover.

Cover Type and Nest Success

Nests in shelterbelt ranked highest in hatching success among residual cover types as 50 percent of the eight nests in shelterbelt during 1973 and 1974 contained hatched clutches (Table 10). Trautman (1960) in eastern South Dakota reported relatively low hatching success in treeland during Soil Bank, 10.5 percent in 1958 and 24.1 percent in 1959.

Second highest hatching success among clutches in residual covers both years occurred in idle farmland with 30.6 percent of all clutches hatching in 1973 and roadsides with 22.2 percent in 1974 (Tables 11 and 12). Hatching success in idle farmland and roadsides for 1973 and 1974 combined ranked second and third, respectively, among residual cover types (Table 10). Trautman (1960) reported similar hatching success in roadsides, 20 percent in 1958 and 28.8 percent in 1959, but did not have a specific idle farmland cover category. Fischer (1956) in North Dakota

Table 9. Importance of cover type to pheasant production in sample plots, 1973-74.

	Percent of area		Percent of all nests		Preference index[a]		Success index[b]	
Cover type	1973	1974	1973	1974	1973	1974	1973	1974
Small grains	16.5	16.4	10.8	6.7	0.7	0.4	1.6	1.4
Pasture	16.2	17.8	12.6	1.3	0.8	0.1	0.4	0.0
Alfalfa	9.8	8.2	9.9	17.3	1.0	2.1	0.0	0.6
Idle farmland	8.6	5.3	32.5	26.6	3.8	5.0	1.5	0.7
Flax	3.9	6.7	0.0	6.7	0.0	1.0	0.0	3.6
Shelterbelt	2.5	2.5	2.7	8.0	1.1	3.2	1.6	1.8
Fencerow	1.8	1.9	6.3	10.7	3.5	5.6	0.7	0.0
Roadside	1.7	1.8	17.1	12.0	10.1	6.7	1.0	0.8
Tame hay	0.8	1.3	8.1	10.7	10.1	8.2	0.5	1.3

[a]Calculated by dividing the percentage of all nests by the percentage of area.
[b]Calculated by dividing the percentage of total nests with hatched clutches by the percentage of all nests.

Table 10. Summary of the results of nesting and production in nine cover types on sample plots, 1973-74.[a]

Cover type	Total nests	Percent hatched	Hatched nests per hectare	Percent destroyed	Percent abandoned	Percent of total hatched nests[b]
Idle farmland	56	26.8	0.29	57.1	16.1	34.1
Roadside	28	21.4	0.46	46.4	32.2	13.6
Alfalfa	24	8.3	0.03	87.5	4.2	4.5
Tame hay	17	23.5	0.51	41.2	35.3	9.1
Small grain	16	37.5	0.05	56.3	6.2	13.6
Fencerow	15	6.7	0.07	86.6	6.7	2.3
Pasture	15	6.7	0.01	40.0	53.3	2.3
Shelterbelt	8	50.0	0.22	37.5	12.5	9.1
Flax	5	100.0	0.13	0.0	0.0	11.4
Total or average	184		0.10			100.0

[a]Excluding two nests of unknown fate. One each in small grain and shelterbelt.
[b]Calculated by dividing the number of nests with hatched clutches per cover type by the total number of nests with hatched clutches.

Table 11. Results of nesting and production in nine cover types on sample plots, 1973.[a]

Cover type	Total nests	Percent hatched	Hatched nests per hectare	Percent destroyed	Percent abandoned	Percent of total hatched nests[b]
Idle farmland	36	30.6	0.35	44.4	25.0	47.8
Roadside	19	21.1	0.63	42.1	36.8	17.5
Pasture	14	7.1	0.02	35.7	57.2	4.3
Alfalfa	11	0.0	0.00	100.0	0.0	0.0
Small grain	11	36.4	0.07	54.6	9.0	17.5
Tame hay	9	11.1	0.34	44.5	44.4	4.3
Fencerow	7	14.3	0.16	71.4	14.3	4.3
Shelterbelt	2	50.0	0.11	0.0	50.0	4.3
Flax	0	0.0	0.00	0.0	0.0	0.0
Total or average	109		0.10			100.0

[a]Excluding two nests of unknown fate. One each in small grain and shelterbelt.
[b]Calculated by dividing the number of nests with hatched clutches per cover type by the total number of nests with hatched clutches.

Table 12. Results of nesting and production in nine cover types on sample plots, 1974.

Cover type	Total nests	Percent hatched	Hatched nests per hectare	Percent destroyed	Percent abandoned	Percent of total hatched nests[a]
Idle farmland	20	20.0	0.21	80.0	0.0	19.1
Alfalfa	13	15.4	0.07	76.9	7.7	9.5
Roadside	9	22.2	0.29	55.6	22.2	9.5
Tame hay	8	37.5	0.62	37.5	25.0	14.3
Fencerow	8	0.0	0.00	100.0	0.0	0.0
Shelterbelt	6	50.0	0.33	50.0	0.0	14.3
Small grain	5	40.0	0.03	60.0	0.0	9.5
Flax	5	100.0	0.21	0.0	0.0	23.8
Pasture	1	0.0	0.00	100.0	0.0	0.0
Total or average	75		0.09			100.0

[a]Calculated by dividing the number of nests with hatched clutches per cover type by the total number of nests with hatched clutches.

reported only 8.3 percent hatching success on idle lands.

Fencerow had the lowest percentage of nests with hatched clutches among residual covers in both years. Predation and nest disturbance were responsible for the destruction. Approximately 14.3 percent of all nests in fencerow contained hatched clutches in 1973 while no nests with hatched clutches were found in fencerow during 1974 (Tables 11 and 12). Hatching success in fencerow for 1973 and 1974 combined was 6.7 percent (Table 10). Linder et al. (1960) in Nebraska reported no nests with hatched clutches in fencerow during 1955-59. Trautman (1960) reported 11.8 percent hatching success in fencerow during 1958 and 6.4 percent in 1959. In North Dakota, hatching success in fencerow and roadside combined was 9.6 percent (Fischer 1956).

Hatching success in tame hay varied from 11.1 percent in 1973 to 37.5 percent in 1974 (Tables 11 and 12). Nest densities in tame hay exceeded all other cover types in both years (Table 7). Compensatory reproductive mechanisms were evident in tame hay as nest densities in 1973 were exceptionally high at 3.10 nests per hectare (Table 7) while hatching success was only 11.1 percent (Table 11). As nest densities dropped to 1.63 nests per hectare in 1974 (Table 7), hatching success increased to 37.5 percent (Table 12). Trautman (1960) during Soil Bank reported that 33.3 percent of all nests in tame hay contained hatched clutches in 1958 and 32.2 percent in 1959.

Hatching success in small grains was high in both years although density of nests was low (Table 7). Approximately 36.4 percent of all nests in small grains in 1973 and 40 percent in 1974 contained hatched clutches (Tables 11 and 12). Hatching success in small grains for 1973 and 1974 combined was 37.5 percent (Table 10). Compared to sample plots, hatching success in supplemental fields of small grains for 1973 and 1974 was slightly higher (Table 8). Trautman (1960) in eastern South Dakota reported rates of hatching success in excess of 50 percent in wheat. Linder et al. (1960) in Nebraska found that during 1955-59 wheat contained the highest average percentage of hatched clutches, 24.8 percent, of all cover types where nesting occurred. In Wisconsin, Gates (1964) reported 50 percent hatching success in small grains. High hatching success of clutches in small grains result from late harvests well beyond peak hatching and large small grain fields which hamper predators (Linder et al. 1960).

All five nests located on sample plots in flax in 1974 contained hatched clutches (Table 12). Only two nests were found in supplemental fields of flax in 1974 but both contained hatched clutches (Table 8). There were no nests in flax in 1973 on either sample plots (Table 11) or supplemental fields. Trautman (1960) in South Dakota reported

62.5 percent hatching success in flax in 1958 and 35.6 percent in 1959. The percentage of all nests with hatched clutches produced in flax was 7.6 in 1958 and 8.4 in 1959 (Trautman 1960). In this study 23.8 percent of all nests with hatched clutches found within sample plots in 1974 were produced in flax (Table 12).

Hatching success in alfalfa was low as none and 15.4 percent of all nests in alfalfa contained hatched clutches in 1973 and 1974, respectively (Tables 11 and 12). Only 8.3 percent of all clutches in alfalfa on sample plots during 1973 and 1974 were hatched (Table 10). Twelve percent of all nests found on supplemental fields of alfalfa during 1973 and 1974 contained hatched clutches (Table 8). Trautman (1960) reported hatching success in mowed alfalfa at 7.6 percent in 1958 and 6.2 percent in 1959. Linder et al. (1960) in Nebraska found only 3.8 percent hatching success in alfalfa. Mowing was the greatest single factor reported as causing low hatching success in alfalfa (Eklund 1942, Kozicky and Hendrickson 1956, Wright and Otte 1962).

Hatching success in pasture was low each year during the study period with only one of 15 nests containing a hatched clutch (Tables 11 and 12). Linder et al. (1960) in Nebraska recorded only 7.1 percent hatching success in pasture during 1955-59. However, Trautman (1960) in South Dakota found 25 percent hatching success in grazed pasture in 1958 and 33.9 percent in 1959.

Highest indexes of hatching success in 1973 were calculated for clutches in shelterbelt, small grains, idle farmland, and roadsides while highest indexes in 1974 were calculated for clutches in flax, shelterbelt, small grains, and tame hay (Table 9). No nests with hatched clutches were found in alfalfa and flax in 1973 or fencerow and pasture in 1974.

The percentage of total nests with hatched clutches contributed by each cover type was calculated for 1973 and 1974. Idle farmland, roadside, and small grains contributed 47.8, 17.5, and 17.5 percent, respectively, of the total number of nests with hatched clutches in 1973 (Table 11). In 1974, flax, idle farmland, tame hay, and shelterbelt contributed 23.8, 19.1, 14.3, and 14.3 percent, respectively, of the total number of nests with hatched clutches (Table 12). Cover types contributing the highest percentage of the total number of nests with hatched clutches for 1973 and 1974 combined were idle farmland, roadside, and small grains (Table 10). Trautman (1960) ranked small grains, pasture, and strip covers highest in the percentage of nests with hatched clutches contributed to the total number of nests with hatched clutches in 1958 and 1959. In this study, pasture and fencerow contributed least to the total number of nests with hatched clutches.

Cover Quality and Nest Success

Chi square analysis in this study showed no significant relationship between condition of cover and hatching success in 1973 and 1974 (Table 13). Apparently the cover judged as excellent or good was not of significantly greater value for hatching than lower ratings. Hamerstrom (1936) in northwest Iowa found hatching success only slightly higher in excellent (29.3 percent) and good (29.5 percent) cover when compared with fair (22.0 percent) and poor (26.4 percent). Wright and Otte (1962) in central Iowa evaluated cover conditions in terms of cover density and found no significant relationship with nest success using chi square analysis.

Chi square analysis revealed no significant relationship between the amount of dead vegetation at nest sites and nest success in 1973 or 1974 (Table 14). Opposite trends in hatching success emerged between 1973 and 1974 with regard to the amount of dead vegetation at nest sites. The amount of dead vegetation was not recorded for nests located in harvested crops (wheat, oats, flax, and alfalfa). Lower hatching success and greater nest destruction occurred in nests with greater amounts of dead vegetation in 1973. Hatching success in 1973 decreased from 29 percent in nests with 0-25 and 26-50 percent dead vegetation to 8.3 percent in nests with 76-100 percent dead vegetation. The percentage

Table 13. Number and percentage (in parentheses) of nests with hatched, abandoned, and destroyed clutches in cover conditions rated as excellent, good, fair, and poor, 1973-74.

	Excellent	Good	Fair and poor
1973			
Hatched	4 (18.2)	12 (22.2)	3 (20.0)
Abandoned	12 (54.5)	13 (24.1)	7 (46.7)
Destroyed	6 (27.3)	29 (53.7)	5 (33.3)
Subtotal	22	54	15
1974			
Hatched	5 (17.2)	5 (35.7)	2 (14.3)
Abandoned	4 (13.8)	1 (7.1)	1 (7.1)
Destroyed	20 (69.0)	8 (57.2)	11 (78.6)
Subtotal	29	14	14
Total	51	68	29

Table 14. Number and percentage (in parentheses) of nests with hatched, abandoned, and destroyed clutches as related to amount of dead vegetation at nest site, 1973-74.

	Percent dead vegetation			
	0-25	26-50	51-75	76-100
1973				
Hatched	9 (29.0)	9 (29.0)	4 (18.2)	1 (8.3)
Abandoned	13 (42.0)	10 (32.3)	4 (18.2)	5 (41.7)
Destroyed	9 (29.0)	12 (38.7)	14 (63.6)	6 (50.0)
Subtotal	31	31	22	12
1974				
Hatched	2 (18.2)	1 (10.0)	11 (34.4)	4 (30.8)
Abandoned	2 (18.2)	0	3 (9.4)	1 (7.7)
Destroyed	7 (63.6)	9 (90.0)	18 (56.2)	8 (61.5)
Subtotal	11	10	32	13
Total	42	41	54	25

of nests destroyed in 1973 correspondingly increased with higher amounts of dead vegetation at nests. In 1974, hatching success increased from 18.2 percent in nests with 0-25 percent dead vegetation to 30.8 percent in nests with 76-100 percent dead vegetation at the nest site.

Chi square analysis showed no significant relationship between height of vegetation and nest success in 1973 and 1974 (Table 15). However, there was a trend toward greater hatching success in taller vegetation during 1974. Clutches in nests where surrounding vegetation was greater than 61 cm in 1974 exhibited 32.4 percent hatching success and vegetation 31-60 cm, 13.6 percent. No nests with hatched clutches were found in cover 0-30 cm. Hatching success in 1973 was highest in vegetation 31-60 cm, 22.9 percent. Wright and Otte (1962) in central Iowa also found no significant relationship using chi square analysis between vegetation height and nest success.

Statistical comparisons between the physiognomy of vegetation over the nest and nest success using chi square analysis showed no significant relationship in 1973 and 1974 (Table 16). However, type D vegetation occurred most frequently over nests in 1973 and 1974. Highest hatching success in 1973 occurred in type D vegetation as 26.1 percent of all clutches hatched. In 1974, 29.4 percent of all clutches hatched in nests under type C physiognomy.

Table 15. Number and percentage (in parentheses) of nests with hatched, abandoned, and destroyed clutches as related to height of vegetation at nest site, 1973-74.

	Height of vegetation (cm)		
	0-30	31-60	61+
1973			
Hatched	2 (15.4)	14 (22.9)	3 (18.8)
Abandoned	6 (46.2)	18 (29.5)	8 (50.0)
Destroyed	5 (38.4)	29 (47.6)	5 (31.2)
Subtotal	13	61	16
1974			
Hatched	0	3 (13.6)	11 (32.4)
Abandoned	0	4 (18.2)	2 (5.9)
Destroyed	1 (100.0)	15 (68.2)	21 (61.7)
Subtotal	1	22	34
Total	14	83	50

Table 16. Number and percentage (in parentheses) of nests with hatched, abandoned, and destroyed clutches having different physiognomy of vegetation over the nest, 1973-74.

	Physiognomy of vegetation[a]		
	Type A & B combined	Type C	Type D
1973			
Hatched	5 (20.9)	3 (18.7)	12 (26.1)
Abandoned	8 (33.3)	6 (37.5)	15 (32.6)
Destroyed	11 (45.8)	7 (43.8)	19 (41.3)
Subtotal	24	16	46
1974			
Hatched	0	5 (29.4)	7 (24.1)
Abandoned	2 (18.2)	2 (11.8)	2 (6.9)
Destroyed	9 (81.8)	10 (58.8)	20 (69.0)
Subtotal	11	17	29
Total	35	33	75

[a]Type A: Erect vegetation surrounding the nest with lateral branching stems and broad leaves to form a closed canopy over the nest.
Type B: Surrounding vegetation leaning from two or more sides of the nest and directed toward the center of the nest to form a "tent" canopy.
Type C: Surrounding vegetation leaning from one side of the nest, directed to opposite side to form a canopy.
Type D: Erect vegetation surrounding the nest with no laterally branching stems or broad leaves forming an open canopy.

Hamerstrom (1936) in northwest Iowa found higher hatching success, 31.6 percent, in nests with complete concealment over the top.

Chi square analysis showed no significant relationship between the category of cover plots and nest success in 1973 or 1974 (Table 17). However, when compared with other plot categories, hatching success on type D plots appeared higher with 26.1 percent hatched clutches in 1973 and 38.2 percent in 1974. Chi square analysis showed no significant relationship between concealing vegetation and nest success in 1973 or 1974.

Nesting Losses

Major causes of nest failure during the 1973 and 1974 nesting seasons were (1) predation, (2) agricultural machinery, and (3) abandonment. Predation on clutches in nests varies with (1) predator populations, (2) cover quality, (3) nest density, and (4) proximity to dens and lairs (Lyon 1952, Trautman et al. 1959). Baskett (1947) and Klonglan (1955) observed higher rates of predation in the early nesting season when cover was sparse. Trautman et al. (1959) recorded heaviest nest predation in old, established cover types and light predation in cover types with new vegetative growth. Losses to predation were recorded by Hamerstrom (1936) in northwest Iowa, 19.5 percent of all

Table 17. Number and percentage (in parentheses) of nests with hatched, abandoned, and destroyed clutches listed according to category of plot, 1973-74.

	Plot category[a]		
	Type A & B combined	Type C	Type D
1973			
Hatched	6 (15.8)	1 (11.2)	18 (26.1)
Abandoned	14 (36.8)	4 (44.4)	15 (21.7)
Destroyed	18 (47.4)	4 (44.4)	36 (52.2)
Subtotal	38	9	69
1974			
Hatched	6 (24.0)	4 (18.2)	13 (38.2)
Abandoned	4 (16.0)	2 (9.1)	1 (2.9)
Destroyed	15 (60.0)	16 (72.7)	20 (58.9)
Subtotal	25	22	34
Total	63	31	103

[a]Type A: A rectangular area longer than wide with maximum width less than 61 m.
Type B: An area of irregular shape less than 61 m in width surrounding basins containing water.
Type C: A distinct unit of similar land use or vegetation of two ha or less having a minimum width of 61 m and differing from the surrounding land use or vegetation.
Type D: A distinct unit of similar land use or vegetation larger than two ha and having a minimum width of 61 m.

destroyed nests; Baskett (1947) in northcentral Iowa, 37.6 percent; Fischer (1956) in southwestern North Dakota, 80.9 percent; and Bartmann (1969) in northern Utah, 75 percent.

Losses to predation were difficult to estimate in this study since many clutches of eggs in nests destroyed by predators may have been inactive or abandoned before destruction. Wright and Otte (1962) in central Iowa reported that there was no way to determine if clutches destroyed by predators (and in some cases by mowers) were being incubated at the time of destruction or deserted for some unknown reason before being destroyed. In this study, destroyed clutches that were not incubated or of unknown incubation stage may have been inactive or abandoned before destruction; due to factors other than disturbance by predators (i.e. voluntary nest abandonment, disturbance of the hen from agricultural operations, cattle, or man, etc.). However, predators were assumed to be directly responsible for destroyed clutches where incubation occurred.

Of 79 destroyed clutches attributed to mammalian and avian predators (Table 18), eggs in 28 nests (35.4 percent) were incubated, and the nest was probably active when predation occurred. Nests active in the pre-incubation period, nests with clutches of unknown stage of incubation, and abandoned nests made up 64.6 percent (51) of the nests destroyed by predators. Of 199 total nests found during

Table 18. Total number and percentage of unsuccessful nests attributed to each cause of failure, 1973-74.[a]

Causes of nest failure	No. nests	Percent of nest failure	Number of nests in:								
			Idle farmland	Roadside	Alfalfa	Fencerow	Pasture	Tame hay	Small grain	Shelterbelt	Flax
1973											
Mammal	40	43.9	16	8	2	5	4	2	3	0	0
Machine	15	16.5	0	0	9	0	0	3	3	0	0
Bird	1	1.1	1	0	0	0	0	0	0	0	0
Man	1	1.1	1	0	0	0	0	0	0	0	0
Cow	1	1.1	0	0	0	0	1	0	0	0	0
Abandoned	33	36.3	11	8	0	1	8	3	1	1	0
Subtotal	91[b]	100.0	29	16	11	6	13	8	7	1	0
1974											
Mammal	36	62.1	17	3	1	7	1	3	2	2	0
Machine	10	17.2	0	0	9	0	0	0	1	0	0
Bird	2	3.5	1	0	0	1	0	0	0	0	0
Man	2	3.5	0	2	0	0	0	0	0	0	0
Cow	1	1.7	0	0	0	0	0	0	0	1	0
Abandoned	7	12.0	0	3	1	1	0	2	0	0	0
Subtotal	58	100.0	18	8	11	9	1	5	3	3	0
Total	149		47	24	22	15	14	13	10	4	0

[a]Includes three destroyed and two abandoned nests in 1973 which were accidently found while walking to or from study plots and two each of abandoned and destroyed nests in 1974.

[b]Two nests of unknown fate not included.

1973 and 1974, 14 percent of the clutches had been incubated when predation occurred and 26 percent of the nests destroyed by predators were active in the pre-incubation period, not incubated, or of unknown stage of incubation.

Mammals were associated with 43.9 percent of all nest failures in 1973 and 62.1 percent in 1974 (Table 18). Linder et al. (1960) in Nebraska reported that of 160 nests destroyed by predators during 1955-59, 144 were due to mammalian predators. Skunks (Mephitis mephitis), opossums (Didelphis marsupialis), badgers (Taxidea taxus), and feral cats were the major predators in Nebraska (Linder et al. 1960). Carlson (1953) in North Dakota reported that 46.9 percent of all nests destroyed by predators were due to skunks while 17.3 percent were destroyed by badgers. Kimball (1948) in South Dakota reported 55.7 percent of all causes of nest destruction resulted from skunks and badgers.

We were unable to identify the predator in most cases during the current study. However, skunks and raccoons (Procyon lotor) were most commonly implicated as probable nest predators.

Nests with hatched clutches and nests destroyed by predators on sample plots were compared with nine cover types in 1973 and 1974 using chi square analysis. There was a highly significant ($P<.05$) relationship between cover type and nest destruction by predators in 1974 but no significant relationship in 1973. A trend toward higher nest destruction and lower hatching success among the residual cover types such as fencerow, pasture, roadside, and idle farmland was evident in 1974 (Table 12). In 1973, nests with hatched clutches and destroyed nests were more evenly distributed among cover types (Table 11).

Fencerow, idle farmland, and roadside ranked highest among residual covers on sample plots in the percentage of active and/or inactive nests destroyed in 1973 and 1974 (Table 10). Trautman et al. (1959) in South Dakota reported heaviest predation in old, established cover types such as roadside, fencerow, wild hay, and shelterbelt. Carlson (1953) in North Dakota theorized that intensive farming would result in high densities of nesting hens on small areas of residual cover and make it easier for predators to locate nests. In this study all eight nests in fencerow on sample plots in 1974 and five (71.4 percent) in 1973 were destroyed (Tables 11 and 12). Baskett (1947) in north-central Iowa and Trautman (1960) in South Dakota reported extensive predation and abandonment of nests in narrow fencerows and mentioned use by mammalian predators of narrow fencerows as natural travel lanes. In the current study, idle farmland and roadside covers contained 44.4 and 42.1 percent of the destroyed nests in 1973 and 80.0 and 55.6 percent in 1974, respectively (Tables 11 and 12).

The percentage of nesting failures (destroyed and abandoned) in small grains and alfalfa on sample plots in 1973 and 1974 combined was 62.5 percent and 91.7 percent, respectively (Table 10). Nesting failures were mainly due to agricultural machinery in alfalfa and to abandonment or predation prior to mowing in small grains. Forty-six percent of all nests in supplemental fields of small grains in 1973 and 1974 were abandoned or destroyed before harvesting (Table 8). Specific rates of predation and abandonment before harvesting could not be determined. In supplemental fields of alfalfa the percentage of nests failing due to abandonment or predation was secondary to mowing losses (Table 8).

Losses to machines in harvested crops on sample plots ranked second as the leading cause of nest destruction and accounted for 16.5 percent of all unsuccessful nests in 1973 and 17.2 percent in 1974 (Table 18). Mowing was the primary cause of nest failure in alfalfa as 56 percent of the nests in supplemental fields of alfalfa in 1973 and 88 percent in 1974 were destroyed (Table 8). Nest destruction in alfalfa is generally massive since the first mowing usually occurs just prior to peak hatching (Wright and Otte 1962). Ninety percent of the alfalfa searched on sample plots and supplemental fields in 1973 was mowed between 13-22 June while 67 percent was mowed between 12-22

June in 1974; peak hatching occurred 16-30 June each year. Hamerstrom (1936) observed that 86.4 percent of all nests in alfalfa were destroyed by mowing, Eklund (1942), 47.5 percent; Baskett (1947), 83.4-90.3 percent; and Gates (1964), 85 percent. Mowing accounted for 63 percent of the 83 percent total unsuccessful nests in Iowa (Klonglan 1955). Linder et al. (1960) in Nebraska reported that of the total nests established on his study area, 37.2 percent were destroyed by farming operations, including 22.2 percent by alfalfa-mowing operations.

Delayed mowing of alfalfa resulted in higher nesting success. In Ohio, sweet clover mowed in late summer contained 87.4 percent hatched clutches (Strode and Leedy 1940). Trautman et al. (1959) in South Dakota reported 35 percent hatched clutches in sweet clover mowed after 1 July.

Losses to machines decrease and hatching success increases in small grains because dates for harvesting crops fall well after peak hatching, and a greater percentage of clutches in nests have time to hatch before being disturbed by farming operations (Wright and Otte 1962). Only 12 percent of the clutches in nests found in supplemental fields of small grain in 1973 and 1974 were destroyed by agricultural machinery while 42 percent were hatched (Table 8). Peak harvest of small grains on sample plots and supplemental fields was 20-28 July in 1973 and 23 July- 1 August in 1974; approximately 4 to 5 weeks after overall peak hatching. Dates of peak of hatching in small grains were not obtained. There were no losses to machines in flax on either sample plots or supplemental fields as peak of crop harvest occurred from 4-8 August in 1973 and 12-23 August in 1974 (Table 8).

Nest abandonment on sample plots in 1973 and 1974 was highest in pasture, 53.3 percent; tame hay, 35.3 percent; and roadside, 32.2 percent (Table 10). Causes of nest abandonment were unknown, however, in some cases predators, machines, livestock, and man were thought to cause desertion through disturbance of the hen. Twelve percent of all nesting failures in 1974 and 36.3 percent in 1973 resulted from abandoned nests with undisturbed eggs, and causes of failure were unknown (Table 18).

SUMMARY AND CONCLUSIONS

Nesting densities have greatly declined in eastern South Dakota since Trautman (1960) conducted nesting studies in an area near my study site. However, the percentage of nests with hatched clutches recorded by Trautman (1960) was similar to the percentage of nests with hatched clutches recorded in my study area of low population density. Reduced pheasant populations may be explained by a difference in the percentage of hens successful in hatching clutches since this parameter is the major factor governing yearly production (Linder et al. 1960). Both Trautman (1960) in South Dakota and Linder et al. (1960) in Nebraska recorded a higher percentage of hens successful in hatching clutches in comparison to this study. A low percentage of successful hens could be a factor contributing to maintenance of low populations or population declines in eastern South Dakota.

Rates of nest destruction on my study area were not unduly high when compared with other studies. Trautman (1960) and I both observed high nest destruction in undisturbed, residual strip cover such as fencerows where nest densities were also high. Undisturbed, residual strip covers such as fencerow may be the only dense vegetation attractive to nesting hens in areas where intensive farming has resulted in reduced nesting cover.

Cover types with relatively high nest densities and relatively high rates of destruction warrant management to increase hatching success. Fencerows, for example, might be widened to increase security of nesting hens in this cover and reduce mammalian predation. Possible seeding of widened fencerows with an alfalfa-smooth brome mixture or allowing normal growth of smooth brome would provide good to excellent nesting cover. Such cover, when well established, could reduce problems from undesirable weed species. Grazing or harvesting of the grass or hay crop along widened fencerows would be compatible with pheasant nesting if the harvest occurred in mid to late July.

Roadsides remain as potentially manageable sources of nesting cover. Development of an extensive and coordinated management program involving landowners, state, and county highway departments could result in conversion of roadsides into a highly productive cover type. Managing roadside for dense nesting cover by eliminating, reducing, or delaying mowing for hay production and weed control could increase pheasant production significantly. Establishment of desirable nesting cover on roadsides could deter the growth of undesirable weeds and eliminate the need for extensive weed control.

Although pastures in South Dakota usually occupy a large percentage of the land area, the percentage of nests with hatched clutches is generally low. Pheasant production in this cover type could be greatly increased under carefully planned and executed management programs. Delayed grazing or a well executed rotational grazing schedule, especially in spring and early summer until after peak hatching, may allow sufficient development of suitable nesting cover and attract nesting hens.

Early harvesting of alfalfa just prior to peak hatching will continue to reduce pheasant production unless dates of mowing are delayed. Modern, high-speed mowers aggravate both hen mortality and nest destruction. Delayed mowing would increase the percentage of clutches hatching while flushing bars and sonic devices to flush nesting hens may reduce hen mortality. Losses to agricultural machinery in small grains and flax are not a serious problem.

Developing and managing undisturbed, dense nesting cover is the greatest single factor favoring high pheasant populations, particularly where winter cover is sufficient. A significant increase in pheasant densities would probably occur if cover types of low pheasant production were managed for cover improvement.

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