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**AND SOILS IN CENTRAL IOWA.**

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RELATIONSHIP OF PHEASANT POPULATIONS  
AND SOILS IN CENTRAL IOWA

by

David Louis Lyon

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## INTRODUCTION

The ring-necked pheasant Phasianus colchicus Linnaeus is Iowa's most abundant and sought-after game bird. With few exceptions, the greatest populations of this species traditionally have been confined to the northern one-half of the state. Despite frequent stocking of pheasants in southern Iowa from 1927 through 1930 after they had become well-established in northern counties (Faber 1946), populations in most areas have remained at a level much below that of northern Iowa. During this same period equally disappointing results were obtained by other Midwestern states which attempted to introduce pheasants south of their established range limits. Since superficially, many of these southern areas appeared equally as suitable for pheasants as areas farther north, the almost complete failure of pheasants to maintain self-sustaining populations proved particularly perplexing.

No noticeable changes in pheasant numbers were apparent in southern Iowa for many years, but during the period 1950-1954, a rapid increase in pheasant populations was noted in a small, local area in Union and Adair counties in southwestern Iowa. Possible reasons for this build-up in pheasant numbers were investigated by Klonglan (1962).

The Union-Adair County high-population area, because of its isolated and restricted position non-contiguous with the major pheasant range in northern Iowa, may represent a complex of associated factors and conditions not typical of populations in the continuous range farther north. Little information on pheasant populations had been obtained on pheasant

ecology in central Iowa where similar large differentials in pheasant densities within short north-to-south distances existed. Whereas noticeable differences in the appearance of the pheasant habitat in the isolated southwestern Iowa population compared to that of the major portion of the Iowa pheasant range were apparent, in central Iowa adjacent areas supporting populations varying in density appeared to show no detectable differences in topography, agricultural land usage and cover distribution. Thus, in 1960 a new pheasant research area was established in central Iowa which purposely overlapped the "fall-off line" in pheasant numbers. A preliminary investigation (Bolstad 1962) was initiated of the relationships between pheasants and habitat, agricultural practices, weather and other environmental factors suspected of limiting the pheasant in central Iowa. The results of this study, however, indicated no clear-cut differences between areas north and south of the fall-off line either in the above factors or in quantity of food, clutch size and hatchability and fertility of eggs; however, there appeared to be a suggestion of possible soil-pheasant density relationships which seemed to warrant further study. Thus, the present study was the next logical step in attempting to determine the factors regulating and controlling populations of pheasants within this area of rapidly-changing pheasant numbers. Limited information on the ecology of reproduction had been collected prior to the initiation of the present study, but a more intensive investigation of such factors as pattern and success of nesting, production of young, juvenile mortality and soils in relation to population densities was needed. It was hoped that comparison of these factors

from designated areas above, below and within the fall-off area itself might bring to light important differences which in turn would provide further insights into factors regulating pheasant populations. These were the primary purposes for initiating this study.

## REVIEW OF LITERATURE

## Influence of Calcium and Temperature on Pheasant Distribution

Since its introduction in the early 1900's in many sections of the United States and Canada, the ring-necked pheasant has become firmly established only in the northern and central portions of that general area commonly known as the "farm belt," in isolated pockets in western and northwestern United States, and in southcentral and southwest Canada (Aldrich and Duvall 1955). Within this general region, however, and immediately north of it are found extensive areas in which pheasants are scarce or absent because of lack of suitable habitat. The success of the pheasant on the North American continent apparently depends largely upon the presence of cultivated grain crops, so that it is not difficult to understand why it has not become established in non-agricultural areas. However, at the southern edge of the presently occupied range pheasant populations decline abruptly, and even though this area appears superficially to resemble closely that immediately to the north, repeated attempts to establish pheasants farther south in the United States have failed. The reason for this failure is not well understood, but to account for it two major hypotheses have been proposed; the glaciation or calcium hypothesis and the temperature hypothesis.

Leopold (1931) was the first to attempt an explanation for this phenomenon. He observed that in the Midwest pheasants appeared limited to glaciated areas, the highest populations occurring in areas of the most recent (Wisconsin) glaciation. Furthermore, established populations

found south of recently glaciated regions appeared to be restricted to river systems flowing south out of glaciated areas. His interpretation was that glaciation effected the success of populations by providing fresh glacial deposits that contained "lime or grit of a quantity or quality necessary to the welfare of these birds." In addition, he proposed a nutritional hypothesis which he felt explained the failure of populations, which after appearing established progressively declined and eventually disappeared. The absence or deficiency of a mineral or vitamin, he believed, would not necessarily be detrimental to first-generation transplants because of the nutrient reserve they carried, but if the diet in the new release area was deficient in any particular mineral the reserve would be partially utilized. That remaining, however, would be passed on to the next generation and ultimately, because each passing generation retained less reserve, the population would undergo a marked decline in vigor and reproductive capacity. Dalke (1938) appeared to provide support for this hypothesis when he found that in Michigan the amount of calcareous grit contained in the gizzards of pheasants was greatest during the breeding season, and suggested that this was in some way associated with egg production. McCann (1939) discovered that penned bobwhite quail and pheasants preferred glacial gravel when provided with a choice of three types, and that individuals of both species lost vigor or died if deprived of a source of calcium. Thus, he concluded that game birds such as pheasants which depend largely on cultivated grains are probably dependent on calcareous grit for part of their calcium requirements, the abundance of such grit possibly determining their geographic

distribution. Evidence appearing to support this interpretation was provided by Moore (1955), who reported that pheasant distribution in Ohio closely parallels the southern boundary of the Wisconsin glaciation. Apparently, Kubota and Swanson (1958) noted a similar relationship between pheasant abundance and high-calcium glacial areas in New York State.

The first experimental investigations designed to determine the effect of calcium deficiency on the reproductive capacity of pheasants were those of Dale (1954). Diets believed comparable to those of wild pheasants when fed to penned birds were found inadequate for reproduction unless a calcium supplement was added. Birds deprived of the supplement did not produce a normal quota of eggs and, furthermore, hatchability of these eggs was poor. A 0.5 per cent calcium content in the diet was found minimal for adequate egg production; thus, on this basis he estimated that approximately 250 milligrams of calcium per bird per day needed to be consumed to meet this requirement. Such a requirement, he believed, could not be met by wild pheasants unless they included in the diet calcareous grit or some other satisfactory supplement. In western sections of the United States where calcium content of the soil is much greater, he suggested that calcareous grit would not be needed since it seemed probable that birds could meet their calcium requirements by direct ingestion of the soil or through the increased calcium content of the grain itself. Further investigations by Dale concerning the effects of calcium on reproduction were prompted by his observation that a limestone-rich area in Pennsylvania supported a higher pheasant population than an immediately adjacent but non-calcareous area (Dale 1955). Caged

pheasants, when fed a natural diet with calcareous grit supplemented laid normally, but failed to do so when provided with granite grit only; those fed granite grit produced normal eggs in the ovary but ovulated only a few. He therefore offered this as an explanation for the failure of pheasants in non-calcareous areas. Dale and DeWitt (1958) concluded that a total of 600 milligrams of calcium per kilogram per day was sufficient to assure adequate production of eggs and young provided the birds had not experienced a calcium or phosphorus deficiency the previous winter. They also demonstrated an accumulative deficiency in each succeeding generation and suggested this as an explanation for the protracted type of population reduction ending in extinction referred to by Leopold (1931) as "stragglings failure".

Recently, McCann (1961) measured the calcium content of grit in various regions of Minnesota and reported that, in general, pheasant densities were directly proportional to the quality of grit. Regions of the state having soils rich in high-calcium grit were the most recently glaciated. Also, because excess magnesium carbonate had been known to affect both the growth (Buckner *et al.* 1932) and egg production (Alder 1927) of domestic chickens, he suggested that the presence of outcroppings of dolomitic limestone in southeast Minnesota could be an additional reason for the low populations of pheasants in that area.

The above studies appear to lend strong supporting evidence for the "glaciation" hypothesis. However, more recent evidence does not appear to uphold the earlier interpretations. Sadler (1961) demonstrated that hen pheasants respond with great facility to their internal calcium

needs during the period of egg laying. Wild-trapped Iowa pheasants and Iranian Blackneck pheasants were fed a commercial game feed containing 2.65 per cent calcium in a homogeneous granite-limestone grit mixture. The removal of the commercial feed resulted in an increase in limestone grit consumption of over 400 per cent; however, egg production did not decrease. Changing the ratio of feeding compartments from 2:2 to 3:1 (limestone:granite grit) did not alter limestone grit consumption, and conversely, increasing the amount of granite grit did not result in an increase in the consumption of this type of grit. He concluded that if "calcium is available in amounts abundant enough to be measured, pheasant hens possess the potential ability to maintain calcium in the body to a level adequate for reproduction." Harper (1963, 1964) found that both wild adult hens and juvenile pheasants in Illinois possess the ability to selectively consume calcium-rich grit whenever physiologically desirable. The level of calcium in grit from gizzards of wild hens was greatest during the nesting season, and in addition, such grit contained disproportionately more calcite than was expected from its potential availability. In birds 6-8 weeks of age, grit ingested contained 4.9 per cent calcium whereas that from birds 4 months or older contained only 0.3 per cent. Calcite grit comprised 2.1 per cent and dolomite only 0.1 per cent of the grit in the gizzard, even though the available grit in roads and fields in the area averaged 0.6 per cent and 14.6 per cent calcitic limestone, and 0.1 per cent and 16.3 per cent dolomitic limestone in roads and fields, respectively. Korschgen (1964) found during a 2-year study that prior to the breeding season in eleven Midwest States,

including Iowa, significantly greater amounts of calcium-bearing particles were found in the gizzards of hen pheasants than during the remainder of the year. Hens from low-population areas within these states, however, showed no important differences in the amounts of calcareous material found in the gizzard than those from high populations. Similarly, Greeley (1962) found no evidence of a decline in bone-ash content in hens released south of the pheasant range in Illinois and subsequently collected during the succeeding breeding season. Also, Klonglan (1962) reported that the pheasant population in an area in southwestern Iowa isolated south of the primary range, supported a population as high as that of a recognized high-population area within the primary range, even though soil tests indicated less lime present. In Illinois, attempts to establish pheasants in an area south of the primary range have failed, despite findings which show that this anciently glaciated area supports quantitatively and qualitatively a grit equally as rich in grit as a recently glaciated area in the heart of the Illinois pheasant range (Harper and Labisky 1964). Also in Illinois, Anderson (1964) found that reproductive success of pheasants released south of the presently occupied range was similar to that of pheasants in self-maintaining populations, thereby indicating that the continued decline, and probable eventual failure of the release was not due to a calcium deficiency during the breeding season.

Bennett and Terrill (1940) were apparently the first to propose temperature as the factor most likely responsible for the failure of the pheasant in the southern United States. High temperatures during the

nesting season, they felt, could cause significant embryonic mortality, especially since the protective canopy associated with pheasant nests is generally poor. The presence of small local populations along river courses south of the primary range they believed could be attributed to increased chances for reproductive success due to the better nesting habitat resulting from higher moisture conditions.

This line of reasoning was further followed and refined by Graham and Hesterberg (1948) who suggested that either temperature alone or temperature and precipitation operating together during the nesting season could be the factors limiting the success of pheasant populations in the south. Climatographs were constructed for three areas within the established pheasant range and for three areas outside the range. During the period April, May and June, climatographs for areas within the range showed segments all falling within the same area, while segments of the climatographs for the other three areas fell outside this area. The authors concluded that in the south exposure of eggs to intense insolation during laying or prior to incubation could cause high embryonic mortality. A similar conclusion was reached by Yeatter (1950). He observed that in central Illinois a sharp decrease occurred in the number of young per brood and in the hatchability of eggs in successful nests established after the first week in July. Nesting studies conducted in 1947 and 1948 showed that about 43 per cent of the fertile eggs in nests hatched after July 1 contained dead embryos (usually at a very early stage of incubation). Subnormal young from late nests were also found. Thus he concluded that failure of renesting attempts due to high

temperature was the reason for the general failure of the pheasant in this area. Succeeding experimental investigations revealed that groups of pheasant eggs subjected to increasing temperatures (68 degrees F. to 88 degrees F.) showed correspondingly poorer hatchability. Fertile bobwhite quail eggs subjected to the same temperatures, however, showed no such variation in hatchability. Consequently, he believed that the absence of pheasant populations in the south was directly correlated with the vulnerability of pheasant embryos to air temperature during the laying period. Further studies by Yeatter (New pheasant for Illinois 1956) demonstrated that eggs of wild California pheasants when exposed to high pre-incubation temperatures showed higher hatchability than eggs of pheasants from the Midwest. Thus, he suggested that the presence of thriving pheasant populations in southern California and southern Rocky Mountain regions could be explained on the basis of their possible southern Asian origin and thus their greater tolerance of high temperatures during the nesting season.

Robertson (1958) regarded temperature and calcium as factors working complementally to determine the southern limits of the pheasant range in Illinois. Steen (1954) believed that the temperature hypothesis alone was not adequate to explain the failure of the pheasant to extend its range southward. Landauer (1948) reported that domestic chickens fed a calcium-deficient diet laid eggs with thinner shells. Such eggs might increase the chances of high embryonic mortality because of the increased moisture loss which would occur upon exposure to high temperatures. Therefore, Steen (1954) concluded that some such interaction of tempera-

ture and calcium availability was a more valid explanation than was either hypothesis alone.

Recent studies, however, appear to cast doubt on the validity of the temperature hypothesis. Klonglan (1962) concluded that the difference in mean air temperature and soil surface temperature between southern and northern Iowa during the nesting season seemed too small to account for the poorer success of pheasants in southern Iowa. Moreover, within the nesting cover itself temperatures lethal to pheasant eggs were seldom reached in southern Iowa. Therefore he concluded that "most nests on the study area were safely placed relative to ill effects to egg or embryo from high temperatures resulting from intense insolation."

Ellis and Anderson (1963) reported that clutch sizes and chick survival in pheasant releases in southern Illinois were believed similar to those reported from long-established populations. Instead, population losses from fall to the following breeding season seemed excessive when compared to those of thriving populations. Thus, they concluded that factors affecting the survival of pheasants from late summer to the following spring were more responsible for the continual decline of these releases.

It therefore appears that the calcium and temperature hypotheses, although the only explanations presently available, do not adequately explain the distribution of the ring-necked pheasant in this country. Either or both hypotheses may possess varying degrees of validity, but the matter is obviously more complex than suspected originally. Other factors at present unknown or others not previously considered, may be

involved. Furthermore, the recent study of Anderson (1964) questions the assumption that the factors responsible act only through reproduction.

Thus, at the start of the current study much conflicting and inconclusive evidence was available, but the problem seemed not much closer to solution than it did thirty years ago. The present study was initiated in the expectation that further evidence would be obtained which would aid in the solution of this problem.

### Relationship of Soil Nutrients to Wildlife

#### Role of soil elements in welfare of wildlife populations

The existence of a general relationship between soil fertility and wildlife populations has been noted in many studies. Browne (1938) indicated that calcium and phosphorus, and particularly the latter was the one element whose deficiency in the soil was linked with the greatest number of disturbances in animal health, and was also the element which demonstrated best the close relationship between the chemical composition of the soil and the health and vigor of animals and plants living on it. Albrecht and Smith (1941) demonstrated that not all nutrient benefits to animals could be measured by the usual soil tests which determine the quantitative sufficiency of an element. Lespedeza cuttings from two plots, one treated with applications of lime and phosphorus and the other with phosphorus only, contained equal amounts of calcium and phosphorus in the plant tissue, yet when both were fed to cattle, the lespedeza from the first plot permitted a 60 to 80 per cent greater increase in meat

production. Denny (1944) believed that the distribution of all wildlife species in Missouri was primarily determined by soil type, both directly through soil fertility and indirectly by the kind of land-use pattern dictated by the soil type. He further postulated that wildlife, like any other crop, was in proportion to the fertility of the soil, and that land too infertile to produce domestic crops and livestock was also sub-marginal for wildlife. With the use of trapping and hunting records, Crawford (1950) found there existed specific soil fertility-animal response patterns for several species of wild animals in Missouri. For both the raccoon and the cottontail rabbit the average body weights and total harvest were highest in high-fertility areas and lowest in areas of least fertility. In the cottontail, a positive relationship was also demonstrated between the average weight, length, thickness, diameter, breaking strength and volume of femurs and the fertility of the soil as measured by soil concentrations of calcium, nitrogen, phosphorus and potassium, and crop yields. In addition, it was found that litters of fox squirrels produced on high-fertility cultivated soils averaged 0.5 an animal larger than those from low-fertility areas.

More specifically, the apparent relationship between pheasant distribution and density, and soils have been pointed out by several workers. Leopold (1931) suggested that either the quantity or quality of grit in the soil was of prime importance in determining pheasant abundance. Moore (1955) observed that in Ohio the southern limits of pheasant distribution closely paralleled the most southerly boundary of recent

glaciation. A high correlation between pheasant densities and availability of calcium in surface soils was demonstrated by Dale (1954). Kubota and Swanson (1958) in New York indicated that the best pheasant populations in that state were found on glacial soils of high lime content.

Brown (1936) defined five basic soil areas in Iowa, of which two, the Wisconsin and Iowa drifts, are derived from materials of glacial origin and three, the Missouri loess, Mississippi loess and southern Iowa loess, from wind-blown material. Loess from the Wisconsin glaciation continuously covers the state except on eroded slopes and on the Wisconsin drift itself (Ruhe 1954). Underlying much of his area, however, are drift deposits from previous glaciations--the Nebraskan, Kansan and Illinoian, and where the topography is more rough, rolling or steep and more mature, considerable erosion has occurred leaving the original till exposed over extensive areas. Where loess appears in these areas it is shallow and greatly leached (Brown 1936).

Both the Central Iowa and Winnebago areas lie within the Wisconsin drift area. The Winnebago Area and the Northern Area are located within the currently recognized Mankato substage of the Wisconsin (Ruhe 1952), while the Middle and Southern areas fall just outside this substage and in the bordering Cary substage of the Wisconsin. Despite the distinction in substage designation, however, no known important differences occur in the soils of the two regions; both regions are within the Clarion-Webster Soil Association Area. The soils found within this soil association area, because they are formed almost entirely from calcareous Wisconsin till (Meldrum et al. 1941) and therefore of recent

origin, are some of the most fertile in the state. The Clarion, Nicollet and Webster are the principal upland soils. In Winnebago County these soils together comprise approximately 84 per cent of all the soils (Stevenson et al. 1922), and in central Iowa these soils in combination make up approximately 95 per cent (Stevenson et al. 1921), 87 per cent (Meldrum et al. 1941) and 88 per cent (Stevenson et al. 1924), respectively, of the soils of Hamilton, Story and Boone counties. The lime content of these soils is usually high. In small areas scattered throughout larger bodies of Webster soils where drainage has been notably poor, so-called "high-lime" or "alkali" spots occur (Meldrum et al. 1941). Other upland drift soils which occur within the Clarion-Webster Soil Association Area are the Hayden, Ames, Lester, Lakeville, Thurman and Dickinson (Riecken and Smith 1949), but these are not extensive and consequently are unimportant for farming except locally. Bottomland and terrace soils include the Bremer, Wabash and Lamoure soils, but these, too, are restricted in area, occurring only along main rivers and streams (Meldrum et al. 1941).

#### Importance of various chemical elements in the physiology of birds

The need of pheasants for calcium, especially prior to and during the nesting season is a well-known and demonstrated fact. About 98 per cent of the shell of the egg of the domestic chicken consists of calcium and approximately 60 per cent of the egg contents are calcium (Romanoff and Romanoff 1949). If we assume that physiological processes concerned with egg production in the chicken are approximated by those of the pheasant, then this percentage probably holds true for the pheasant egg

as well. This calcium comes either directly from the diet or is withdrawn from calcium reserves maintained in the shaft cavities of the long or medullary bones under the control of estrogens (Hohn 1961). Common (1943) found that average daily retention of calcium from the food of laying hens was approximately 50 per cent of that ingested, except on days of egg shell secretion when as much as 70 per cent was retained. However, according to Tyler (1940) no more than approximately 1 gram of calcium can be withdrawn from the bones on any day in which egg-laying occurs, and conversely, not more than 1 gram can be deposited on any day in which egg-laying does not occur. In the pheasant, Dale and DeWitt (1958) found that during reproduction, 600 milligrams of calcium per kilogram of body weight per day were necessary to maintain production of eggs and young from hens receiving adequate calcium during the previous winter. Dale (1955) reported that penned pheasants fed granite grit did not lay adequately, but upon substitution of calcium powder for the granite grit production of eggs returned to normal. In another pen study, Greeley (1962) demonstrated that a diet containing less than 1.09 per cent calcium led to reduced egg production and egg shell thickness and resulted in less heavy eggs and tibiae and femurs of laying pheasant hens, whereas a diet containing 2.01 per cent calcium or greater prevented such reductions.

Even though elements other than calcium are known to be important in birds for the proper functioning of body processes, probably for several reasons few of these have been investigated in pheasants. Since

calcium, up to the present has appeared the one element most likely affecting or governing pheasant distribution, particularly since it is involved in reproduction, most research has centered in this area to the detriment of possible fruitful investigations into other soil nutrients. Secondly, the other essential elements, with the exception of phosphorus and magnesium, appear to be needed in only minute quantities so that it was probably often assumed that deficiencies of these minerals in birds were unlikely. Moreover, although inadequate levels of soil calcium, phosphorus and potassium, for proper crop growth are common and well-documented, reports of other soil element deficiencies are fewer and usually of importance only in restricted areas. Also, since the levels of abundance of some of these elements, both in the soil or within living systems are extremely low, special techniques and equipment are required for their determination.

Phosphorus, like calcium, is important in the metabolism of birds, particularly in the formation of bone (Norris and Scott 1959). In addition to its role in bone formation, phosphorus is important in the metabolism of carbohydrates and fats. Further, it is an important constituent of all living cells and its salts are necessary for the maintenance of the acid-base balance. The minimum phosphorus requirement for growing young chickens appears to be approximately 0.4 per cent of the ration (Gillis et al. 1949).

Potassium is widely distributed in feedstuffs of both plant and animal origin and it is therefore unlikely that this element under

natural conditions would be present in deficient quantity (Ewing 1963). The role of potassium in metabolism is not well understood. It is known necessary for normal heart activity, however, inasmuch as it reduces the contractility of heart muscle thereby allowing relaxation (Norris and Scott 1959). Potassium also appears to function in maintaining membrane potentials, particularly as related to action potentials in muscle. Symptoms of potassium deficiency in the young of domestic chickens include retarded growth, weakness, loss of use of legs and the excretion of large amounts of urates (Scott et al. 1944).

Magnesium is closely associated with calcium and phosphorus in body metabolism and as such is necessary for bone formation (Norris and Scott 1959). Almost two-thirds of body magnesium is found in bone, usually as magnesium carbonate. In addition, this element is essential for carbohydrate metabolism and the activation of a number of enzymes. Also, excesses of this element, as well as deficiencies can occur, producing deleterious effects. Buckner et al. (1932) found that a magnesium level of 7.05 per cent of the ration upset the calcium and phosphorus balance, causing deformed bones of low ash and calcium content. Alder (1927) reported that feeding of dolomitic limestone to laying hens for 4 months caused a decrease in egg production and egg shell thickness. Deficiency symptoms, on the other hand, include poor growth, nervous tremors, gasping and convulsions (Scott et al. 1956).

Manganese is an essential "trace element" required for normal bone formation in growing domestic chicks. Caskey et al. (1939) found that manganese deficiency in the diet of chicks caused shortening of the

bones of the legs, wings and spinal column. In addition, the ash content of the bones of chicks deficient in manganese was lower than that of chicks on a ration adequate in manganese. Wilgus et al. (1936) reported that in poultry perosis--an anatomical deformity of the leg bones of gallinaceous birds which can result in complete crippling--was caused largely by a deficiency of manganese. Apparently, a disproportionately greater retardation in the development of bones than in the development of other body tissues in chicks results in weak bones which are not strong enough to support the weight of the body, thereby causing bone malformation (Norris and Scott 1959). In mature fowl, manganese is needed to prevent decreased egg production and fertility (Gallup and Norris 1937) and poorer hatchability of eggs (Lyons and Insko 1937). Caskey and Norris (1938) concluded that 20 p.p.m. of manganese in the diet of hens was sufficient to prevent such reductions in hatchability and egg production.

Iron and copper are necessary for normal hemoglobin formation (Norris and Scott 1959). Iron is a constituent of hemoglobin itself, but copper, while essential for hemoglobin formation does not enter into its composition. In the absence of copper, however, anemia results. Both elements in excess can also cause physiological disturbances. Too much iron in the diet leads to a lowering of blood phosphorus and results in rickets (Ewing 1963), whereas excess quantities of copper are toxic, resulting in decreased growth of young chicks if over 324 p.p.m. and a marked increase in mortality if higher than 1270 p.p.m. (Mayo et al. 1956).

Zinc appears necessary for life in all animals (Norris and Scott 1959). It apparently is essential for the activation of several enzymes and is itself a constituent of carbonic anhydrase, an enzyme important in maintaining the acid-base balance of the blood and involved in processes concerned with bone calcification and deposition of the egg shell. O'Dell and Savage (1957) reported increases in growth of chicks supplied with 100 p.p.m. of zinc in the diet after they had been fed a diet containing 15 to 20 p.p.m. of this mineral. Zinc deficiency in chicks results in poor weight gains, shortening and thickening of the leg bones, a reduction in bone-ash and poor feather development (Ewing 1963). In laying hens, zinc deficiency can lead to thinner-shelled eggs than normal, lowered hatchability and higher embryo mortality. However, the extremely small quantity of this element needed by poultry was demonstrated by Zeigler et al. (1958); zinc deficiency symptoms were exhibited by chicks only when galvanized feeders were replaced with stainless steel feeders or the galvanized battery cages were coated with a plastic resin.

Molybdenum appears to increase the growth of domestic chickens, but the daily requirement of the chick for this mineral is only about 0.25 p.p.m. (Norris et al. 1957). The exact role of molybdenum in metabolism is apparently unknown.

Traces of iodine are required for normal functioning of the thyroid gland in all animals. Deficient quantities of this element in the diet lead to an enlargement of the thyroid tissue and the condition known as goiter (Norris and Scott 1959). The problem of iodine deficiency is

usually confined to areas in which the soil contains inadequate amounts of this element, such as in the Great Lakes region or the Northwest, but goiter has been found in poultry from many regions of the United States. Creek et al. (1954) reported that 0.05 p.p.m. of iodine failed to support normal growth. Even though 0.075 p.p.m. seemed sufficient for adequate weight gains, greater amounts were required for normal thyroid activity. Thus, iodine requirement for chicks can easily be met by adding 0.5 per cent iodized salt to the ration (Norris and Scott 1959).

Sulfur is a constituent of some amino acids and protein and is therefore an essential element for all animals. Unlike other elements necessary for proper body functioning, sulfur must be supplied almost entirely by organic sources such as the amino acids methionine and cystine (Ewing 1963). In laying hens, as egg production increases the amount of sulfur retained by the hen decreases. If the feed consumed by the hen does not contain adequate sulfur during the peak of egg laying, the hen withdraws part of the needed sulfur from her body and this in turn may lead to serious physiological disturbances (Ewing 1963).

Sodium as chloride, carbonate and phosphate is found chiefly in the blood and body fluids. Sodium chloride is an important inorganic constituent of blood plasma and as such is intimately concerned with regulation of the hydrogen ion concentration in the blood (Norris and Scott 1959). Also, along with calcium and phosphorus, sodium is necessary for proper heart activity. Prentice (1933) showed that lack of salt in the diet of laying hens caused a decrease in egg production, egg size and body weight, and encouraged cannibalism. Excessive amounts

of sodium salts in the diet, however, are toxic to chickens. Symptoms of salt intoxication include intense thirst, pronounced muscular weakness, inability to stand and convulsive movements followed by death (Norris and Scott 1959).

Selenium has recently been demonstrated to classify as an essential element for young chickens (Patterson et al. 1957), but problems arising in connection with this element usually involve excesses, since selenium is known to be highly toxic. At levels greater than 10 p.p.m. chick growth is reduced and at 5 p.p.m. in the diet of laying hens, hatchability is greatly reduced (Poley et al. 1941). Deficiencies of selenium under practical conditions probably seldom occur in poultry because of its high levels in cereal grains (Ewing 1963).

Cobalt has long been recognized as an essential element for ruminants, but as long as the diet contains adequate vitamin B 12 it does not appear essential for poultry (Davis et al. 1953). Fluorine, although not presently considered by some as an essential element for animals, is highly toxic in small concentrations. Halpin and Lamb (1932) showed that excess fluorine resulted in retarded growth in young chickens and in lower egg production and loss of weight in laying hens.

Thus, it is apparent that the determination of the role and inter-relationships of individual elements in the metabolism of birds is both difficult and complex. Recognizing this, the approach to the problem of soil and pheasant relationships in the present study was necessarily an

oversimplification. Since, however, pheasant-soil nutrient relationships are with the exception of calcium, entirely unstudied, it was believed fruitful to begin preliminary studies in this area to determine if any clear-cut differences in concentrations of soil minerals might occur between areas and thus be singled out for more detailed study at a later date.

## DESCRIPTION OF RESEARCH AREAS

## Location

The three Central Iowa Pheasant Research Areas are located in Hamilton, Story and Boone counties in the immediate vicinity of Ames, Iowa. The Hamilton and Story County areas are located directly north of Ames and the Boone County area is situated slightly southwest of Ames (Figure 1). More specifically, the Hamilton County area (hereafter to be known as the Northern Area) consists of sections 19, 30 and 31 Ellsworth Township (T.86N, R.24W.), Hamilton County and section 6 La Fayette Township (T.85N, R.24W.), Story County. The Story County area (Middle Area) includes sections 6 and 7 Franklin Township (T.84N, R.24W.), Story County and sections 29 and 32 La Fayette Township, Story County. The Boone County area (Southern Area) consists of sections 15, 22, 27 and 34 Colfax Township (T.83N, R.25W.), Boone County, all of the 5th Principal Meridian. The general area within which the Central Iowa Research Areas are located lies at approximately longitude 93 degrees 39'N. and 42 degrees 00'W. This is about 114 miles south and 6 miles east of the Winnebago County Research Area, which is located at longitude 93 degrees 45'W. and latitude 43 degrees 28'N. (Figure 2).

Winter and spring direct censuses were conducted on the four sections which comprise each of the Central Iowa Research Areas. The study of nesting, however, was carried out on only one-half of each area. This area included the eastern one-half sections of the sections comprising the Northern Area, the western one-half sections of sections 29 and 32,

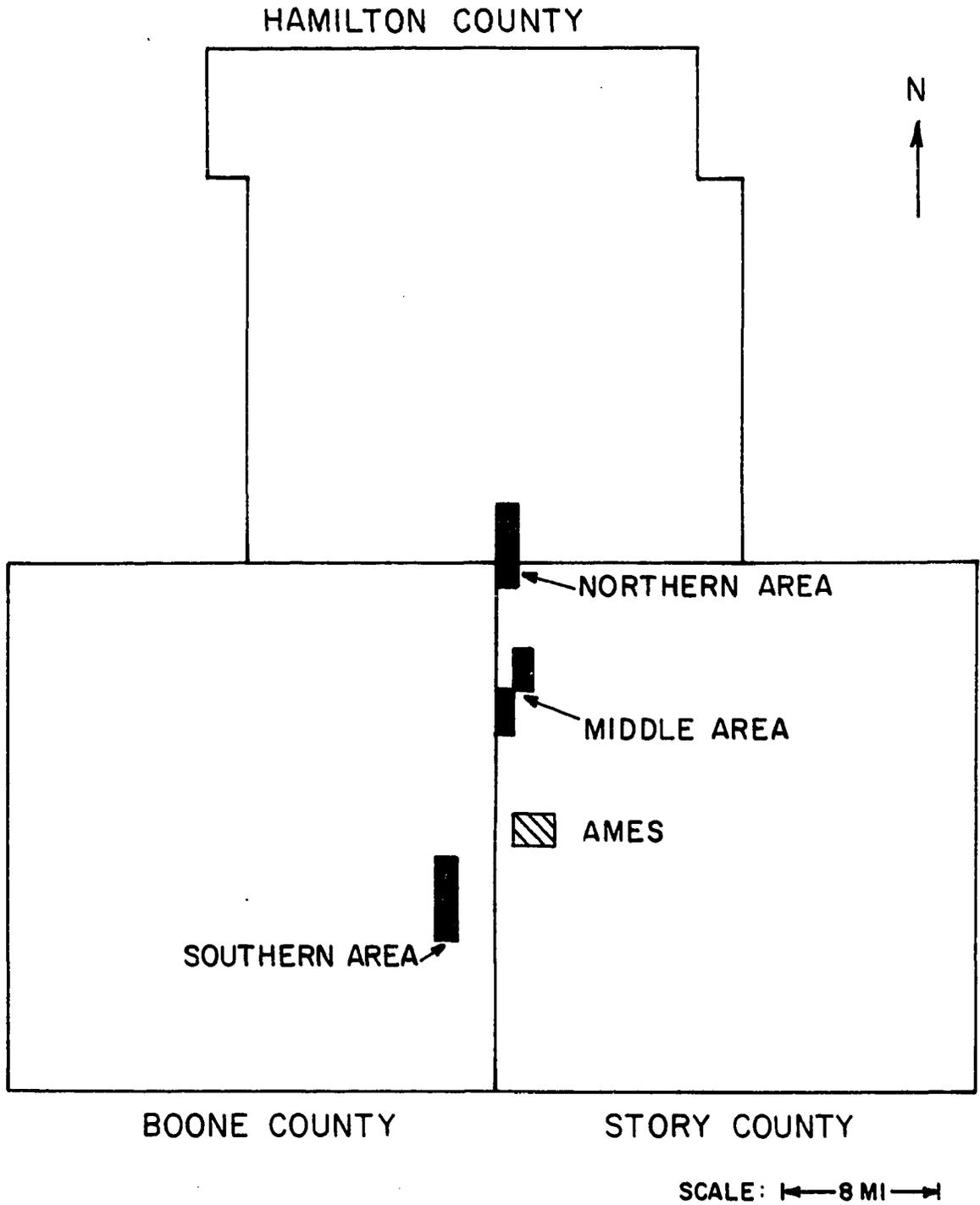


Figure 1. Location of the Central Iowa Research Areas in relation to Ames, Iowa

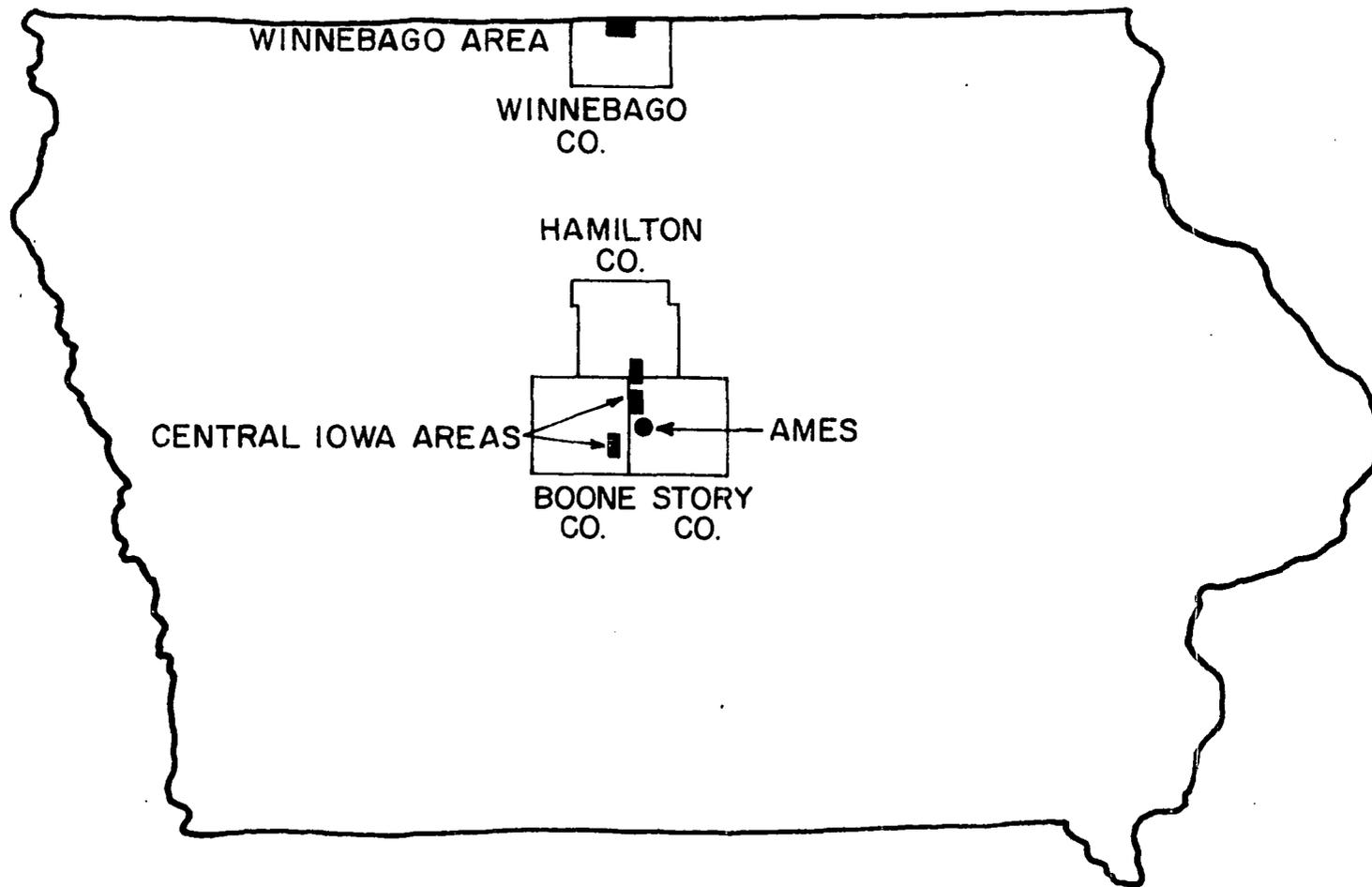


Figure 2. Location of the Central Iowa Research Areas in relation to the Winnebago County Pheasant Research Area

La Fayette Township and the eastern one-half sections of sections 6 and 7, Franklin Township, all four sections of which comprise the Middle Area, and the western one-half sections of those sections making up the Southern Area (Table 1). Section 6 of Franklin Township, Story County is an "oversize" section of 701 acres (the entire 24 sections of the county in that particular tier are all larger than standard). However, the supposed one-half section fenceline in section 7 of Franklin Township was displaced about 400 feet west of the true one-half section line, and therefore the acreage included in the nesting study was about the same as if two standard 320 acre one-half sections had been involved.

Spring, summer and fall roadside counts and spring sex ratio counts by necessity were not confined entirely to either the census area or the nest study area. However, the routes established for these counts were seldom more than 1 mile from the census area.

Table 1. Number of acres included in the census area and nest study area on each of the Central Iowa Study Areas

Area	Area in acres	
	Census area	Nest study area
Northern	2560	1280
Middle	2621	1262
Southern 2560	2560	1280

### Physiography

The three counties in which the Central Iowa Areas are located, because of similar geology are much alike in their physiographic features.

In most respects a description of the physiography of Story County, Iowa can serve as representative of the entire three-county area.

The topography of Story County is predominantly undulating but with a few nearly level and rolling to hilly areas (Meldrum et al. 1941). The present drainageways are not well-developed and consequently any rough and broken land is restricted to areas immediately bordering stream valleys. For the same reason, flood plains along these valleys are not extensive. Locally the undulating uplands are interrupted by prominent hills and frequent small swells of glacial origin. Many morainic ridges and hills consisting of belts of sandy or gravelly knolls project above the level of the till plain. Sloughs and saucer-shaped basins are scattered among the low ridges and are especially common on the more level divides occurring between distant stream valleys. Many of these basins and sloughs have been permanently drained by tile and now provide some of the best areas for crop production (Brown 1936).

Drainage in the three-county area is in a southerly direction. In Story County the principal streams are the Skunk River and its tributary, Squaw Creek, which drains the western part of the county and Indian Creek, which drains much of the eastern part (Meldrum et al. 1941). The Des Moines River and its tributaries provide most of the drainage for Boone County (Stevenson et al. 1924). Drainage in Hamilton County is brought about mainly by the Skunk River, which drains the eastern portion of the county and the Boone River and its tributaries which drain most of the western part (Stevenson et al. 1921).

All three counties lie within the Wisconsin glacial drift area.

This Wisconsin till consists of clays, sands, gravels, pebbles and boulders and varies in depth from 10 to 40 feet (Stevenson et al. 1924). Frequently, calcareous material is found within the top 3 feet of soil but occasionally such materials cannot be found except at extreme depths. Underlying the Wisconsin till is drift material from the earlier Kansan glaciation but it very seldom appears naturally at the land surface; consequently, very few of the soils in the area have been derived from it. Kansan till ranges in depth from 50 to 150 feet and consists mainly of an unoxidized bluish, gritty clay containing many pebbles and boulders (Stevenson et al. 1921). Occasionally, Kansan till outcrops along stream and river channels.

#### Climate

The climate of central Iowa is characterized by moderately hot summers and cold winters, with extremes in temperature ranging from highs of almost 110 degrees F. to lows of about -35 degrees F. The normal annual temperature as computed by the United States Weather Bureau for the period 1931-1960 at Ames, Iowa is 48.7 degrees F., with average monthly normals ranging from 20.0 degrees F. in January to 74.8 degrees F. in July (Table 2). Precipitation averages 31.12 inches annually, 49.5 per cent which falls during April, May, June and July. Rains in early spring, in autumn, and in summer usually occur as lengthy, gentle showers, but during warmer periods in summer, electrical storms and thundershowers are common (Meldrum et al. 1941) and occasionally hailstorms cause crop damage. The average date of the last spring freeze is May 1 and of the

Table 2. Normal monthly temperatures and precipitation, Ames, Iowa, based on period 1931-1960

Month	Temperature (degrees F.)	Precipitation (inches)
January	20.0	1.08
February	23.9	0.98
March	34.2	1.88
April	49.1	2.59
May	60.5	4.28
June	70.2	5.21
July	74.8	3.31
August	72.7	3.85
September	64.3	3.30
October	53.3	2.00
November	36.7	1.62
December	25.1	1.02
	Annual average 48.7	Annual total 30.16

first fall freeze, October 5 (Shaw et al. 1954), giving a freeze-free season of 157 days. However, temperatures of 32 degrees F. or lower have occurred as early as September 13 and as late as May 29.

#### Native Vegetation

At the time Iowa was first settled by white men, central Iowa was a part of a larger area of the state covered by native prairie grasses and forbs; forested areas were restricted to stream and river valleys and the adjacent rough or rolling lands (Meldrum et al. 1941). Grasses on the uplands consisted, in part, of big bluestem (Andropogon gerardii), little bluestem (Andropogon scoparius), indiagrass (Sorghastrum nutans) and various dropseeds (Sporobolus sp.). In sloughs and basins the vegeta-

tion included sloughgrass (Spartina pectinata), reed (Phragmites communis) and Glyceria sp. Porcupine grass (Stipa spartea) and some of the grammas (Bouteloua sp.) were among the species growing locally in drier places. Trees in stream valleys and rough bordering areas included mainly oak (Quercus sp.), elm (Ulmus sp.), hickory (Carya sp.) and ash (Fraxinus sp.) on the rougher areas and principally black walnut (Juglans nigra), butternut (Juglans cinerea), sycamore (Platanus occidentalis), maple (Acer sp.), willow (Salix sp.), elm and cottonwood (Populus deltoides) in the stream bottoms. Timbered areas, although modified in extent and species composition, still remain in many of these areas, but due to intensive agricultural practices the native prairie has been reduced to remnant parcels scattered throughout the state.

At present, the only woody vegetation found on the Central Iowa Areas are planted groves and windbreaks around farmsteads, occasional larger trees in pastures, thickets of wild plum (Prunus americana) and infrequent small black locusts (Robinia pseudo-acacia) and cedars (Juniperus virginiana) along fencerows and roadsides, and in small, untilled waste areas. A two-acre parcel of native grasses and forbs on the Northern Area is the only representative of the native prairie remaining on the Central Iowa Areas.

#### Soils

The soils found on the Central Iowa Research Areas, having been formed entirely from Wisconsin glacial till and under similar conditions of topography, climate and vegetation belong to the Webster-Clarion Soil

Association Area (Riecken and Smith 1949). The Clarion, Webster and Nicollet are the principal upland soils, which because of their high productivity are the soils most extensively used for corn and soybeans. Clarion occurs on gentle to moderately sloping topography, Nicollet is found on nearly level topography and Webster dominates on the level areas. All have been developed under a grass vegetation. Surface layers range from dark brown to black and have textures of loam to silty clay loam. Clarion soils on the steeper slopes are subject to erosion and may need lime for optimum crop production. Webster soils require drainage and are usually tilled. Nicollet soils are intermediate in drainage and rarely need tile. Glencoe and Harpster soils occur in depressions within Webster soils and collect surface runoff during heavy rains and become ponded. Drainage of these areas is often prevented because outlets are poor. Harpster soils occur as rims surrounding Glencoe soils and can often be recognized by the presence of snail shell fragments which give the surface a lighter cast than contiguous soils. Storden soils are developed on slopes with an 8 to 30 per cent grade and differ from the Clarion soils in displaying a lighter surface and having lime at shallower depths. Hayden and Ames soils are found in areas which were originally forested, the Hayden occurring on slopes of 3 to 20 per cent and the Ames on more level areas of 0 to 2 per cent. Hayden soils usually have adequate internal drainage and do not need tiling, but Ames soils possess slowly permeable, clayey subsoils which are difficult to drain even if tilled. Minor upland soils which occur are the Lakeville, Thurman and Dickinson. The Lakeville is developed from very gravelly materials, the

Thurman from incoherent sand deposits, and the Dickinson from coherent sand deposits. The Bremer, Wabash, Waukesha, Lamoure, Buckner, O'Neil and Sarpy are minor bottomland or terrace soils which are important only locally.

In most respects the Winnebago County Research Area is very similar to the Central Iowa Areas; historically, the climate, vegetation and glaciation have been much alike in the two locations; consequently the physiography and soils are almost identical. The Winnebago Area, however, being farther north shows a slightly lower normal annual temperature (46.3 degrees F.) and a shorter freeze-free season (about 146 days) than the Central Iowa Areas (47.1 degrees and 157 days, respectively). Moreover, it is more level and less well-drained than the Central Iowa Areas and hence sloughs and pot-holes were once probably more common. As occurred on the Central Iowa Areas, however, most of these were drained and converted to cropland. Also, even less woody vegetation remains than on the Central Iowa Areas; farm windbreaks constitute almost all woody cover, with only an occasional tree along a fencerow (Klonglan 1962).

#### Agricultural Land Use

Approximately 94 per cent of the land in Story, Hamilton and Boone Counties was under intensive agricultural use in 1963 according to the Iowa Book of Agriculture for 1963. (The year 1963 was chosen as representative of the three-year period during which the study was conducted.) Corn was the leading cash crop, accounting for an average of 38.7 per cent of all farmland, followed by soybeans, 19.8 per cent and oats, 6.9

Table 3. Agricultural land use in Story, Hamilton and Boone Counties, Iowa, 1963

County	Acres in							Total
	Corn	Oats	Soybeans	Hay	Pasture	Unpastured	Miscellaneous <sup>a</sup>	
Story	137,684 (40.1%)	22,692 (6.6%)	61,814 (18.0%)	27,458 (8.0%)	34,204 (10.0%)	36,924 (10.8%)	22,434 (6.5%)	343,210 (100.0%)
Hamilton	149,244 (41.4%)	23,925 (6.6%)	82,640 (22.8%)	21,793 (6.0%)	30,673 (8.5%)	31,936 (8.8%)	21,388 (5.9%)	361,599 (100.0%)
Boone	122,674 (35.3%)	26,353 (7.6%)	64,374 (18.5%)	25,391 (7.3%)	52,645 (15.2%)	34,996 (10.1%)	20,835 (6.0%)	347,268 (100.0%)
Total	409,602	72,970	208,828	74,642	117,522	103,856	64,657	1,052,077
Mean	136,534.0 (38.9%)	24,323.3 (6.9%)	69,609.3 (19.8%)	24,880.7 (7.2%)	39,140.7 (11.2%)	34,618.7 (9.9%)	21,552.3 (6.1%)	350,692.3 --

<sup>a</sup>Miscellaneous includes lots, roads, buildings, woods and waste areas.

per cent (Table 3). Pasture, including both permanent and rotation comprised 11.2 per cent of all farmland. Unpastured farmland (fallow, idle and crop failure acreages) amounted to 9.9 per cent and a miscellaneous classification consisting of lots, roads, buildings, woods and waste areas accounted for 6.1 per cent. Approximately 65 per cent of the total land area in the three counties was in farms.

The Central Iowa Areas, like the counties in which they are located, are intensively farmed. An average of approximately 96 per cent of the study areas was in corn, soybeans, oats, hay and pasture during the 3 years; corn, soybeans and oats alone accounted for over 80 per cent of the total acreage (Table 4). The Winnebago Area, by comparison, during an earlier 3-year period (1956-1958-1959) had 92 per cent of the land under direct agricultural use (Klonglan 1962). Baskett (1947) and Klonglan (1955b) also reported about 92 per cent of the Winnebago Area under cultivation during an earlier period.

Table 4. Major land use classification on the Central Iowa Research Areas, 3-year average, 1962-1964

Land use	Area			mean	Per cent of mean total acreage
	Northern (1280 acres)	Middle (1260 acres)	Southern (1280 acres)		
Hay <sup>a</sup> (mainly alfalfa and red clover)	146.0	115.3	147.2	136.2	11.0
Oats <sup>a</sup>	264.9	248.6	202.7	238.7	19.3
Pasture	60.2	66.1	67.0	64.4	5.2
Corn	535.1	453.9	498.6	495.9	40.2
Soybeans	173.9	296.1	297.0	255.7	20.7
Non-agricultural (Road-sides, waste areas and farmsteads)	46.8	42.1	41.4	43.4	3.6

<sup>a</sup>Includes feed grain reserve acreages of the respective crop type.

## TECHNIQUES OF INVESTIGATION

## Censuses and Population Indices

Censuses or indices of pheasant populations were secured during late winter or early spring and late summer. The techniques used in obtaining these counts were winter or spring censuses, cock crowing counts and summer roadside counts.

Winter census

Winter censuses were conducted on the Central Iowa Areas in 1962 and 1964 and on the Winnebago County Area in 1962, 1963 and 1964. Such counts were made in late January, February and early March, but only under conditions which included snow depths of 4 inches or more, winds greater than 10 miles per hour and temperatures 20 degrees F. or lower. Restricting the counts to such periods of adverse weather insured that birds would be concentrated in restricted areas of heavier cover such as farm groves, sloughs, fencerows, road ditches, tile ditches and other waste areas. On the Winnebago County Area only one winter census was made annually. On each of the Central Iowa Areas, however, if conditions permitted an additional census was secured to assure the precision of the original count. Under the conditions described above, winter censuses were regarded as accurate and accounted for essentially all birds present on the area at the time of the census. Any potential inaccuracies which might have occurred were more likely the result of chance variation in pheasant numbers due to the small size of the census area rather than to inacc-

racies in counting.

### Spring census

Spring censuses were conducted only on the Central Iowa Areas and then only in years when the absence of proper counting conditions prevented making an earlier winter census. Under such circumstances the results of the spring census were substituted for and equated to those normally obtained during winter. The census entailed counting resident cocks on each section of the study areas during April and early May, and thus by the use of sex ratios collected on each Central Iowa Area during the previous winter and current spring, computing the spring breeding population for each area. The technique used in these counts was similar to that employed in Illinois as described by Robertson (1958), but with some basic improvisations.

The counts were begun at one-half hour before sunrise and usually took about one hour to complete. The observer, equipped with section maps of each area, drove around the perimeter of each section, stopping at the one-fourth mile and three-fourths mile station on each section side and listened for a period sufficient to satisfy him that the approximate position of each crowing cock within his range of hearing had been recorded. Repetition of the procedure along each of the three remaining section borders permitted, by audio-triangulation locating each cock within the section. To increase the efficiency of the technique a second observer was stationed at the center of the section prior to the start of the census. The observers faced each other and synchronized listening

periods, thereby permitting the censusing of individual quarter sections and increasing to about 20 the number of cocks per section which could be counted with accuracy. Since only the number of cocks needed to be counted, the rate of crowing was unimportant and counts could therefore be conducted under any weather conditions except those not permitting good audibility. Figure 3 is typical of the type of record obtained.

This technique in itself appeared fairly accurate; however, the accuracy of sex ratios used in the computation of the hen segment of the population, were in some cases questionable. For this reason the population during the late winter as determined by the winter census, was preferred over the spring census to represent the breeding population, even though the spring census was made more proximate to the breeding period itself.

Thirty-mile crowing counts (Kimball 1949) were conducted on both the Central Iowa Areas (Figure 4) and the Winnebago County Area (Figure 5), but since direct late winter or spring censuses were obtained these counts were used only to aid in determining the accuracy of the direct censuses.

#### Summer roadside counts

A complete census of the pheasant population during the period between the breeding-nesting season and the succeeding winter, though desirable, is difficult to secure due mainly to the extensive heavy cover present at this time of the year. Thus, a method yielding an index to populations had to be relied on rather than a total count.

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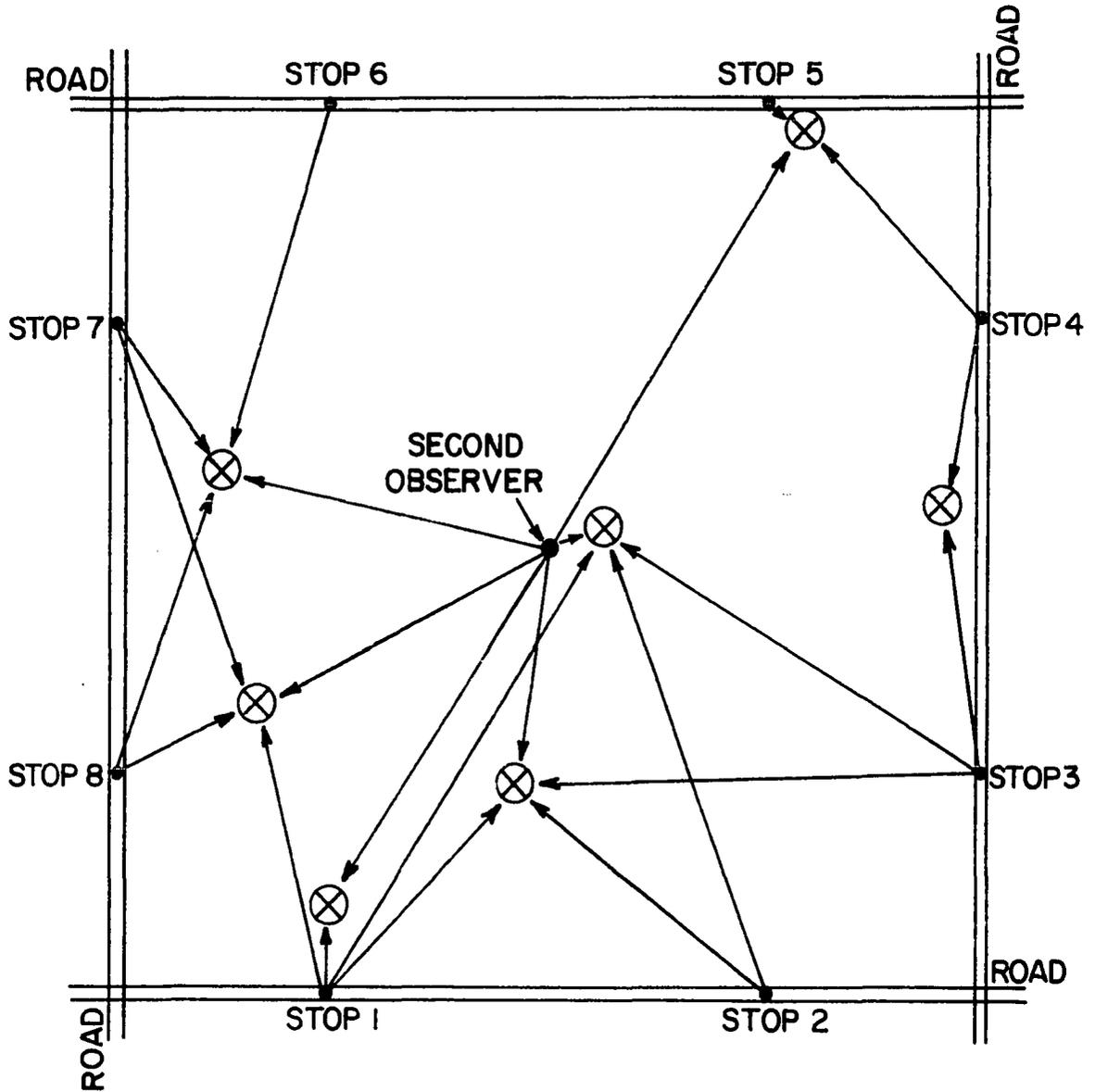


Figure 3. Record of a pheasant crowing cock census by the line intercept method, section 29, La Fayette Township, Story County, Iowa, April 22, 1963

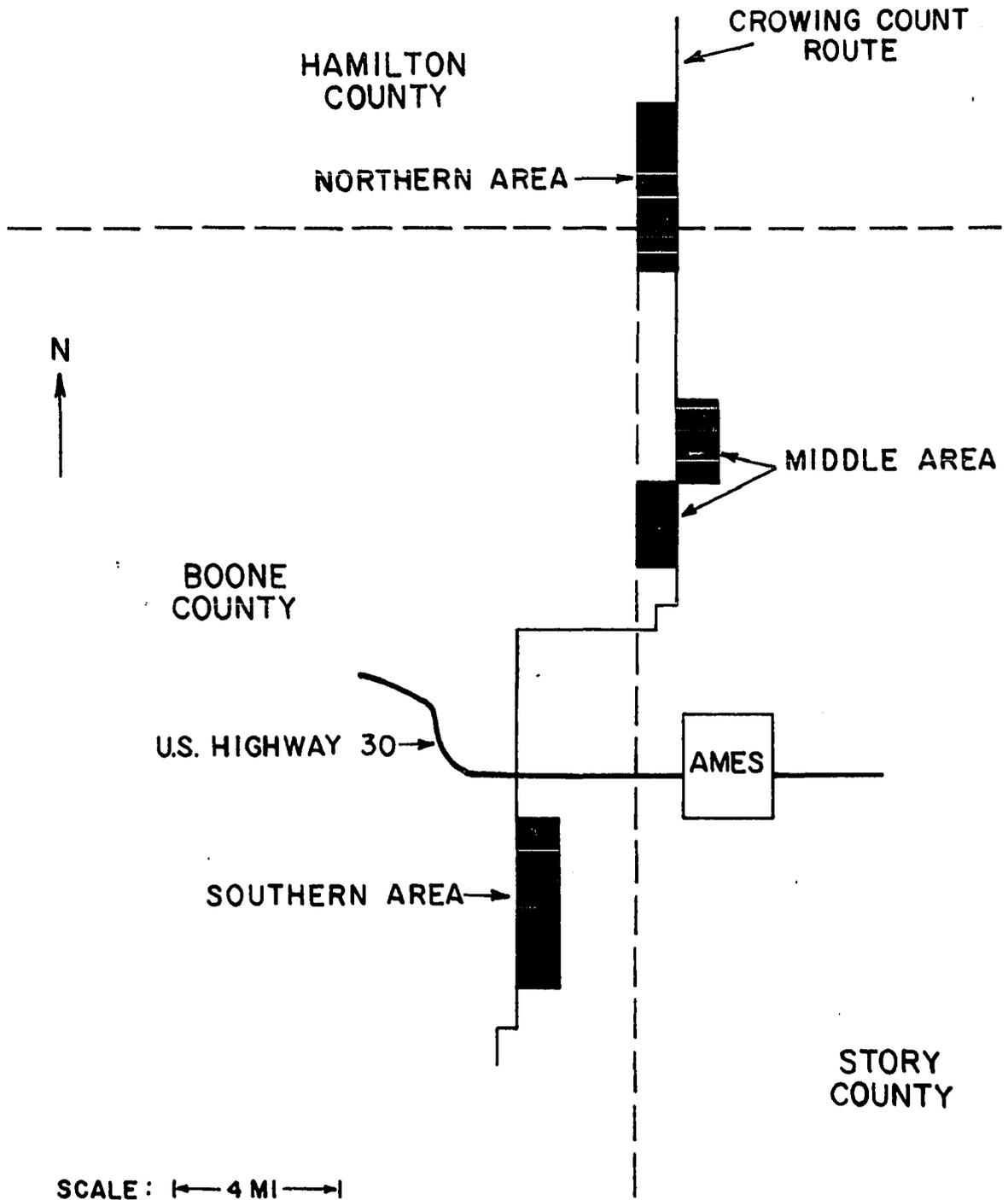


Figure 4. Location of 30-mile pheasant crowing count route, Central Iowa Areas

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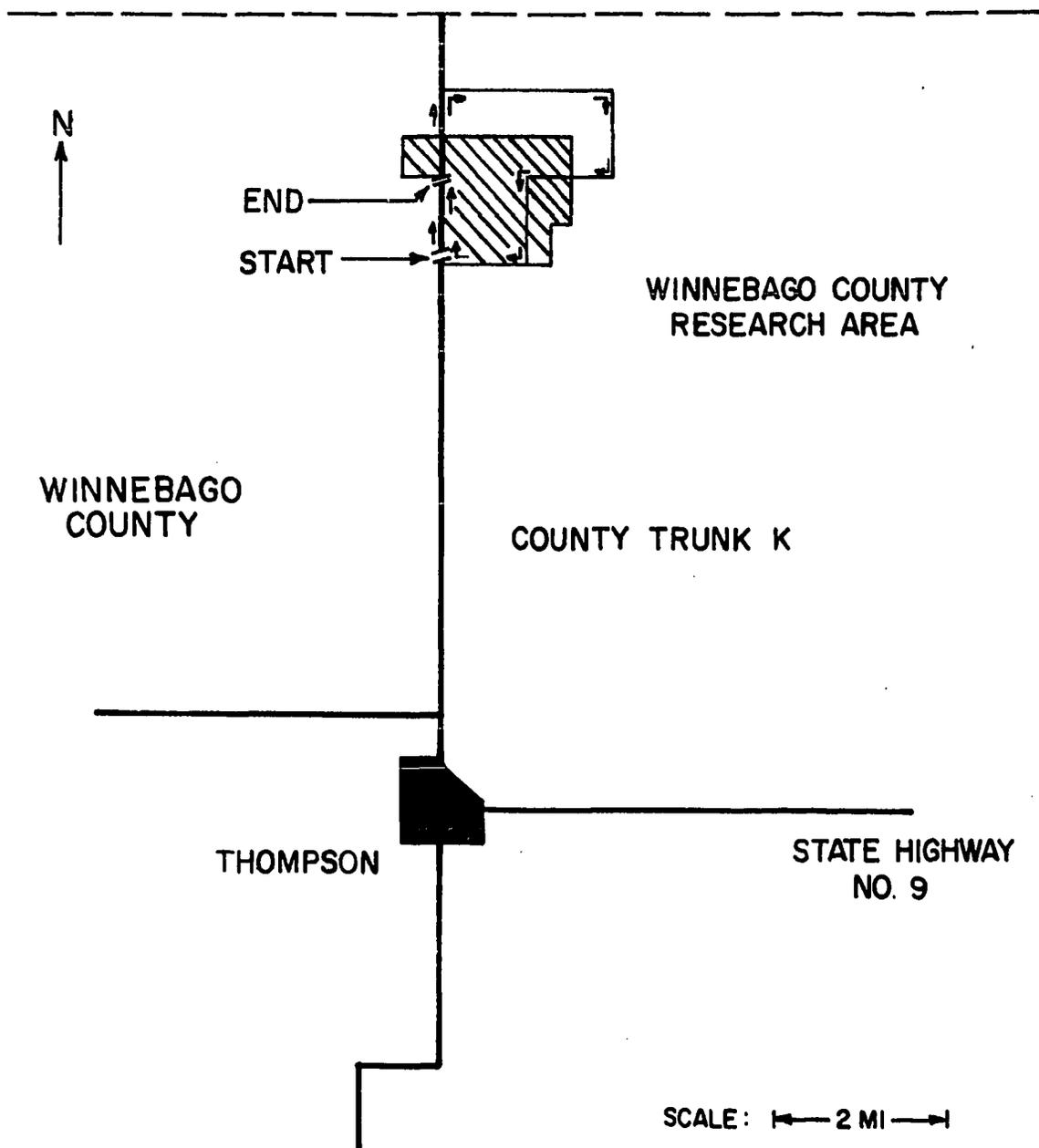


Figure 5. Location of 10-mile pheasant crowing count route, Winnebago County Pheasant Research Area

The index used most commonly, and the one employed in the present study, was the pheasant roadside brood count, first described by Bennett and Hendrickson (1938). Klonglan (1955a) found that in Iowa, late August and September were the months best suited for securing this count, but on the Central Iowa Areas because a greater volume of information on size of broods was desired, the counts were initiated in mid-July.

A partially circuitous 21-mile route on which counts were made was established for each of the Central Iowa Areas (Figure 6). The routes selected provided good coverage of both the study area and the immediate vicinity and at the same time because of their length permitted the collection of a larger sample than could have been realized by confining the routes to the study areas alone. On the Winnebago County Area a limited number of counts were made in late August and early September on a route (Figure 7) established in 1952 (Klonglan 1955a).

All counts began at sunrise at the same point and were secured by traveling in the same direction on the route. The vehicle was driven at 10 to 20 miles per hour and an attempt was made to record the sex and age of all pheasants seen. Weather information, including estimates of dewfall, were recorded at the time of each count.

#### Nesting and Production of Young

To facilitate an evaluation of nesting success on the Central Iowa Areas, various habitat types were considered and a separate evaluation was made for each type. This evaluation was patterned after methods by Stokes (1954) and Linder et al. (1960); each of these investigators made

a thorough search of samples of the various cover types, determining the frequency of nesting and the rate of nest success by sampling each type in proportion to the anticipated nest density in that type. Cover types checked were hay, oats, pasture, roadsides and waste areas. Rates of sampling for each cover type varied each year depending upon the number of assistants available to aid in nest searching.

Detailed cover maps of the areas were made each year. A counting device installed on the front hub cap of an automobile was used to measure distance through a count of wheel revolutions. A special table was used to convert distance directly to a millimeter scale, thereby permitting the investigator to map the size of cover areas without having to leave the vehicle. Occasional field borders obstructed from view because of rolling terrain had to be mapped on foot. Permanent structures and certain land features such as houses, barns and sheds, fencerows, road ditches and sloughs remained unchanged and needed to be mapped only at the outset of the study.

Total acreages of some cover types were searched. In other types, except in oats and roadsides, linear transects were used to sample each field in the different cover types. Location of transects was determined on the cover maps. The width of each field on the map was marked in millimeters, each division was assigned a number, and by random selection of these numbers the north or west boundary of a transect was determined. Each transect extended the length or width of the field (whichever facilitated a more thorough coverage of the plot); the width or length was adjusted so that the transect covered the desired area.

To sample oats, portions of fields or entire fields in which the grain had been harvested and subsequently raked free of straw were searched. In addition, in fields which had been harvested and the straw windrowed, the area between the windrows was checked for nests and served as the sample plot. Sample plots in roadsides were determined by dividing each mile of roadside into equal segments and then selecting one segment as the plot by random drawing. Fencerows were not sampled, since past experience had shown they contributed little to pheasant production. Furthermore, the effort expended in searching this type would have involved considerable time that could be better spent obtaining a larger sample from the more important cover types. Figure 8 shows a typical pattern and arrangement of nest plots.

Each field or plot was searched once within the period June 1-August 15. For each nest found, data concerning the nest and eggs were recorded on mimeographed forms (Appendix). If a hen was on the nest when it was found, an effort was made to leave her undisturbed. The location of the nest was noted and it was revisited at approximately weekly intervals. Information regarding the nest and eggs was recorded when it was apparent that the hen was no longer using the nest. If the number of eggs in a nest could not be determined with accuracy, the average clutch size of all other nests found in that cover type was assigned. Information from nests found off nest plots during the performance of other field duties and from nests reported by farmers was also recorded, but was not used in calculating chick production.

On the Northern Area, the total number of nests found on sample

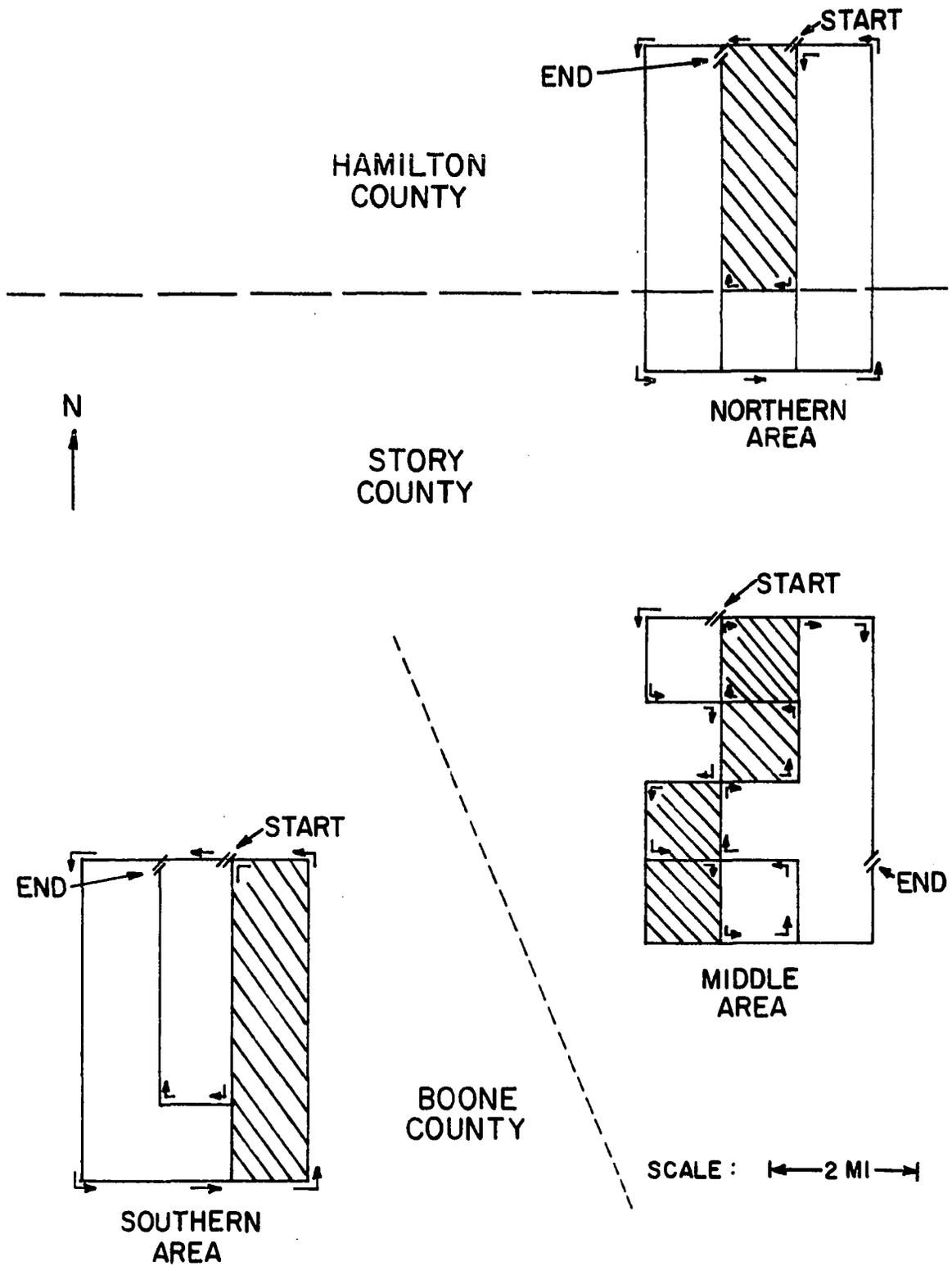


Figure 6. Summer roadside pheasant count routes, Central Iowa Areas

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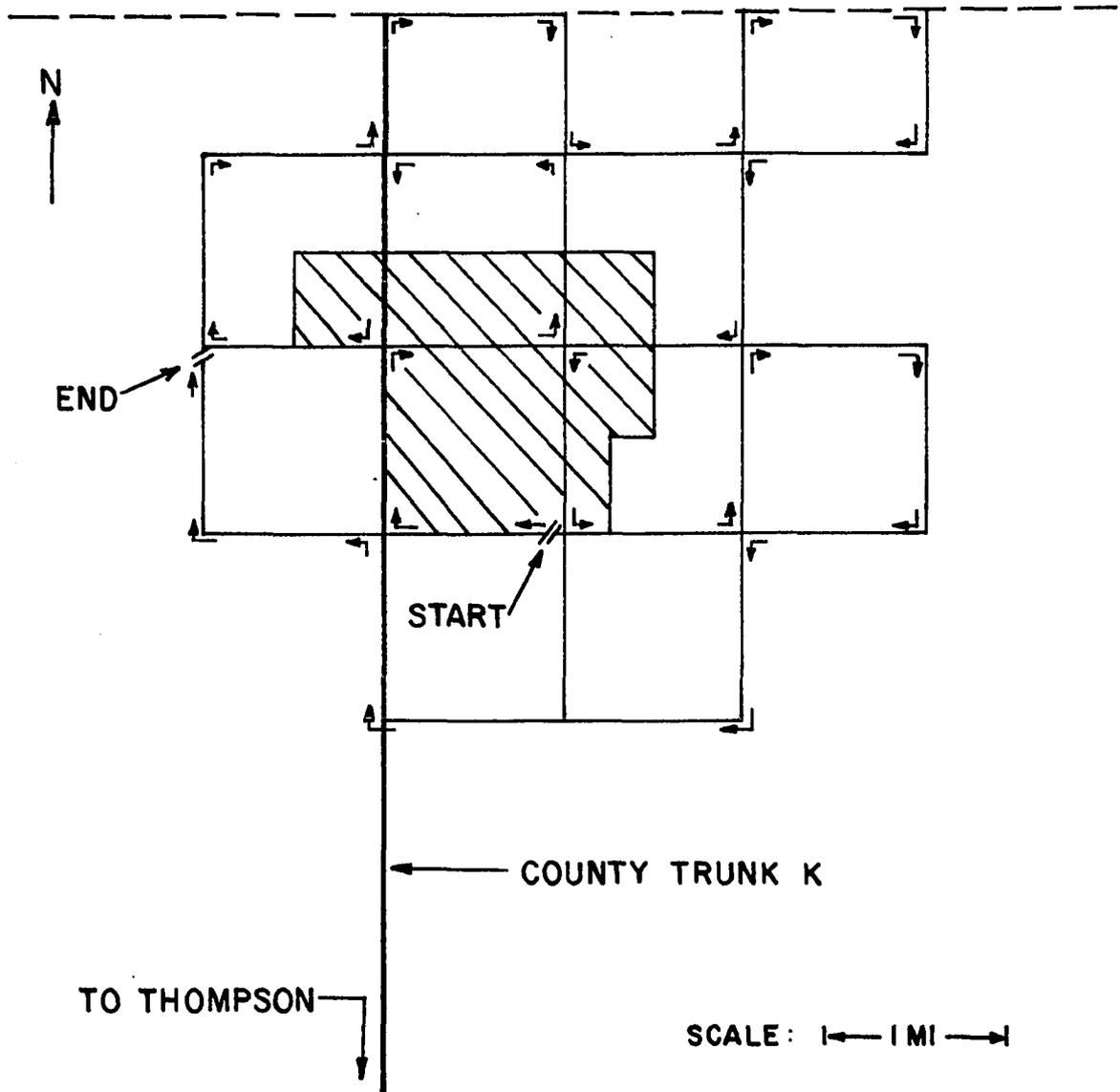


Figure 7. Summer roadside pheasant count route, Winnebago County Research Area

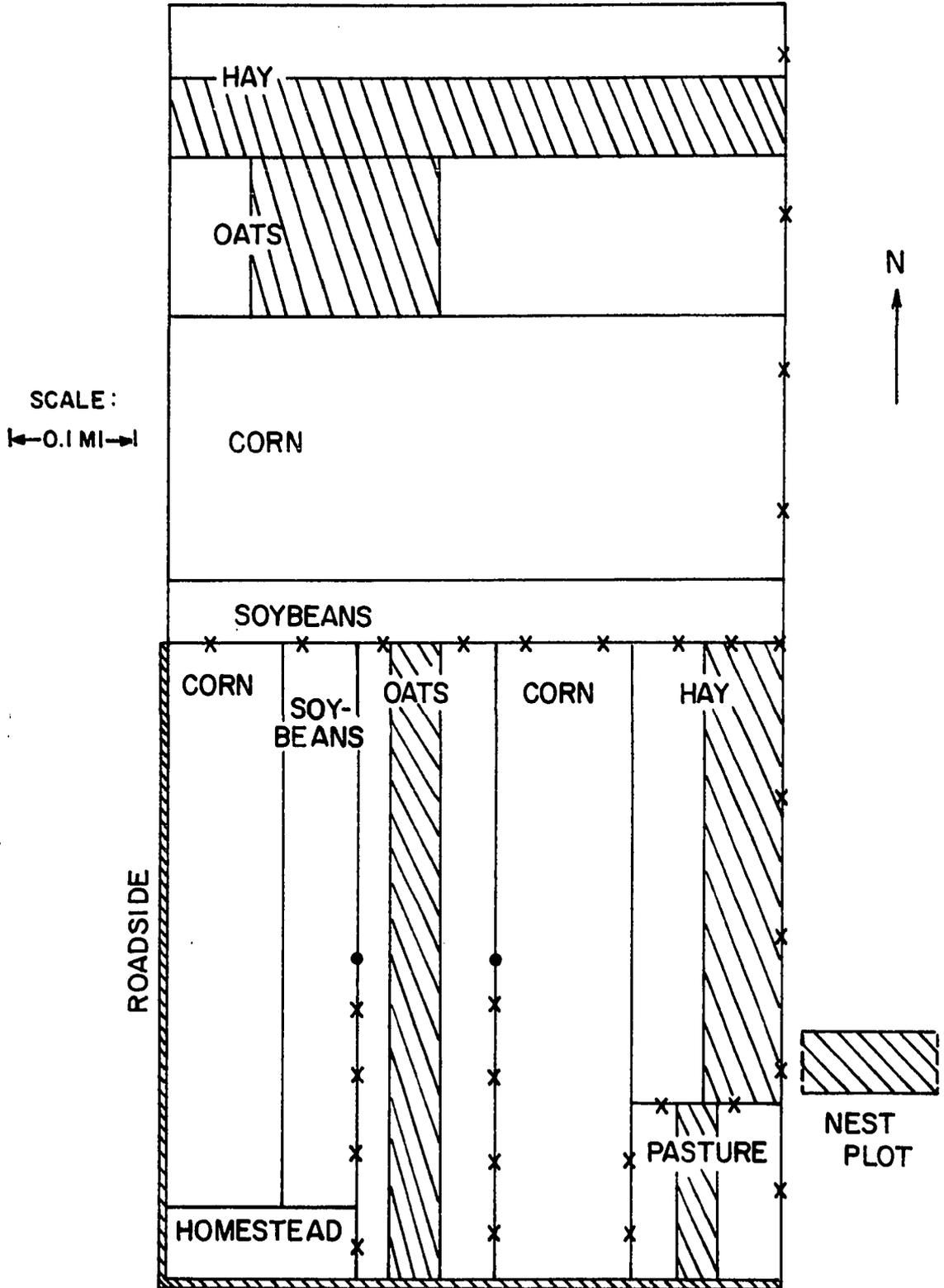


Figure 8. Location of nest plots on western one-half section, section 22, Colfax Township, Boone County (Southern Area)

plots in a single cover type was projected to give an estimate of the total number of nests present in that cover type. Multiplying the calculated number of nests by the average clutch size of all nests found gave the number of eggs in each type. Similarly, multiplying the calculated number of eggs by the per cent of eggs hatched in each cover type equalled the number of chicks produced in each type. The number of nests found on the Middle and Southern Areas was too small to permit what was considered a reliable estimate of chick production. Nesting studies were not conducted on the Winnebago County Area.

#### Weather

Temperature and precipitation records for the Central Iowa Areas were obtained at the Iowa State Agronomy Farm located 2 miles southwest of Ames, Iowa. Additional precipitation data were procured from the Weather Bureau Station in Jewell, Iowa, a town 23 miles due north of Ames and approximately three and one-half miles northeast of the Northern Area. Temperature and precipitation records for the Winnebago County Area were obtained at the Weather Bureau Station in Forest City, Iowa.

#### Soils

On each of the Central Iowa Areas 10 soil samples were collected and submitted to the Ohio Agricultural Experiment Station at Wooster, Ohio for analysis. A newly-available spectrophotometric method permitted soil analysis for available magnesium, manganese, iron, boron, copper, zinc, aluminum, molybdenum, cobalt, sodium, and strontium, as well as

the usual calcium, phosphorus, potassium and pH. ("Available" refers to the amount of a given nutrient presumed to be useable by plants.)

Detailed soil maps of portions of the Central Iowa Areas obtained from the Soil Conservation Service offices for Boone, Story and Hamilton counties served as the basis for the random selection of soil collection sites. To avoid encountering the extreme variation in the quantity of various soil elements known to occur among various soils, samples were taken only from a single soil series, the Nicollet, which accounts for approximately 20-40 per cent of the soils on the Central Iowa Areas. On the soil maps the different soil types within this series were partitioned on each area into 4-millimeter squares in the form of a grid, each square was assigned a number and the collection sites were determined by random selection. Soil samples were taken with an auger to a depth of 9 inches and placed in a polyethylene bag ready for shipment.

#### Movements of Pheasants

Pheasant trapping was carried out on the Northern Area of the Central Iowa Areas as part of a study designed to gain information on the movements of pheasants in central Iowa. During the winter of 1961-1962 weather conditions were sufficiently adverse to permit the use of a wire trap similar to the Ohio-type trap first described by Hicks and Leedy (1939). Cold, windy weather prevailed for long periods and deep snow covered the food supply, forcing birds into areas of brushy or woody

vegetation where they were easily trapped. In other years pheasants were captured at night during late summer and fall with the use of spotlighting equipment. A specially-rigged United States Army weapons carrier equipped with five 150 watt flood lamps and spotlights which were powered by a gasoline-driven, 120 volt, 1500 watt, Onan (AC) generator was driven systematically through oat stubble, soil bank and uncut hayfields. Birds were trapped by means of long-handled aluminum hand-nets after having first been spotted in the vegetation by use of the floodlights and then held motionless by a concentrated beam from a 12 volt, 100,000 candle power spotlight. All captured pheasants large enough were promptly banded with aluminum leg bands and affixed with a harness-type back tag constructed of Naguahyde similar to that described by Labisky and Mann (1962). Birds less than 9 weeks of age were too small to be tagged; those less than 6 weeks old could not be banded. All birds were released at the site of their capture immediately after they had been tagged and banded.

## RESULTS

## Breeding Populations

The start of the reproductive cycle of the pheasant is for convenience designated by most investigators as spring. Although biologically, no specific point within the cycle can be claimed with safety as "the" beginning, the late-winter-early-spring period marks the start of renewed sexual activity in anticipation of nesting. The number of birds present in the population at this time prior to nesting is perhaps the most valuable single population statistic available to the investigator of populations of upland game birds. Such an inventory serves as the basis for the interpretation of various population phenomena and is a necessary statistic in determining the population dynamics of this species; therefore, a census of the Central Iowa Areas and the Winnebago County Area during this period was necessary each year.

Ideally, the most useful censuses of the breeding population would have been secured in March or April during the peak of mating activity and immediately prior to nesting. Several of the counts were taken during this period. For example, in 1962 a census of the Southern Area was made in March (Table 5). In the winter of that year, snow accumulations of record depth occurred in central Iowa, with sub-zero temperatures persisting well into March. Such a combination of conditions permitted the taking of censuses at later dates than usual. Censuses of the Northern, Middle and Winnebago County Areas were made in late February under similar conditions and only shortly before the census of the Southern Area.

Table 5. General period of winter and spring pheasant censuses, Central Iowa Areas and Winnebago County Area

Year	Central Iowa Areas			Winnebago Area
	Northern	Middle	Southern	
1962	late February	late February	early March	late February
1963	<u>late April</u> <sup>a</sup>	<u>mid-April</u> <sup>a</sup>	<u>early April</u> <sup>a</sup>	late January
1964	late March	<u>late April</u> <sup>a</sup>	late March	late March

<sup>a</sup>Spring census.

Similarly, in 1964 the census of both the Southern Area and Northern Area occurred at later dates than usual. On March 26 and 27 an unseasonal blizzard with winds of 15 to 25 miles per hour brought 4 inches of snow to the central Iowa region. For a brief period immediately following the storm, temperatures dropped to 15 to 20 degrees F. and winds remained at high velocities, making possible the census of the two study areas. Shortly, however, temperatures recovered and birds dispersed from cover, thereby preventing the censusing of the Middle Area. During this same storm, the Winnebago County Area was censused by two biologists of the Iowa Conservation Commission. Conditions under which the Winnebago count was made were identical to those recorded for the Central Iowa Areas.

Some censuses, however, were made earlier than desirable. One such census was obtained on the Winnebago Area on January 25, 1963. Although the winter of 1963 was colder than normal in Iowa, very little snowfall occurred. As a result, winter censuses were not secured on any of the

Central Iowa Areas that year. However, a winter storm which struck northern Iowa early in the winter made possible a census of the Winnebago County Area on January 25, but thereafter the proper counting conditions failed to reoccur and prevented a later and more satisfactory census.

In years when winter censuses were not obtained, an alternate census method, the location of crowing cocks by audio-triangulation, was employed during April, and in conjunction with sex ratios obtained in the previous winter and early spring was used to calculate the breeding populations of the Central Iowa Areas. Similar methods have been used successfully by pheasant biologists in Illinois (Robertson 1958). In the winter of 1963, for example, the desired counting conditions did not materialize, precluding winter censuses on the Central Iowa Areas and requiring the use of the alternate method. In 1963, suitable conditions for counting occurred only long enough to complete censuses on two of the Central Iowa Areas and again necessitated the adoption of the alternate method. Table 6 demonstrates the method used to compute the breeding populations in years when the alternate method was employed.

Winter censuses were preferred over the alternate spring censuses even though the latter were obtained during April, a time usually considered more desirable for the censusing of the spring breeding population. The accuracy of the audio-triangulation method is dependent upon the assumption that all males crow, and at rates sufficiently high to assure the efficient recording of all cocks within the hearing range of the investigator during a designated time interval. Very little is known, however, about the crowing behavior of wild cock pheasants. Nelson

Table 6. Calculated spring pheasant populations on the Central Iowa Areas as determined from a census of crowing cocks

Area	Year	Number cocks	Observed sex ratio	Calculated number hens	Calculated total population
Northern	1963	53	1M:3.7F	196	249
Middle	1963	17	1M:2.6F	44	61
Southern	1963	20	1M:1.9F	38	58
Middle	1964	38	1M:2.0F	76	114

et al. (1962) found that among groups of captive cock pheasants the individual variation in frequency of crowing was highly significant; one bird crowed only 44 times during an observation period of 1 1/2 hours, another crowed 494 times during the same period. However, even the lowest rate recorded would probably have been satisfactory for the purposes of the present study, since the observer remained at each station for an average of approximately 8-10 minutes. Nevertheless, the possibility exists that occasional cocks with low rates of crowing may have been missed during the census, especially if such cocks produced calls of low volume or audibility. Furthermore, it is possible that in the wild some cocks crow only infrequently at irregular intervals or not at all. Such cocks might be expected to exhibit reduced sexual activity, including territorial crowing. Isolated observations of my own may suggest the presence of such individuals in pheasant populations in central Iowa. On occasions, single cocks were observed which did not call for intervals as long as 25 minutes. The behavior of these birds

during morning crowing activities, in contrast with the bold, aggressive manner of other males, appeared submissive and arrested, some not moving more than approximately 10 feet from the point at which they were originally observed. No hens were ever observed in the presence of such individuals. All, however, appeared alert and able-bodied, and gave no indication of being diseased or in poor health.

Even though the audio-triangulation method made possible the accurate censusing of up to 20 birds per section, the distribution of crowing cocks was occasionally clumped, with as many as eight occurring in a single quarter section. Even with the second observer stationed at the center of the section, accurate determination of the number of cocks present became difficult.

Weaknesses associated with population size occurred in both winter and spring censuses. On the low-population Southern and Middle areas, the spring and winter sex ratios used in computations of spring populations were based on small sample sizes and were therefore subject to potentially greater chance variation than those obtained on the Northern Area and based on much larger samples. Conversely, the spring cock census was probably more accurate on the Middle and Southern Areas because of fewer possibilities for confusing the location of individual calling cocks. Winter censuses, on the other hand, were potentially inaccurate in a different respect. In terms of the total number of birds present on the areas during the census period, these counts were very accurate; however, the actual proportion of the population comprised by each sex was more difficult to determine. On the Northern Area, flocks

of greater than 200 pheasants were occasionally encountered, but to accurately determine the sex of all individuals as they were flushed was not possible. Since, also, sex ratios obtained from smaller groups in which the sexes were easily identifiable were probably not representative of the entire population, other sex ratio information collected during suitable periods in winter and early spring were used to compute the number of individuals of each sex in the population. On the Southern and Middle Areas this problem was less important inasmuch as such large groups were never encountered and the sex of individual pheasants could almost always be determined.

Shortcomings of greater or lesser importance are inherent in all census methods involving small study areas. Despite the weaknesses and failings discussed above, the breeding populations on both the Winnebago and Central Iowa Areas were considered sufficiently representative to serve as reference points for the dynamics of nesting and reproduction.

#### Winter and spring censuses

Results of winter and spring censuses during the 3-year period, 1962-1964, showed that pheasant populations fluctuated noticeably on each of the Central Iowa Areas (Table 7). Hen populations on the Northern and Middle areas fluctuated in phase, first decreasing from 1962 to 1963, then recovering and reaching their highest point in 1964 (Figure 9). The hen population on the Southern Area, in contrast, showed a steady increase during the same period.

Cock populations tended to fluctuate even more widely than hen popu-

Table 7. Pheasant breeding populations on the Central Iowa Areas and Winnebago Area as determined by winter and spring censuses

Area	1962				1963				1964			
	Cocks	Hens	Birds/ sect.	Sex ratio	Cocks	Hens	Birds/ sect.	Sex ratio	Cocks	Hens	Birds/ sect.	Sex ratio
Northern	78	239	79.3	1M:3.1F	53	196	62.3	1M:3.7F	87	320	101.8	1M:3.7F
Middle	28	62	22.5	1M:2.2F	17	44	15.3	1M:2.6F	38	76	28.5	1M:2.0F
Southern	16	23	9.8	1M:1.5F	20	38	14.5	1M:1.9F	20	53	18.3	1M:2.6F
Winnebago	119	285	101.0	1M:2.4F	64	252	79.0	1M:3.9F	40	218	64.5	1M:5.4F

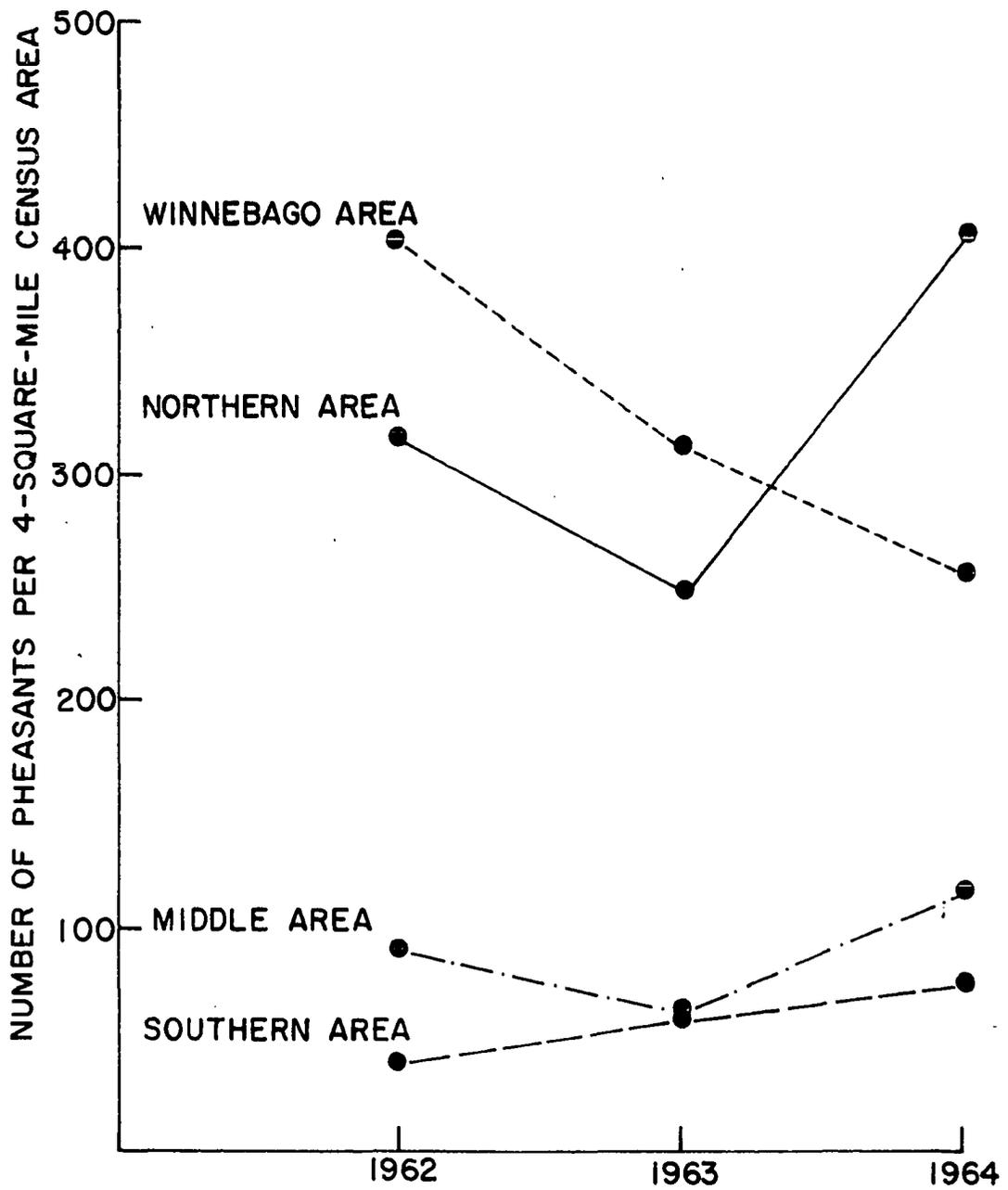


Figure 9. Yearly trends in breeding pheasant populations, Central Iowa Areas (Northern, Middle and Southern) and Winnebago County Area, 1962-1964

lations. Such adjunctive fluctuations by the cock segment of the population over and above that demonstrated by the hen population were due mainly to the degree of success experienced by hunters in the hunting season previous to each census (Figure 10). For example, on the Northern Area the apparently greater distortion in sex ratios in the 1964 breeding population compared to the 1963 breeding population was likely due to the greater numbers of birds and the increased length of the hunting season in 1963. A similar tendency for cock numbers to fluctuate disproportionately in relation to hen numbers was noted on the Southern Area. The proportion of cocks in the breeding population steadily decreased during the 3-year period because fall populations increased each year, thereby making it less difficult for hunters to harvest increasingly greater proportions of the cock population. However, such a tendency on this area may have been only apparent, since the difference in observed sex ratios between any two years was not statistically significant at the .05 probability level as determined by a chi-square analysis. On the Middle Area yearly changes in observed sex ratios could not be directly related to these same factors.

The fluctuations in the total pheasant population tended to closely parallel those exhibited by the hen fraction because hens comprised such a large proportion of the population. The percentage difference between the highest and lowest population was 39 per cent on the Northern Area, 46 per cent on the Middle Area and 47 per cent on the Southern Area (Table 8).

Breeding populations on the Winnebago County Area showed a steady

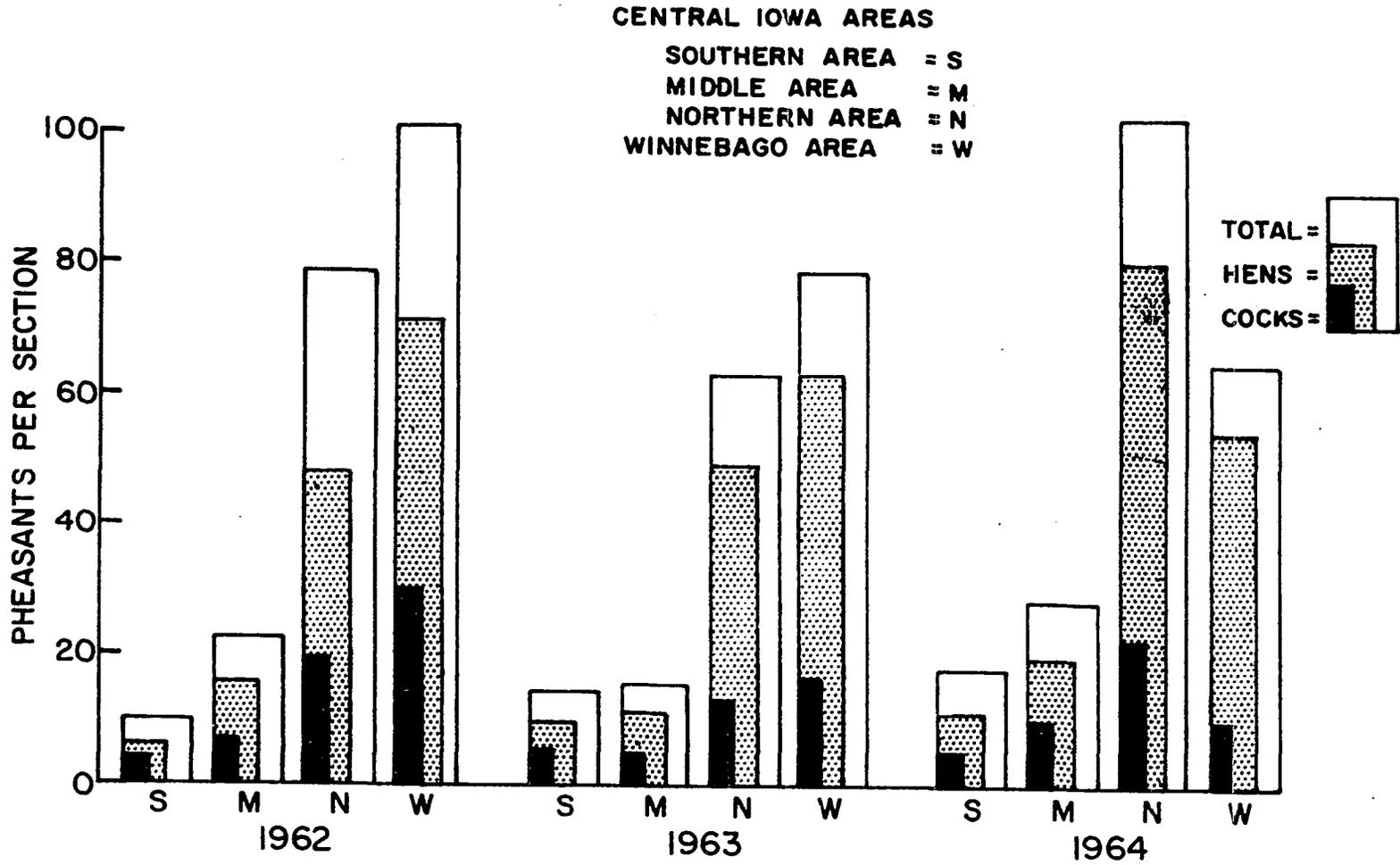


Figure 10. Number of pheasants per section in breeding population on the Central Iowa Areas and Winnebago County Area, 1962-1964

Table 8. Percentage yearly change in pheasant breeding populations on the Central Iowa Areas and the Winnebago Area, 1962-1964

Area	Population in									Percent change from previous year in					
	1962			1963			1964			1963			1964		
	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total
Northern	78	239	317	53	196	249	87	320	407	-32	-18	-22	+64	+63	+63
Middle	28	62	90	17	44	61	38	76	114	-39	-29	-32	+124	+73	+87
Southern	16	23	39	20	38	58	20	53	73	+25	+65	+33	0	+40	+26
Winnebago	119	285	404	64	252	316	40	218	258	-46	-12	-22	-38	-14	-18

decrease during the 3-year period. The drop in numbers on this area in 1963 approximated proportionately the corresponding decreases on the more southerly Northern and Middle Areas. In 1964, however, a rapid recovery similar to that exhibited by these populations did not materialize. The probable principal cause of the failure of such a recovery was the occurrence of successive hail storms in early July and August of 1963 which thoroughly shredded standing corn, destroyed nesting habitat and undoubtedly resulted in the failure of most pheasant renesting attempts. (A more thorough discussion of this incident will occur in a later appropriate section on page 130) The per cent decrease in the total population during the 3-year period was 36 per cent and in the hen population, 27 per cent.

As was true on the Central Iowa Areas, the yearly sex ratios obtained on the Winnebago Area reflected the success of hunters during the previous hunting season (Table 7). The sex ratio of 1 cock to 4.2 hens in 1964 was the most distorted sex ratio figure ever recorded in the 30 years of investigations on this area. That year the Iowa Conservation Commission reported excellent fall pheasant populations in the entire northcentral Iowa region, thereby encouraging larger numbers of hunters than usual to concentrate in this area. Within this general region, however, were small isolated areas, including the Winnebago Area, which were heavily hit by hail. At the opening of the pheasant season these areas undoubtedly supported poorer populations than surrounding areas. Most hunters, nonetheless, were unaware of these population differences and this probably resulted in hunters in such hail areas harvesting a greater

proportion of the cock population, even though their rate of success was probably poorer.

### Nesting and Production of Young

#### Accuracy of nest census

When compared to nests of some other ground-nesting species of birds, ring-necked pheasant nests are usually not particularly well-hidden; yet in any pheasant nesting study in which a total nest census is desired, this goal is probably seldom achieved. Even under what would be considered optimal conditions for a complete nest count, such inherent human traits as carelessness and lapses in attentiveness preclude the possibility of a completely thorough nest search. In addition, individual nest searchers vary in power of visual acuity as well as in the characteristics already mentioned, so that the probability was small of securing each year counts which were comparable. Furthermore, in heavy vegetation such as occurs in some roadside ditches and waste areas, it was impossible to locate all nests with the use of known methods. Thus, though some degree of error can be assumed, the magnitude of this error undoubtedly varied from year to year, depending upon changes in personnel, density of nesting cover and phenology of nest searching activities. The percent error which incurred in each year of the nesting study was estimated for each type of nesting cover (Table 9). Such estimates were based solely on the investigator's personal field experience and his interpretation of the importance of yearly differences in both the density of nesting cover and the thoroughness of the search permitted by the

Table 9. Estimated error in the nest census expressed as the per cent of pheasant nests not found<sup>a</sup>

Cover type	Year		
	1962	1963	1964
Hay	10	10	10
Oats	20	20	20
Roadside	20	35	30
Pasture	25	15	15
Waste areas	20	35	30

<sup>a</sup>Estimates based on experience and personal evaluation of efficiency of personnel.

number and ability of personnel.

The basis for these error estimates is the assumption that both successful and unsuccessful nests had equal probability of being overlooked. Within the unsuccessful category, certain types of nests were less likely to be missed than others. Nests destroyed by predators, for example, were among those most easily found. Egg shells and membranes were usually scattered about the nest site and the vegetation in the immediate vicinity was often flattened. Similarly, nests destroyed by farm machinery were not likely to be overlooked, even though the number of eggs in such nests was often difficult to determine. Frequently, eggs in these nests were crushed and shattered and consequently individually indiscernible. In addition, nests destroyed in hay and oats as a result of mowing and combining were particularly susceptible to pilfering

by predators once the fields had been raked or windrowed and the nests left exposed. It was rare, however, for all eggs in such nests to be carried off, thereby leaving no indication of the presence of the nest. The computations used in deriving the total number of successful eggs and chicks, however, were based only on those nests for which the size of the clutch could be determined, so that inexact counts of eggs in these nests was not overly important. Occasionally, however, entire clutches were known to disappear. Although the agents responsible were not positively identified, thirteen-lined ground squirrels (Citellus tridecemlineatus) and bull snakes (Pituophis melanoleucus) were suspected. Since the complete disappearance of a few clutches of eggs under investigation occurred, it is reasonable to assume that a certain percentage of unsuccessful nests had vanished and left no trace of their presence prior to the time the plot had been checked. Potentially, this type of error was considerably more important than that concerned with inexact counts of clutches, since the computations used in the estimation of chick production were based directly on the number of nests found. Actually, however, nests not located for this reason were probably few, and thus the degree of error attributable to this type of nest destruction was probably small and of little importance.

Nests classified as deserted or abandoned were the types of unsuccessful nests most likely to be missed during nest searching, especially those located in dense, undisturbed vegetation in roadsides and waste areas. In many cases, vegetation had fallen over the nest bowl, and the eggs had become darkened and soiled from settling dust and moisture.

As was true for unsuccessful nests, some successful nests were more apt to be found than other such nests. Those hatched in hayfields and oatfields and later exposed after removal of hay and straw were as easily found as destroyed or deserted and abandoned nests similarly situated. Successful nests in roadsides, waste areas and more rarely in pasture, however, could have been easily overlooked for the same reasons as deserted and abandoned nests located in these same cover types may have been overlooked.

In summary, probabilities of discovery of successful or unsuccessful nests disproportionate to their true occurrence, were unlikely. The possibility of any nest being found, therefore, appeared to be determined almost entirely by its particular location within cover types, not by its fate.

#### Reliability of sampling procedure

The three Central Iowa Research Areas, as originally established (Bolstad 1962) consisted of 2 sections each, or a combined total of 6 sections. To thoroughly search all potential nesting cover on each area was not possible. Cover types used for nesting such as hay, roadsides and waste areas could often be searched completely, but oats could not, because of the large acreage devoted to this cover type and the slow pace often required to thoroughly check particular plots. Had the newly-seeded hay crop for which the oats served as a nurse crop not grown so rapidly, there would have been ample time to make a complete search of this type. Also, the relatively long distance between the two northern-

most areas and the Southern Area caused a loss of time which potentially could have been spent in nest searching.

The thin rectangular shape and small size of each area presented unique problems in relating winter and spring population estimates to nesting populations. The tendency for pheasants to concentrate during periods of adverse winter weather made possible accurate censusing of populations. However, the type of coverts used by pheasants during these periods were relatively scarce and often widely separated so that birds had to move as much as 1 to 2 miles to cover during winter storms. The range of individual pheasants probably tends to be somewhat circular or irregular. The normal daily range of pheasants therefore would more often overlap the boundaries of a thin rectangular area than one of the same acreage but more square and with proportionately less perimeter. Thus, the probability for resident birds not to be counted would be greater on such areas of linear shape simply because of their chance absence during the census. Compounding this problem was the occasional occurrence of large concentrations of up to 200 pheasants on the edges of the census areas. It was known that a certain percentage of these birds were not resident birds, but it was assumed that an equal number of resident birds had left the area. That some resident birds left and subsequently returned to the area was later confirmed by sightings of tagged birds, but whether or not the net gain and loss in pheasant numbers was proportionate could not be verified. Some of these same factors operated during spring counts of crowing cocks; however, since pheasants are more evenly distributed during spring than in winter and

their movements are more local and restricted, inaccuracies due to the described possibilities for error were less important.

For the above reasons, in 1962, the year the most assistance was available for nest searching, the decision was made to enlarge the nest study area on each of the Central Iowa Areas to the 4 sections originally designated as the census area, thereby hoping to reduce the potential error which could occur due to the particular shape and small size of each area. In 1963 and 1964, however, funds providing for personnel to aid in nest searching were limited, the number of summer assistants being reduced to one in 1964 and none in 1963. Therefore, the area included in the nesting study had to be reduced again on each of the Central Iowa Areas to the original two-section area.

Because of the circumstances described, statistical justification for the design and procedure is not intended; therefore, no probability statements concerning population information is proposed. Although the absence of statistical support of the design limits the certainty of some of these statements, still, much meaningful information can be obtained. Moreover, correlative support is available for some of the data, and consequently the likeliness of its accuracy need not be based solely on its own weight.

Measurements concerned with some aspect of pheasant reproduction such as percentage of nests successful, clutch size, nest density and nesting hen mortality can probably be regarded as representative on the Northern Area, but because of small samples corresponding measurements obtained on the Middle and Southern Area must be considered less reliable.

and thus comparisons of these figures among areas should be made with caution. The computed estimates of chick production, conversely, are perhaps the figures least dependable, but even these appear to be largely substantiated by additional supporting evidence. Thus, the sampling design and procedure used, despite its weaknesses was considered to be the best method available at the outset of the nesting study to obtain the most reliable and useful information possible. Although the lack of statistical backing weakens the strength of some of these data, information from other sources seem to verify the accuracy of the data and make conclusions based upon them less subject to error.

#### Location and success of nests

Hayfields on the Central Iowa Areas were composed mainly of alfalfa and red clover, but most fields contained varying amounts of either orchard grass (Dactylis glomerata), bromegrass or timothy (Phleum pratense). Alfalfa and red clover sometimes were present in pure stands, but it was more common for these types to occur in combination. Alfalfa-red clover was the most common mixture but all possible combinations of the above species could be found. In some fields all species occurred together in approximately equal proportions so that it was not possible to determine a single dominant species. Although there appeared to be some tendency for farmers to cut alfalfa mixtures at earlier dates than red clover or red clover mixtures, the date of mowing seemed to be governed more by the traditional habits of individual farmers and the weather conditions during the mowing period rather than by the rate of growth and time of maturity of particular hay types. In any event, the greatest number of

successful nests found in hay during the 3-year period on any single area (16 on the Northern Area) was too small to permit the determination of the relative contribution of the various pure stands and mixtures to the total hatch. For the same reason it was not possible to determine the relationship each year of nest success to date of mowing.

During the three nesting seasons, 260 nests were found on the three Central Iowa Areas; 192 on the Northern Area, 36 on the Middle Area and 32 on the Southern Area (Tables 10, 11 and 12). These nests contained 2245 eggs. Further information concerning the projected number of nests, the density and success of nests and the relative importance of each cover type for nesting is given in Tables 13 through 16. Although important differences in nesting were apparent each year on the study areas, yearly data for each area were combined to give an inclusive picture of nesting during the 3-year period.

Approximately 82 per cent of the nests from all three study areas were estimated to have been located in areas considered as agricultural. Hay and oats contained an average of 37 per cent and 42 per cent of the total nests, respectively, during the 3 years, and pasture accounted for 2 per cent. The remaining percentage of nests occurred in roadsides (14%) and waste areas (4%).

#### Hay

Central Iowa Areas, 1962-1964 During the 3 years, 45 per cent of all nests on the Northern Area were established in hayfields (Table 13); thus, this type apparently provided the most attractive sites for nesting. However, due to the usually high rate of destruction of

Table 10. Nests and eggs found in nest plots on the Central Iowa Areas, 1962

Cover type	Nests				Eggs			
	No. un- success- ful	No. success- ful	Total	Per cent success- ful	No. un- success- ful	No. success- ful	Total	Per cent success- ful
Northern Area								
Hay	21	6	27	22	165	52	217	24
Oats	4	2	6	33	35	16	51	31
Roadside	1	1	2	50	14	12	26	46
Pasture	3	2	5	40	28	16	44	36
Waste areas	2	0	2	0	18	0	18	0
Total	31	11	42		260	96	356	
Mean				26				27
Middle Area								
Hay	2	1	3	33	19	8	27	42
Oats	1	1	2	50	9	11	20	55
Roadside	1	0	1	0	9	0	9	0
Pasture	0	0	0	0	0	0	0	0
Waste areas	0	0	0	0	0	0	0	0
Total	4	2	6		37	19	56	
Mean				33				34
Southern Area								
Hay	2	2	4	50	12	20	32	62
Oats	0	1	1	100	6	2	8	25
Roadside	1	2	3	66	14	25	39	64
Pasture	0	0	0	0	0	0	0	0
Waste areas	0	0	0	0	0	0	0	0
Total	3	5	8		32	47	79	
Mean				62				60

Table 11. Nests and eggs found in nest plots on the Central Iowa Areas, 1963

Cover type	Nests				Eggs			
	No. un- success- ful	No. success- ful	Total	Per cent success- ful	No. un- success- ful	No. success- ful	Total	Per cent success- ful
Northern Area								
Hay	26	4	30	13	199	32	231	13
Oats	8	3	11	27	70	24	94	25
Roadside	7	2	9	22	77	19	96	20
Pasture	0	0	0	0	0	0	0	0
Waste areas	2	1	3	33	19	11	30	36
Total	43	10	53		365	86	451	
Mean				19				19
Middle Area								
Hay	6	2	8	25	42	19	61	31
Oats	3	1	4	25	24	8	32	25
Roadside	2	1	3	33	17	11	28	39
Pasture	0	0	0	0	0	0	0	0
Waste areas	2	0	2	0	19	0	19	0
Total	13	4	17		102	38	140	
Mean				23				27
Southern Area								
Hay	4	0	4	0	30	0	30	0
Oats	2	1	3	33	9	8	17	47
Roadside	3	1	4	25	20	11	31	36
Pasture	1	0	1	0	13	0	13	0
Waste area	0	0	0	0	0	0	0	0
Total	10	2	12		72	19	91	
Mean				17				21

Table 12. Nests and eggs found in nest plots on the Central Iowa Areas, 1964

Cover type	Nests				Eggs			
	No. un- success- ful	No. success- ful	Total	Per cent success- ful	No. un- success- ful	No. success- ful	Total	Per cent success- ful
Northern Area								
Hay	66	6	72	8	519	73	592	12
Oats	4	3	7	43	30	32	62	52
Roadside	11	4	15	27	105	44	149	30
Pastures	0	0	0	0	0	0	0	0
Waste areas	2	1	3	33	20	9	29	31
Total	83	14	97		674	145	819	
Mean				14				18
Middle Area								
Hay	5	1	6	17	37	8	45	18
Oats	1	1	2	50	13	8	21	38
Roadside	4	1	5	20	29	8	37	22
Pasture	0	0	0	0	0	0	0	0
Waste areas	1	1	2	50	12	6	18	33
Total	11	4	15		91	30	121	
Mean				27				25
Southern Area								
Hay	3	3	6	50	25	38	63	60
Oats	1	0	1	0	11	0	11	0
Roadside	4	3	7	43	41	17	58	29
Pasture	0	0	0	0	0	0	0	0
Total	8	6	14		77	55	132	
Mean				43				42

Table 13. Estimated number of nests on 2 square miles of each of the Centri

Cover type	Calculated <sup>a</sup> number of nests	Acres per nest	Nests per 100 acres	Per cent of all nests	Per cent of nests successf
					Northern
Hay	173.3	2.5	40.0	45	14
Oats	144.1	5.5	18.2	37	31
Roadside	40.3	1.5	66.7	11	28
Pasture	13.4	17.7	5.7	4	40
Waste areas	13.9	2.7	37.0	4	39
Total	385.0				
Mean		4.0	25.0		23.6
					Middle
Hay	22.3	15.5	6.5	20	25
Oats	69.8	10.7	9.4	61	35
Roadside	15.0	3.9	25.6	13	18
Pasture	0.0	0.0	0.0	0	0
Waste areas	6.8	3.3	30.3	6	22
Total	113.9				
Mean		12.0	8.3		31
					Southern
Hay	24.4	17.9	5.6	27	29
Oats	33.9	17.8	5.6	38	26
Roadside	29.8	2.6	38.5	33	37
Pasture	1.2	159.7	0.6	1	0
Total	89.3				
Mean		14.7	6.8		33

<sup>a</sup>Proportion of nests attributable to 1962 reduced to basis of 2 square

les of each of the Central Iowa Areas, 1962-1964

Per cent of all nests	Per cent of nests successful	Calculated <sup>a</sup> no. of successful nests	Acres per successful nest	Successful nests per 100 acres	Per all ful
Northern Area					
45	14	24.4	17.8	5.6	2
37	31	44.3	17.3	5.8	4
11	28	11.3	5.5	18.2	1
4	40	5.4	43.9	2.3	
4	39	5.4	7.0	14.3	
		90.8			
	23.6		17.1	5.9	
Middle Area					
20	25	5.5	62.9	1.6	1
61	35	24.5	30.5	3.3	7
13	18	2.8	20.7	4.8	
0	0	0.0	0.0	0.0	
6	22	1.5	14.8	6.8	
		34.3			
	31		38.1	2.6	
Southern Area					
27	29	7.9	55.4	1.8	2
38	26	8.7	69.4	1.4	3
33	37	12.4	6.3	15.9	4
1	0	0.0	0.0	0.0	
		29.0			
	33		45.2	2.2	

ced to basis of 2 square miles to allow comparison with other 2 years.

, 1962-1964

ated <sup>a</sup> success- nests	Acres per successful nest	Successful nests per 100 acres	Per cent of all success- ful nests
.4	17.8	5.6	27
.3	17.3	5.8	49
.3	5.5	18.2	12
.4	43.9	2.3	6
.4	7.0	14.3	6
.8	17.1	5.9	
.5	62.9	1.6	16
.5	30.5	3.3	71
.8	20.7	4.8	8
.0	0.0	0.0	0
.5	14.8	6.8	4
.3	38.1	2.6	
.9	55.4	1.8	27
.7	69.4	1.4	30
.4	6.3	15.9	43
.0	0.0	0.0	0
.0	45.2	2.2	

low comparison with other 2 years.

Table 14. Estimated number of nests on 4 square miles of each of the Central Iowa

Cover type	Sam- pling rate	No. nests found	Estimated percentage nests not found	Calcu- lated no. nests	Acres per nest	Nests per 100 acres	Per cent of all nests
Northern Area							
Hay	1/4.0	27	10	120.0	2.2	45.5	60
Oats	1/4.5	6	20	33.8	14.9	6.7	17
Roadside	1/4.0	2	20	10.0	4.1	24.4	5
Pasture	1/4.0	5	25	26.7	7.5	13.3	13
Waste	1/4.0	2	20	10.0	3.8	26.3	5
areas							
Total	--	42	--	200.5 (100.3) <sup>a</sup>			
Mean					5.2	19.2	
Middle Area							
Hay	1/4.0	3	10	13.3	16.4	6.0	43
Oats	1/5.2	2	20	13.0	40.8	2.5	42
Roadside	1/4.0	1	20	5.0	7.8	12.8	16
Pasture	1/4.0	0	25	0.0	0.0	0.0	0
Waste	1/4.0	0	20	0.0	0.0	0.0	0
areas							
Total	--	6	--	31.3 (6.1) <sup>a</sup>			
Mean					29.2	3.4	
Southern Area							
Hay	1/4.0	4	10	17.8	18.7	5.3	48
Oats	1/3.6	1	20	4.5	108.4	0.9	12
Roadside	1/4.0	3	20	15.0	15.8	6.3	40
Pasture	1/4.0	0	25	0.0	0.0	0.0	0
Total	--	8	--	37.3 (18.7) <sup>a</sup>			
Mean					27.1	3.7	

<sup>a</sup>Reduced to a basis of 2 square miles to allow direct comparison with other 2

Central Iowa Areas, 1962

Per cent of all nests	Per cent nests successful	Calculated no. successful nests	Acres per successful nest	Successful nests per 100 acres	Per cent of all successful nests
Northern Area					
60	22	26.6	10.4	9.8	50
17	33	11.2	45.0	2.0	21
5	50	5.0	8.2	12.2	9
13	40	10.7	18.7	5.3	20
5	0	0.0	0.0	0.0	0
		53.5 (26.8) <sup>a</sup>			
	27		19.5	5.1	
Middle Area					
43	33	4.4	52.1	1.9	42
42	50	6.5	93.1	1.1	58
16	0	0.0	0.0	0.0	0
0	0	0.0	0.0	0.0	0
0	0	0.0	0.0	0.0	0
		10.9 (5.5) <sup>a</sup>			
	35		83.9	1.2	
Southern Area					
48	50	8.9	37.3	2.7	38
12	100	4.5	108.4	0.9	19
40	67	10.0	5.2	19.2	43
0	0	0.0	0.0	0.0	0
		23.4 (11.7) <sup>a</sup>			
	63		43.2	2.3	

with other 2 years.

Table 15. Estimated number of nests on 2 square miles of each of the Central Iowa Area

Cover type	Sam- pling rate	No. nests found	Estimated percentage nests not found	Calcu- lated no. nests	Acres per nest	Nests per 100 acres	Per cent of all nests
Northern Area							
Hay	1/1	30	10	33.3	4.2	23.8	22
Oats	1/7.4	11	20	101.8	2.7	37.0	66
Roadside	1/1	9	35	13.9	1.5	66.7	9
Pasture	1/1	0	15	0.0	0.0	0.0	0
Waste areas	1/1	3	35	4.6	2.2	45.5	3
Total	--	53	--	153.6			
Mean					3.3	30.3	
Middle Area							
Hay	1/1	8	10	8.9	13.1	7.6	15
Oats	1/8.4	4	20	42.0	3.9	2.6	70
Roadside	1/1	3	35	5.4	3.6	2.8	9
Pasture	1/2	0	15	0.0	0.0	0.0	0
Waste areas	1/1	2	35	3.9	11.8	8.5	6
Total	--	17	--	60.2			
Mean					6.6	15.2	
Southern Area							
Hay	1/2	4	10	8.8	17.6	5.7	21
Oats	1/5.1	3	20	19.1	10.1	9.9	46
Roadside	1/2	4	35	12.3	2.2	45.4	30
Pasture	1/1	1	15	1.2	57.8	1.7	3
Total	--	12	--	41.4			
Mean					10.7	9.4	

ral Iowa Areas, 1963

sts er 0 res	Per cent of all nests	Per cent of nests success- ful	Calculated no. of successful nests	Acres per success- ful nest	Success- ful nests per 100 acres	Per cent of all success- ful nests
<b>Northern Area</b>						
.8	22	13	4.4	3.2	3.1	12
.0	66	27	27.8	9.7	10.3	76
.7	9	22	3.1	6.7	14.9	8
.0	0	0	0.0	0.0	0.0	0
.5	3	33	1.5	6.7	14.9	4
			36.8			
.3		24		13.9	7.2	
<b>Middle Area</b>						
.6	15	25	2.2	55.6	1.8	15
.6	70	25	10.5	16.7	6.0	72
.8	9	33	1.8	11.3	8.9	12
.0	0	0	0.0	0.0	0.0	0
.5	6	0	0.0	0.0	0.0	0
			14.5			
.2		24		27.2	3.7	
<b>Southern Area</b>						
.7	21	0	0.0	0.0	0.0	0
.9	46	33	6.4	33.3	3.0	67
.4	30	25	3.1	10.4	9.6	33
.7	3	0	0.0	0.0	0.0	0
			9.5			
.4		23		46.8	2.1	

Table 16. Estimated number of nests on 2 square miles of each of the Central Iowa Area

Cover type	Sampling rate	Number nests found	Percentage error estimate	Calculated number of nests	Acres per nest	Nests per 100 acres	Per cent of all nests
Northern Area							
Hay	1/1	72	10	80.0	21	47.6	61
Oats	1/2.9	7	20	25.4	10.4	9.6	19
Roadside	1/1	15	30	21.4	1.0	100.0	16
Pasture	1/1	0	15	0.0	0.0	0.0	0
Waste areas	1/1	3	30	4.3	2.5	40.0	3
Total	--	97	--	131.1			
Mean					4.0	4.7	
Middle Area							
Hay	1/1	6	10	6.7	17.9	5.6	18
Oats	1/8.5	2	20	21.3	15.1	6.6	56
Roadside	1/1	5	30	7.1	2.7	3.8	19
Pasture	1/1	0	15	0.0	0.0	0.0	0
Waste areas	1/1	2	30	2.9	5.1	19.6	7
Total	--	15	--	38.0			
Mean					14.8	6.8	
Southern Area							
Hay	1/1	6	10	6.7	17.4	5.8	23
Oats	1/8.2	1	20	12.5	13.4	7.5	43
Roadside	1/1	7	30	10.0	2.6	38.5	34
Pasture	1/1	0	15	0.0	0.0	0.0	0
Total	--	14	--	29.2			
Mean					12.7	7.9	

Central Iowa Areas, 1964

Nests per 100 acres	Per cent of all nests	Per cent of all nests successful	Calculated number of successful nests	Acres per successful nest	Successful nests per 100 acres	Per cent of all successful nests
Northern Area						
47.6	61	8	6.7	24.4	4.1	27
9.6	19	43	10.9	24.2	4.1	44
100.0	16	27	5.7	3.6	27.8	23
0.0	0	0	0.0	0.0	0.0	0
40.0	3	33	1.4	7.7	13.0	6
			24.7			
4.7		19		21.2	4.7	
Middle Area						
5.6	18	17	1.1	108.7	0.9	8
6.6	56	50	10.7	30.0	3.3	73
3.8	19	20	1.4	11.1	9.0	10
0.0	0	0	0.0	0.0	0.0	0
19.6	7	50	1.5	9.8	10.3	10
			14.7			
6.8		40		37.1	2.7	
Southern Area						
5.8	23	50	3.4	34.3	2.9	44
7.5	43	0	0.0	0.0	0.0	0
38.5	34	43	4.3	6.1	16.4	56
0.0	0	0	0.0	0.0	0.0	0
			7.7			
7.9		26		48.3	2.1	

nests in this type, only 14 per cent of these nests were successful and only 27 per cent of all successful nests occurred in hay. Similarly, during the 3 years 20 per cent of the nests on the Middle Area and 27 per cent of the nests on the Southern Area occurred in hay, with an average rate of success of 25 per cent and 29 per cent, respectively (Tables 13 and 17). Sixteen per cent of all successful nests were in hay on the Middle Area, but on the Southern Area 27 per cent were in this type.

Bolstad (1962) initiated a nesting study on the Central Iowa Areas in 1960, and Wright and Otte (1962) continued these investigations in 1961. The per cent of nests successful and the percentage of all nests in hay recorded in these studies are presented in Table 17 along with similar data from the present study. The apparently greater range in nest success on the Middle and Southern Areas can probably be attributed to the small samples of nests studied.

Comparison of Central Iowa Areas and the Winnebago Area

Baskett (1947) reported that approximately 22 per cent of the nests established in hay during the period 1939-1941 on the Winnebago County Area were successful (Table 17). This percentage, however, included nests found in native grasses and herbaceous vegetation in meadows and roadside ditches, and in fields of canary grass, all types which were usually mowed much later than the legumes and legume-grass mixtures presently used. When the nests found in these types were excluded from this classification, the success was only 11 per cent. Klonglan (1955b) found only 4 per cent of 69 nests successful on the Winnebago Area in 1954 and only 6 per cent, or eight of 137 nests, were successful on this

Table 17. Comparison of nest success and percentage of nests in hay on the Central Iowa Areas and the Winnebago Area

Source	Period of study	Area	Number nests in hay	Per cent of nests successful	Per cent of all nests
Bolstad (1962)	1960	Central Iowa			
		Northern	24	8	58
		Middle	10	50	71
		Southern	7	29	78
Wright and Otte (1962)	1961	Central Iowa			
		Northern	30	13	49
		Middle	16	38	62
		Southern	6	33	67
This study	1962-1964	Central Iowa			
		Northern	129	14	45
		Middle	17	25	20
		Southern	14	30	27
Baskett (1947)	1939-1941	Winnebago	296	22	56
Klonglan (1955b)	1951-1953	Winnebago	137	6	--
	1954	Winnebago	69	4	55

same area during 1951, 1952 and 1953. Thus, it is apparent that the range in success of nests in hay encountered on the Central Iowa Areas during the three years of the present study was about the same as that reported earlier for the Winnebago Area, especially on the Northern Area where the sample of nests in this type was larger and more meaningful.

In 1962-1964 approximately the same percentage of nests on the Northern Area were established in hayfields as reported by Baskett (1947) and Klonglan (1955b) for the Winnebago Area. Both Baskett and Klonglan

included under the classification of hay roadside ditches which were mowed. However, if nests in such roadside ditches are excluded from the hay category, the per cent of all nests found in hay drops to 43 per cent during the period 1939-1940, and 46 per cent in 1954. The lower proportion of nests in hay on the Middle and Southern Areas compared to the Northern Area and Winnebago Area may reflect the greater relative importance of the other nesting types; however, the small sample of nests from these areas again limits the usefulness of this data.

Comparison of Central Iowa Areas with other areas within the pheasant range The success of nests in hay reported in other studies shows extreme variation, with a range in success of 4 per cent (Linder et al. 1960) to 82 per cent (Wight 1949); however, nest success figures from most of these studies fall within a more restricted range. Representative nest success percentages from these studies are presented in Table 18. The success of nests in hay reported in the present study is therefore fairly typical, judged by that encountered in other studies.

Yearly changes in importance of hay for nesting, Central Iowa Areas On the Northern Area the success of nests in hay decreased each year during the 3-year period (Tables 10, 11 and 12), but the reason for this was not readily apparent. In the spring of 1962 mowing began in late May, but not all hayfields had been cut for the first time until late June (Table 19 and Figure 11), so that the high rate of success recorded that year in this type was anticipated. In 1963, even though the average date of mowing was only 4 days earlier than in 1962, the range in mowing dates was greatly contracted; mowing started on June 5

Table 18. Per cent success of nests in hay on pheasant study areas

Source	Locality	Number nests in hay	Per cent of nests successful
Linder <u>et al.</u> (1960)	Southcentral Nebraska	171	4
Klonglan (1955b)	Northcentral Iowa	206	5
Hamerstrom (1936)	Northwest Iowa	111	14
Baskett (1947)	Northcentral Iowa	296	22
Stokes (1954)	Pelee Island, Ont.	1842	25
Randall (1940)	Eastern Pennsylvania	182	27
Leopold (1937)	Southern Wisconsin	42	43
Eklund (1942)	Oregon	95	46
Knott <u>et al.</u> (1943)	Washington	55	52
Strode and Leedy (1940)	Ohio	358	72
Wight (1949)	Eastern Pennsylvania	?	82

and was completed in 12 days, ending on June 17. Thus, the reduced success observed in this type compared to 1962 was probably explainable on this basis, since almost 2 weeks less time was available for nests to reach hatching. However, the still lower rate of success of nests in hay in the spring of 1964 compared to 1963 is not as easily explained. The phenology of mowing was very similar to that in 1962. Mowing commenced on June 1 but was not finished until June 27, and yet success in hayfields mowed at these dates in late June appeared to be as low as that of nests in hayfields mowed much earlier. Although the reason for this was not clear, two possibilities were most likely; the establishment of first nests occurred at a later date than usual, or a greater proportion of the nests were re-nesting attempts, particularly in those fields cut later in the mowing period, since more time was available for hens to be attracted to these fields before their nests were ultimately

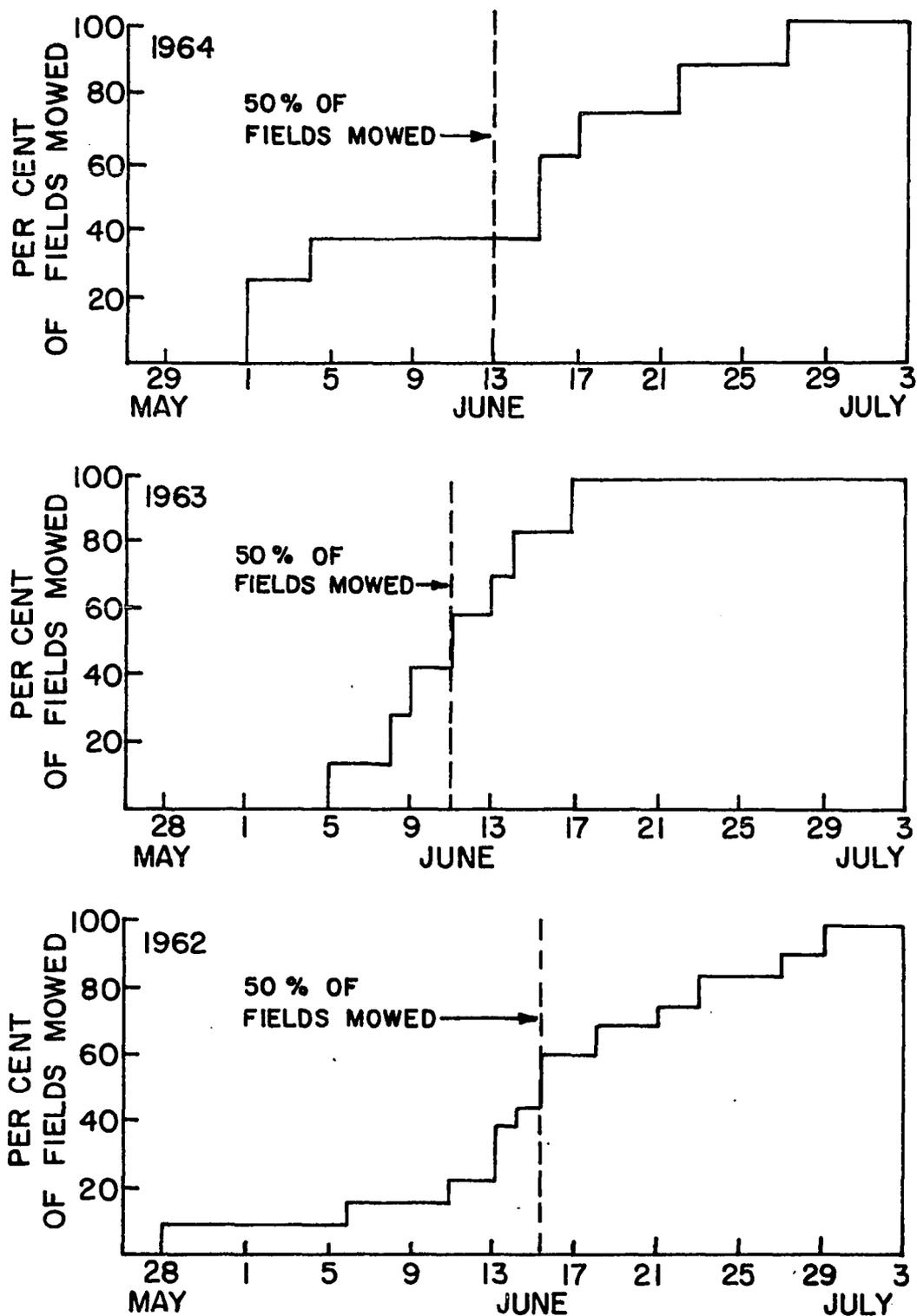


Figure 11. Comparison of phenology of mowing for first crop of hay, Northern Area, 1962-1964 (based on number of fields, not acreage)

Table 19. Comparison of mowing dates for the first cutting of hay on the Northern Area expressed as cumulative percentage of the total fields mowed

Date of mowing	Year		
	1962	1963	1964
May 28	7.7		
29			
30			
June 1			25.0
2			
3			
4			37.5
5		14.3	
6	15.4		
7			
8		28.6	
9		42.9	
10			
11	23.1	57.1	
12			
13	38.5	71.4	
14	46.1	85.7	
15	61.5		62.5
16			
17		100.0	75.0
18	69.2		
19			
20			
21	76.9		
22			87.5
23	84.6		
24			
25			
26			
27	92.3		100.0
28			
29	100.0		

destroyed by mowing. However, even though the first of these explanations cannot be entirely disregarded, there were no apparent factors (such as retardation in the phenology of growth of nesting cover, for example) that could be isolated to account for such a late period of establishment of first nests, but conversely, higher rates of nest destruction in other cover types or abnormal or adverse weather conditions, both which could have caused renesting, were also undemonstrable. Still, this last explanation seemed the most probable even though evidence supporting it is lacking. There is the possibility, too, that a larger proportion of nests in hay were destroyed or deserted prior to mowing in 1962 than in 1964, but again, there was no evidence that such had occurred.

The apparent differences in time and duration of mowing among the 3 years can be explained on the basis of weather conditions which prevailed during late May through mid-June. In 1962 and 1964, the years in which the duration of the mowing period was considerably more protracted than in 1963, heavy and extensive rains of over 3 inches in late May and early June delayed and extended the hay-mowing period, even though early spring weather conditions had resulted in early and rapid crop growth up to this time. Heavy rains of over 2 inches in late May and of greater than 3 inches in some central Iowa areas during the second and third weeks of June similarly retarded the progression of mowing in 1964. In 1963, however, despite the apparent slower growth of hay compared to 1964, precipitation for late May and June was much below normal, permitting an early start and rapid completion of mowing.

On the Middle Area, a similar trend in decreasing success of nests in hay was noted during the 3 years, but no comparable trend was

recorded on the Southern Area (Tables 10, 11 and 12).

The proportion of nests in hay fluctuated widely from year to year on all Central Iowa Areas. On the Northern Area the per cent of all nests in hay decreased substantially in 1963 from 1962, and then recovered in 1964. On the Middle and Southern areas, however, the pattern of fluctuation was somewhat different, showing the same magnitude of decrease in 1963 from 1962, but then failing to demonstrate the prompt recovery in 1964. Nevertheless, the decrease in success in 1963 apparently occurred on all three Central Iowa Areas, reflecting the increased importance of the other cover types for nesting. This subject will be discussed in more detail on page 90 in the following section.

Oats The only type of small grain grown on the Central Iowa Areas during the 3 years was oats. In past years this crop has provided a relatively large cash income for farmers in this area, but in modern times with the increased importance of corn as a cash crop, its survival and continued use in modern agricultural cropping systems is due primarily to its value as a nurse crop for alfalfa, red clover and other types of hays. Other small grains such as winter and spring wheat, rye and barley have been grown in small acreages in the past (Meldrum et al. 1941), but now are rarely found in central Iowa.

Central Iowa Areas, 1962-1964 During the 3 years of the study, 37 per cent of all nests on the Northern Area were established in oats (Table 13) and thus, oats was the type of cover favored second to hay for nesting. In addition, these nests consistently exhibited the highest rate of success (average of 31 per cent), so that during the 3-

year period over 50 per cent of all successful nests occurred in this type. Similarly, during this same period 61 per cent of the nests on the Middle Area and 38 per cent on the Southern Area were estimated to have been established in oats, with an average rate of success of 35 per cent and 25 per cent, respectively (Tables 13 and 17). The greater range in success recorded on these latter areas can again probably be attributed to the smaller number of nests found.

The per cent of nests successful and the percentage of the total nests in oats reported by Bolstad (1962) and Wright and Otte (1962) are compared in Table 20 with the present study along with those of Baskett (1947) and Klonglan (1955b).

Comparison of Central Iowa Areas and the Winnebago Area

Baskett (1947) reported that approximately 46 per cent of the nests found in oats on the Winnebago Area in 1939, 1940 and 1941 were successful (Table 20). The average rate of nest success in oats on this area for the period 1951-1956, excluding 1954, was 54 per cent (Klonglan 1962). Within this interval Klonglan (1955b), reported only 19 per cent of the nests in this type successful in 1954, but he attributed this to an abnormally late freeze in early May which injured the oat crop, delaying nesting to such an extent that destruction of nests due to the harvest of oats was unusually high. The range in nest success recorded for the Northern Area during the period 1960-1964 was therefore well within the range of success of nests in oats reported earlier for the Winnebago Area.

A comparison of the range in the percentage of hatched nests in oats on the Northern and Winnebago areas revealed a similar proportion of nests occurring in oats on the Northern Area as had occurred in the

Table 20. Comparison of nest success and percentage of nests in oats on the Central Iowa Areas and the Winnebago Area

Source	Period of study	Study area	Number nests	Per cent of nests successful	Per cent of all nests
Bolstad (1962)	1960	Central Iowa			
		Northern	5	40	12
		Middle	3	33	21
		Southern	1	0	11
Wright and Otte (1962)	1961	Central Iowa			
		Northern	13	54	21
		Middle	6	0	26
		Southern	0	0	0
This study	1962-1964	Central Iowa			
		Northern	24	31	37
		Middle	8	35	61
		Southern	5	22	38
Baskett (1947)	1939-1941	Winnebago	104	46	20
Klonglan (1955b)	1951-1956 (excl. 1954)	Winnebago	?	54	?
	1954	Winnebago	47	19	28

1950's on the Winnebago Area. In 1951, 1952 and 1953 an average of 66 per cent of all successful nests located by a systematic and intensive search on the Winnebago Area were found in oat fields. Klonglan (1955b) found only 32 per cent of the hatched nests in oats, but he reported that this proportion was much later than normal for this area because of the delayed and unusually poor growth of this type due to an abnormally late freeze. The mean proportion of successful nests in oats during 1939-

1941 was only 35 per cent (Baskett 1947), but both a greater quantity and variety of nesting cover existed then than presently is available on either the Winnebago Area or the Northern Area.

Comparison of Central Iowa Areas and other areas within the pheasant range Apparently the use of oats as a nesting type is not common throughout the continental pheasant range except in the northern Midwest. Direct reference to oats as an important nesting cover is rare. In this connection, studies by Baskett (1947) and Klonglan (1955b) have already been mentioned. Robertson (1958), although not mentioning either the success or proportion of nests in oats, stated that broods produced in oats "may have contributed substantially to total production" in Illinois. In Wisconsin pheasant range the success of nests in oats was reported by Gates (1964) to average approximately 50 per cent. Similarly, Leedy (1939) found 52 per cent of 44 nests in oats were successful in 31 western Ohio counties in 1939. Wheat often replaces oats as the dominant small grain in many areas and appears to satisfactorily substitute for it as one of the important cover types for nesting. Linder et al. (1960) reported an average nest success in wheat based on 100 nests of 24 per cent during the period 1955-1959. In eastern Pennsylvania, Randall (1940) indicated a similar rate of success (30%) for nests established in wheat. However, where wheat and oats occur together, wheat may be both more attractive to nesting hens and more productive. In Ohio, density of 946 nests in wheat was 1.9 nests per acre and success of these nests was 61 per cent, while in this same area density of 44 nests in oats was only 0.8 nests per acre and success averaged 52.3 per cent

(Leedy 1939). On Pelee Island, success of 41 nests in small grains, largely wheat, rye and oats averaged 42 per cent in 1949 and 1950, but most of this success occurred in wheat and rye; oats "were apparently unproductive." Similarly, Klonglan (1962) reported that although success of 30 nests in oatfields in a southwestern Iowa area in 1957 and 1958 averaged 27 per cent, the number of nests in oats was so low that only 9 per cent of all successful nests occurred in this type. Thus, even though the success of nests in oats or other small grains as reported from throughout the pheasant range tends to fall within relatively narrow limits, the proportion of nests in oats in each area seems to depend upon the quantity and variety of associated nesting types.

Yearly changes in importance of oats for nesting, Central Iowa Areas On the Northern Area success of nests in oats was about equal in 1962 and 1963, and then increased moderately in 1964 (Tables 13, 14 and 15). In 1962, the proportion of nests in oats (17%) was the lowest recorded on this area during the 3 years, but the observed rate of success in this type (33%) was high enough to boost the per cent of successful nests in oats to over 20 per cent. In 1963, however, despite a comparatively low rate of success, the proportion of all successful nests in this type increased sharply to 76 per cent, or almost four times this figure in 1962. Because of the higher rate of success in 1964 the percentage of the total successful nests which occurred in this type remained relatively high. The reason for these differences in rates of success of nests among years was not known, but differences in spring weather conditions or phenology of growth and mowing did not appear

responsible. The very noticeable proportional increase in oats in 1963, however, can almost certainly be explained on the basis of the distinctive weather conditions which occurred from mid-May through June. Growth of both hay and oats was rapid and above average early in the season. However, the above normal temperatures during this period, coupled with adequate soil moisture, apparently favored the growth of oats over hay. Furthermore, fairly hard freezes on May 22 and 23 appeared not to adversely affect oats but caused extensive frost damage in parts of some hayfields, thus accentuating the disparity in growth between the two crops. Nevertheless, despite differences in phenology of growth of oats during the 3 years, mowing or combining of oatfields began on July 12 or 13 each year.

The per cent success of nests and the per cent of the total nests in oats on the Middle Area tended to follow the same trends as recorded on the Northern Area, the success decreasing in 1963 and subsequently recovering in 1964 and the proportion increasing greatly in 1963. On the Southern Area such similar corresponding trends did not appear to occur, but the small number of nests precluded the use of this data for meaningful comparisons with the other areas.

Roadsides      Roadsides on the Central Iowa Areas constituted the most important non-agricultural type of cover for pheasants. Of the vegetation in this type, grasses comprised the greatest acreage, and two of these, bluegrass (Poa sp.) and brome grass (Bromus enermis), because of their early growth and abundance were especially important for pheasant nesting. Bluegrass was the most common, but was often heavily inter-

dispersed with other species. Under these circumstances it provided excellent nesting cover. Where it occurred in pure stands, however, because of its poor protective canopy and tendency to lodge easily, it did not provide high-quality cover. Conversely, though it was not as common as bluegrass, bromegrass grew mainly in pure stands and at the same time provided an excellent protective canopy. Most roadsides averaged approximately 20 feet in width, but some were almost 30 feet wide; very few, however, were less than 20 feet. Approximately 10 per cent of the roadsides on each area were mowed every year, but such mowing always took place after July 1. The same roadsides were mowed each year, apparently in an attempt to control weeds.

Central Iowa Areas, 1962-1964      During the 3 years, 11 per cent of all nests and 12 per cent of the hatched nests on the Northern Area were established in roadside ditches (Tables 13 and 21). Thus, on this basis these areas, behind hay and oats constituted the third most important location for pheasant nesting. Success of nests tended to remain constant in this type during the period of the study (particularly if the apparent high rate of nest success in 1962 can be attributed to the small number of nests found), but because the proportion of nests established in this type increased in successive years, the proportion of successful roadside nests to all successful nests rose from 8.4 per cent in 1963 to 23.1 per cent in 1964 (Tables 14 and 15). Similarly, somewhat corresponding trends in nest success and proportion of total nests in roadsides seem to have occurred on the Middle Area (Tables 13, 14 and 15). A trend on the Southern Area paralleling those on the other

Table 21. Comparison of nest success and percentage of nests in roadsides on the Central Iowa Areas and the Winnebago Area

Source	Period of study	Study area	Number nests	Per cent of nests successful	Per cent of all nests
Bolstad (1962)	1960	Central Iowa			
		Northern	6	0	15
		Middle	1	0	7
		Southern	1	0	11
Wright and Otte (1962)	1961	Central Iowa			
		Northern	15	7	25
		Middle	3	67	12
		Southern	2	0	22
This study	1962-1964	Central Iowa			
		Northern	26	28	11
		Middle	9	18	13
		Southern	14	37	33
Baskett (1947)	1939-1941	Winnebago	67	34	13
Klonglan (1955b)	1954	Winnebago	14	50	17

two areas could not be demonstrated; however, as on the Northern and Middle Areas, the total number of nests in this type increased from 1962-1964.

The per cent success of nests and the per cent of all nests in roadsides recorded by Bolstad (1962) and Wright and Otte (1962) are compared with the present study in Table 21 along with similar data from Baskett (1947) and Klonglan (1955b).

Comparison of Central Iowa Areas and the Winnebago Area On the Winnebago Area, Baskett (1947) reported that of 67 nests established

in road ditches during the period 1939-1941, 23, or approximately 34 per cent were successful (Table 21). However, because roadside vegetation was commonly mowed in late June and July, Baskett classified these areas under "hayfields", and though not specifically stated, the assumption was that had not the vegetation been mowed, success would have been much higher. Klonglan (1955b) similarly classified road ditches under "hayfields," reporting seven (50%) of the 14 nests found were successful, but in a later study (Klonglan 1962) he commented that "only about one-third of the total road ditch area was mowed" in his earlier study on the Winnebago Area. Thus, the decrease in the number of road ditches mowed during the interval between the two studies may have been the reason for the higher success recorded in this type in the later study. The reason for the decrease in mowing, as Klonglan (1962) pointed out may have been that the tractor-drawn mowers which in the interim had replaced the horse-drawn mowers were not as well adapted for such mowing. Thus, the average per cent success of nests on the Northern Area during the three years appeared to be slightly lower than that reported earlier by Baskett (1947) and Klonglan (1955b) on the Winnebago Area.

Comparison of Central Iowa Areas and other areas within the pheasant range As in the present study and those of Baskett (1947) and Klonglan (1955b), Shick (1952) found roadsides important for pheasant nesting in eastern Michigan, reporting that the majority of 26 hatched nests occurred in this cover type and in ditch banks. Similarly, Linder et al. (1960) reported that 24 per cent (147 nests) of all nests were in roadsides during 1955-1959 in southcentral Nebraska. Also, Stokes (1954)

found that about 43 to 56 per cent of all nests and 43 to 57 per cent of the successful nests were in "Scrub I," a classification which apparently included roadsides and ditchbanks. In Pennsylvania, Randall (1940), however, recorded only 10 per cent (16 nests) of the total nests and less than 5 per cent of the successful nests in roadside. Also, Klonglan (1962) found that although density of nests in road ditches was high (104 nests per 100 acres), because acreage was limited, only about 5 per cent (5 nests) of the successful nests were in this type.

Yearly changes in importance of roadsides for nesting, Central Iowa Areas Although the success of roadside nests on the Northern Area remained at about the same level during the 3 years, the percentage of nests in this type increased each year. The unusually low proportion (5 per cent of all nests) of nests in roadside in 1962 can in part probably be attributed to the poor quality of the residual cover, largely grasses, left from the previous year. Such cover, along with similar undisturbed cover in waste areas served to provide the only available nesting sites early in the nesting season when new growth had not yet appeared. When this cover was absent, hens were not attracted to these areas until later in the spring when the current year's growth had reached heights of 10 to 12 inches or more and densities sufficient to offer the necessary concealment. In the winter of 1961-1962, however, record snow depths occurred, causing complete lodging of all roadside cover except woody vegetation, so that at the start of the nesting season no residual vegetation was present. In 1963 a similar but incomplete lodging of residual cover occurred. Though snowfall in the previous

winter had been light, high winds during the few periods of snowfall which occurred caused snow to accumulate in roadside ditches. Also, the early and rapid growth of hay and oats, particularly oats, probably attracted nesting hens in greater numbers than usual, resulting in fewer nests in roadsides. In the winter of 1963-64 even less snowfall occurred than in the previous winter and road ditches remained free of snow. As a result, residual cover remained standing into the spring, providing sites for early nesting.

Probably because of the small sample of nests on the Middle and Southern Areas, the success of nests on these areas during the 3 years did not correspond closely each year to success of nests on the Northern Area. However, a similar trend was noted in the proportion of nests in roadside (Tables 14, 15 and 16), suggesting that the same factors which influenced the placement of nests on the Northern Area were operating on these areas as well.

Pasture Pastures on the Central Iowa Areas included both native "bluegrass" pastures and rotation pastures seeded to a mixture of red clover and alfalfa. In the former, cattle were allowed to graze as soon as new growth appeared in the spring, but vegetation in rotation pasture usually reached 6-8 inches before grazing was permitted. In both types, however, almost all cover had disappeared by early June due to over-grazing and trampling, and therefore they were of little value for pheasant nesting. The one exception was a 38-acre pasture (mostly with native grasses other than bluegrass) on the Northern Area in 1962 in which almost 19 per cent of all successful nests that year were estimated

to have been located. Usually during every year, however, one or occasionally two pastures on the Central Iowa Areas provided sufficiently good cover to permit the successful completion of at least one nest.

Central Iowa Areas, 1962-1964 During the 3 years, 4 per cent of the total nests and 6 per cent of all successful nests on the Northern Area were estimated to have been established in pastures (Table 13). Similarly, 1 per cent of the nests on the Southern Area occurred in pastures, but no nests were successful. No nests in pasture were found on the Middle Area.

Bolstad (1962) found five nests in this type in 1960, three (60%) of which were successful. No nests were found in pasture on the Middle and Southern Areas. Wright and Otte (1962), based on the experience of Bolstad (1962) apparently did not check pastures for nests. Thus, the limited data concerning nesting in pastures attests to the unimportance of this type for pheasant nesting on the Central Iowa Areas.

Comparison of Central Iowa Areas, the Winnebago Area and other areas within the pheasant range Baskett (1947) reported less than 5 per cent of the total nests and less than 6 per cent of all successful nests in pasture. Thirty per cent of these were successful. Overgrazing was considered the most important factor limiting nesting. Klonglan (1955b) found that the importance of pasture as nesting cover had not changed greatly since Baskett's study; success of nests was high (40%), but because density was low, only 3 per cent of the successful nests were in this type.

The importance of pasture for nesting apparently varies in different portions of the pheasant range. Often, as in the present study and those

of Baskett (1947) and Klonglan (1955b), density of nests in this type is so low that even though success may be relatively high, few chicks are produced. Linder et al. (1960) reported success of 21 nests in this type was only 7 per cent and only 4 per cent of the total nests were in pasture. Similarly, less than 2 per cent of all nests found in eastern Pennsylvania were in pasture (Randall 1940). However, where grazing pressure is not heavy, or under special conditions pastures can contribute substantially to production. Stokes (1954) found that 20 per cent (359 nests) of all nests and approximately 19 per cent of the successful nests were located in pasture on Pelle Island, Ontario in 1950. Also, Klonglan (1962) reported that about 14 per cent (15 nests) of the successful nests were in ungrazed bluegrass pastures which were harvested for seed.

Waste areas This classification included all non-agricultural areas (except fencerows and roadsides) such as field corners, abandoned farmsteads and some soil bank acreages. Also, small wet areas that farmers did not consider profitable to drain were included in this classification. The type of vegetation composing these areas varied in accordance with the type of each individual unit. Field corners and abandoned farmsteads usually supported annuals such as giant ragweed (Ambrosia trifida), with a heavy interspersion of various annual and perennial grasses. Lilacs (Syringa vulgaris) and scattered other small bushes and trees were often present in abandoned farmsteads. Soilbank areas were usually partially composed of red clover and alfalfa, but one large field on the Northern Area had been seeded to reed canary grass (Phalaris arundinacea) and brome grass; however, many unplanted species had invaded. The one permanent wet spot was located on the Northern Area

and supported a native prairie flora. Despite very small acreages, waste areas on the average were more important for pheasant nesting than pasture. No waste areas, however, were present on the Southern Area.

Central Iowa Areas, 1962-1964 During the 3 years, about 3 per cent of both the total nests and successful nests on the Northern Area were estimated to have been located in waste areas (Table 13). Similarly, on the Middle Area approximately 6 per cent of the total nests and 4 per cent of the successful nests were in this type during this same period. Average rate of nest success was 39 per cent on the Northern Area and 22 per cent on the Middle Area. Per cent nest success and the percentage of the total nests in waste areas, as recorded by Bolstad (1962) and Wright and Otte (1962) are presented in Table 22 along with similar data from Baskett (1947), Klonglan (1955b) and the present study.

Comparison of Central Iowa Areas, the Winnebago Area and other areas within the pheasant range Baskett (1947) recorded 16 per cent (84 nests) of all nests in "Indirect or non-agricultural," a classification including fencerows as well as sloughs, lanes, farm groves, feed lots, straw stacks and gardens. However, if nests in fencerows are excluded from this classification to permit comparison with the present study, only 4 per cent of the total nests and less than 4 per cent of the successful nests were found in these latter areas. Per cent success of these nests, however, was the same (approximately 15%) whether or not fencerows were excluded from the classification. Klonglan (1955b), using a non-agricultural classification similar to Baskett's, recorded about 12 per cent of all nests and 14 per cent of the successful nests in this

Table 22. Comparison of nest success and percentage of nests in waste areas on the Central Iowa Areas and the Winnebago Area

Source	Period of study	Study area	Number nests	Per cent of nests successful	Per cent of all nests
Bolstad (1962)	1960	Central Iowa			
		Northern	1	0	2
		Middle	0	0	0
		Southern	0	0	0
Wright and Otte (1962)	1961	Central Iowa			
		Northern	2	0	3
		Middle	0	0	0
		Southern	1	100	11
This study	1962-1964	Central Iowa			
		Northern	8	39	4
		Middle	4	22	6
		Southern	0	0	0
Baskett (1947)	1939-1941	Winnebago	84	15	16
Klonglan (1955b)	1954	Winnebago	20	20	12

type. However, though fencerows were included in the classification no nests were found there, apparently because the total acreage in fencerows and the width of individual fencerows had decreased in the interim between Baskett's and Klonglan's study. Thus, about the same proportion and success of nests in waste areas was recorded in Baskett's (1947) study as was found in the present study if fencerows are omitted from this category. The somewhat higher percentage of nests in this type reported by Klonglan (1955b) may reflect the increased dependence of pheasants on these idle areas due to the continued loss of cover on the Winnebago Area following Baskett's (1947) investigations.

To compare the importance of such waste areas as defined in the present study with other studies is difficult, mainly because the definition of this classification varies with each study. Linder et al. (1960) reported only 2 per cent (20 nests) of the successful nests in "odd areas," a category approximately equivalent to waste areas in the present study. Eklund (1942) found approximately 15 per cent (22 nests) of the total nests and 17 per cent (11 nests) of the successful nests in unused fields, orchards, wood lots, ditch banks and a railroad right-of-way. Similarly, Knott et al. (1943) reported almost 14 per cent (14 nests) of all nests in "brush cover." In Pennsylvania, approximately 13 per cent of both the total and successful nests were reported from orchards, woods and "wasteland," a category apparently comprised entirely of abandoned farmland (Randall 1940). In southwestern Iowa, Klonglan (1962) recorded about 31 per cent (177 nests) and 11 per cent (19 nests) of the total and successful nests, respectively, in a non-agricultural classification which included fencerows. In a category designated "Weeds" and composed of abandoned farmland, Stokes (1954) recorded approximately 6 per cent (290 nests) of the total nests and 7 per cent (165 nests) of the successful nests. On the 900-acre Prairie Farm in Michigan, Shick (1952) reported almost 44 per cent (38 nests) of the total nests and 23 per cent of the successful nests in fallow fields, brush, weeds and woodlots; however, the Prairie Farm is managed specifically for game birds and small game, and consequently over 50 per cent of its total acreage is devoted to such areas. Thus, the per cent of successful nests produced in waste areas or comparable categories in these studies ranges from 2

per cent (Linder et al. 1960) to 23 per cent (Shick 1952). It is apparent, therefore, that the contribution to production made by waste areas in the present study when compared to the above studies was at the lower end of this range. Like the "odd areas" reported by Linder et al. (1960), the acreage of waste areas in the present study when compared to other nesting types was extremely limited, and thus the importance of these areas for nesting was restricted for this reason alone. Similarly, the category designated "weeds" by Stokes (1954) constituted less than 3 per cent of the nesting cover. In the other studies mentioned, especially in the earlier ones, which were undertaken at a time when nesting cover was more abundant than at present, the ratio of this "waste" type of nesting cover to all nesting cover was greater than in the later studies; consequently more nesting occurred in this type.

Overall success of nests on the Central Iowa Areas, all cover types considered, ranged from 18 per cent on the Northern Area in 1964 (Table 16) to 63 per cent on the Southern Area in 1962 (Table 14). On the Northern Area, where the greater number of nests permitted more valid comparisons, the range was considerably more restricted (19 per cent to 27 per cent in 1962). The average overall nest success during the 3 years on this area was 24 per cent. This compared favorably with the total success of nests recorded in other studies. Reports vary from 15 per cent (Linder et al. 1960) to 51 per cent (Knott et al. 1943). On the Winnebago Area, Baskett found 26 per cent of the nests successful during 1939-1941, and Klonglan (1955b) reported a nest success of 17 per cent on this same area in 1954. Klonglan (1962) found only 16 per cent

of the nests on an area in southwestern Iowa were successful. In a New Zealand study, Westerskov (1956) reported 23 per cent of all nests found hatched, and Eklund (1942), in Oregon recorded a total rate of success of 45 per cent.

#### Clutch size

During the 3 years the average overall clutch size on the Northern Area was  $8.4 \pm 1.9$  eggs and  $8.9 \pm 1.4$  eggs, respectively (Table 23a). The mean clutch size for complete nests during this period was  $10.4 \pm 2.1$  eggs on the Northern Area,  $9.8 \pm 2.1$  eggs on the Middle Area and  $10.9 \pm 2.5$  on the Southern Area (Table 24a). Yearly averages of all clutches on the Northern Area ranged from  $8.3 \pm 3.0$  eggs in 1962 to  $8.4 \pm 3.5$  eggs in 1964. On the Middle Area mean size of all nests ranged from  $8.5 \pm 2.9$  eggs in 1963 to  $9.4 \pm 1.7$  eggs in 1962. A range of  $7.6 \pm 3.4$  eggs per nest to  $9.8 \pm 5.2$  eggs was recorded for the Southern Area. Average size of completed clutches on the Northern Area ranged from  $9.8 \pm 1.9$  eggs to  $11.1 \pm 3.5$  eggs on the Northern Area,  $8.8 \pm 2.2$  eggs per nest to  $10.3 \pm 2.2$  eggs on the Middle Area, and  $9.8 \pm 1.5$  eggs to  $12.0 \pm 4.3$  eggs per nest on the Southern Area.

Klonglan (1955b) found a mean of 9.3 eggs per nest in 162 nests and an average of  $9.9 \pm 1.4$  eggs in 81 completed nests on the Winnebago Area in 1954. Additional information regarding clutch sizes on this area were obtained in 1952 and 1953. Average clutch sizes of 60 completed nests in 1952 was  $9.8 \pm 2.7$  eggs and of 42 completed nests in 1953,  $9.5 \pm 3.2$  eggs. The mean clutch size recorded for completed nests during the entire 1952-1954 period was 9.8 eggs per clutch. Baskett (1947)

Table 23a. Average clutch size of all nests found on the Central Iowa Areas, 1962-1964

Year	Northern Area	No. nests	Middle Area	No. nests	Southern Area	No. nests	Mean
1962	8.3	45	9.4	5	9.8	6	8.6
1963	8.4	45	8.5	15	7.6	10	8.2
1964	8.4	65	8.6	8	9.4	13	8.6
Mean	8.4	51.7	8.7	9.3	8.9	9.7	8.5

Table 24a. Average clutch size of completed nests found on the Central Iowa Areas, 1962-1964

Year	Northern Area	No. nests	Middle Area	No. nests	Southern Area	No. nests	Mean
1962	10.0	21	10.0	2	12.0	4	10.3
1963	9.8	19	10.3	7	9.8	4	9.9
1964	11.1	31	8.8	4	10.9	8	10.8
Mean	10.4	23.7	9.8	4.3	10.9	5.3	10.4

gave no mean clutch size for either the total nests or completed nests, nor did he provide the necessary data from which these could be computed. Thus, the average mean clutch size of completed nests for the Northern Area during the present study was about 0.5 of an egg larger than the mean number of eggs per completed nest reported by Klonglan (1955b); however, the mean clutch size of the total nests recorded in the present study was almost one egg smaller.

Direct comparison of mean clutch size information from the present study with that reported in other studies from other areas of the pheasant range is difficult and could be meaningless or misleading. Valid and useable clutch size data must be based on procedures and techniques which assume that either all nesting cover types be completely searched, or each type be searched in proportion to the percentage of the nesting acreage comprised by that type. Failure to do so may result in biased mean clutch size averages which are not representative of nests in all cover types. For example, average mean clutch size computed from roadside nests might be expected to be greater than that determined from a sample of nests in small grain. Because of the residual cover remaining from the previous year, hens might tend to nest first in roadsides, while a small grain crop would more likely contain first nests laid later (which might on the average be smaller than first nests laid earlier, although no information on this point is available from other studies) and renests, which many investigators have found to be smaller on the average than first clutches. Secondly, determination of mean clutch sizes should be based on nests distributed throughout the entire nesting season. For the same reasons given above, concentrating nest searching during particular periods of the nesting season could result in the collection of biased mean clutch size information. For example, if the sample of nests is overweighted for early nests, the calculated mean would be greater than one based on later nests and thus more apt to include a greater proportion of renests. For these reasons clutch size data from some of the other studies referred to previously as a basis for comparison with

the present study, cannot be used. The following studies, however, satisfied these requisites as defined above and can be compared with clutch sizes in the present study.

In Pennsylvania, Randall (1940) reported an average clutch size of 10.8 for 141 nests. Mean clutch size of 607 incubated nests on Pelee Island, Ontario was  $11.7 \pm 0.2$  eggs in 1949 and of 579 incubated nests was  $11.9 \pm 0.2$  eggs in 1950 (Stokes 1954). Linder *et al.* (1960) reported a mean clutch size of 8.0 eggs during a 5-year period in southcentral Nebraska, with a range of 7.0 eggs in 1959 to 9.5 eggs per nest in 1955. Range in average yearly clutch size for incubated nests was 8.0 eggs in 1959 to 12.1 in 1957, with an average of 9.9 eggs per nest. Klonglan (1962) in southern Iowa recorded an average clutch size of  $11.1 \pm 2.9$  eggs for 59 completed nests in 1957 and  $10.4 \pm 3.2$  eggs for 71 completed nests in 1958, with a combined average for 1957-1958 of  $19.7 \pm 3.1$  eggs per nest. Thus, the computed mean clutch size of completed nests reported in these studies, except for Stokes (1954) is very similar to that recorded for completed nests on the Central Iowa Areas (Table 24a). However, even this apparent agreement in clutch size among areas may not indicate with certainty that the population mechanisms at work during the reproductive period in each area are similar. During the early part of the nesting season it is common for more than one hen to lay in a nest, so that often these dump nests can be detected by their large size alone. It is therefore possible that some of the completed nests included as part of the nest sample in the above studies represented more than one hen. The frequency of such occurring would probably increase

as the number of nesting hens increase, and thus the average clutch size could be affected accordingly. Though no nests definitely identified as dump nests were found in the present study, in the other studies cited this phenomenon might have been operating to some degree, especially on Pelee Island where the density of nesting hens was extremely high (over 500 nesting hens per section estimated in 1950) and a higher frequency of dump nests might therefore have been expected to occur.

The pattern and phenology of nesting in relation to success of nesting must also be considered when evaluating the significance of differences or similarities in clutch size. In areas where success of first nests is high, hens need not reneest, and since clutches in reneests are smaller on the average than in first nests, the average clutch size of both the total nests and completed nests would be greater than in an area where frequent and constant destruction of nests leads to persistent reneesting. This may have been one reason for the apparent large clutch size on Pelee Island (Stokes 1954); success of first nests was over 70 per cent when abandoned nests were excluded, and thus the high clutch size recorded may have reflected high nesting success.

The possibility also exists that the tendency to reneest, per se, may be more common on one area than another due either to a regular and established pattern of nest destruction such as hay mowing, or as a naturally-selected component of the normal mechanisms of the population dynamics of the species in that area. For example, where hay is important in the agricultural land-use program, more reneesting, and therefore a smaller average clutch size could probably be anticipated than in another

area where destruction of nests by hay mowing is not important.

Although each or all of the above phenomena may prevent meaningful comparisons of clutch size data among studies in different regions, the three Central Iowa Areas can be compared directly, since all were subject to essentially the same environmental conditions. Again, however, the small sample of nests from the Middle and Southern areas prevented any valid comparisons both between these two areas individually and between these areas and the Northern Area. Nevertheless, there appeared to be no obvious, consistent differences in mean clutch size of either the total nests or completed nests which could be isolated as relating to the traditional and continued differential in population levels among the three areas (Tables 23a and 24a). However, there appeared to be a stronger agreement in clutch size figures between the Northern and Middle areas than between the Southern Area and either the Northern or Middle areas. Perhaps this could be expected, since the Northern and Middle areas are only 3 miles apart and therefore more likely to have been under the influence of similar conditions in the environment, particularly local weather disturbances.

On the Northern Area, the similarity of mean clutch size of total nests in each of the three years was especially apparent. A similar agreement in clutch size of completed nests occurred in 1962 and 1963 on this same area; however, the mean clutch size of 11.1 eggs per nest in 1964 did not appear to fit the general trend. The reason for this seemingly dissimilar mean clutch size is not known, especially in view of the fact that the hatch in 1964 was the latest recorded during the 3-year

period. Such a delayed hatch could be explained either on the basis of later first nests or more extensive renesting than usual, in which either case the expected response would be a reduction in mean clutch size of completed nests, not an increase.

#### Fates of eggs in successful nests

Although in many successful nests the number and fate of eggs are easily determined, it is sometimes impossible to obtain a complete and accurate count of eggs in all hatched nests. Very early hatched nests, or those not found for a long period after hatching, were very susceptible to the effects of weathering. Such nests often contained eggs which had undergone nearly complete disintegration; pieces of egg shells remaining at the nest site were extremely brittle, and crumbled and powdered easily upon handling. In addition, dead embryos within unhatched eggs had sometimes decayed to such a degree that they were no longer recognizable as embryos, and the eggs were therefore difficult to distinguish from infertile ones in a similar stage of decay. Further disturbance of successful nests after they had hatched was caused by farm machinery, especially in nests located in hay or oats. Crushing of eggs resulting from overrunning by tractors, mowers or combines was the most common type of farm-machinery disturbance. Removal of unhatched eggs from hatched nests by predators introduced still another potential source of error. Nests in all cover types were subject to this type of disturbance, but because roadsides and waste areas provided favorite denning and hunting areas for predators, nests in these areas may have been particularly susceptible. Occasionally, eggs damaged by predators but containing embryos were found. Under such circumstances it was not always possible

to determine whether the embryo had died before disturbance by the predator or if the predator had eaten some of the embryos but left the remaining eggs untouched. Also, on several occasions carrion beetles (Necrophorus sp.) were known to have undermined and buried decaying eggs in the soil. Thus, for these reasons only 49 of the 58 total successful nests found were considered satisfactory for use in computing various itemized mean descriptive statistics for successful nests (Tables 23b, 24b and 25).

Mean clutch size of hatched nests      During the 3-year period 30 undisturbed hatched nests containing 316 eggs and averaging 10.5 eggs per nest were found on the Northern Area (Table 23b). Mean clutch size of undisturbed hatched nests was 9.6 eggs (based on seven nests) on the Middle Area and 11.3 eggs (12 nests) on the Southern Area during this same period. The mean number of eggs hatched per nest on each area for the entire period, however, showed somewhat less variation, ranging from 9.6 on the Northern Area to 9.0 on the Middle Area.

Baskett (1947) during the 3 years of his study found 125 successful nests containing 1319 eggs, for a mean clutch size of 10.6, and with a range of from 10.4 eggs per nest in both 1939 and 1941 to 11.0 eggs in 1940. The average number of eggs hatched per successful nest was 8.7, ranging from 8.6 eggs in 1941 to 9.1 eggs in 1940. Klonglan (1955b) reported a mean of 9.4 eggs in 28 successful nests in 1954. The mean number of hatched eggs per nest was  $8.3 \pm 2.4$ . Similar unpublished data collected by Klonglan in 1952 showed a mean of 8.4 hatched eggs in 29 successful nests. It is therefore apparent that the mean clutch size of

successful nests in the present study was about the same as that reported by Baskett (1947) and Klonglan (1955b) for the Winnebago Area. The mean number of eggs hatched per nest, however, ranged from about one-half egg to almost two eggs higher than on the Winnebago Area. However, judging by the variation in yearly mean clutch size (Tables 23b, 24b and 25), this apparent difference between studies in mean numbers of eggs hatched could be due to chance alone. In any event, there appeared to be no important differences in mean egg figures recorded on the Winnebago and the Northern Central Iowa area. The small number of successful nests found on the Middle and Southern areas prevented meaningful comparisons of egg data from these areas with that from the Northern and Winnebago areas.

The same qualifications regarding the comparison of mean descriptive nest and egg statistics from various studies, previously mentioned in the section on clutch size, apply here also. The following studies have collected and presented the data in a manner permitting comparison with the present study. Stokes (1954) reported a mean clutch size for hatched nests of 11.7 and 11.8 eggs per nest in 1949 and 1950, respectively. In both years an average of 8.7 eggs hatched per nest. Linder et al. (1960) in southcentral Nebraska recorded a mean clutch size for successful nests of 9.9 eggs over a 5-year period, with a range from 8.0 to 12.1 eggs per nest. The mean number of eggs hatched per nest was 8.4. An average of 11.4 total eggs and 9.5 hatched eggs per successful nest was reported by Klonglan (1962) in southern Iowa. It appears from these studies and those of Baskett (1947) and Klonglan (1955b), therefore, that wide

Table 23b. Fates of eggs in successful nests, Northern Area, 1962-1964

Category	1962		1963		1964		Combined total	Per cent of combined total
	Number	Per cent of total	Number	Per cent of total	Number	Per cent of total		
Mean clutch size of successful nests	10.5		9.2		11.9		10.5	
Mean number eggs hatched	9.3		8.6		10.9		9.6	
Successful nests found from which useable data were obtained	12		9		9		30	
Eggs in successful nests	126		83		107		316	
Eggs hatched	112	89	77	93	98	92	287	91
Cause of egg failure								
Infertile or no development	5	4		7	2	2	13	4
Death of embryo	8	6		0	6	6	14	4
Undetermined	0	0		0	1	1	1	0
Predation of individual eggs	1	1		0	0	0	1	0

Table 24b. Fates of eggs in successful nests, Middle Area, 1962-1964

Category	1962		1963		1964		Combined total	Per cent of combined total
	Number	Per cent of total	Number	Per cent of total	Number	Per cent of total		
Mean clutch size of successful nests	11.0		9.3		8.0		9.6	
Mean number eggs hatched	10.0		8.8		8.0		9.0	
Successful nests found from which useable data were obtained	2		4		1		7	
Eggs in successful nests	22		37		8		67	
Eggs hatched	20	91	35	95	8	100	63	94
Cause of egg failure								
Infertile or no development	1	5	2	5	0	0.0	3	5
Death of embryo	0	0	0	0	0	0.0	0	0
Undetermined	1	5	0	0	0	0.0	1	2
Predation on individual eggs	0	0	0	0	0	0.0	0	0

Table 25. Fates of eggs in successful nests, Southern Area, 1962-1964

Category	1962		1963		1964		Combined total	Per cent of combined total
	Number	Per cent of total	Number	Per cent of total	Number	Per cent of total		
Mean clutch size of successful nests	12.0		10.0		11.4		11.3	
Mean number eggs hatched	9.3		9.3		9.2		9.3	
Successful nests found from which useable data were obtained	4		3		5		12	
Eggs in successful nests	48		30		57		135	
Eggs hatched	37	77	28	93	46	81	111	82
Cause of egg failure								
Infertile or no development	4	8	2	7	7	12	13	10
Death of embryo	7	15	0	0	3	5	10	7
Undetermined	0	0	0	0	0	0	0	0
Predation on individual eggs	0	0	0	0	1	2	1	1

variation in both mean number of eggs per successful nest and mean number of eggs hatched is typical, both among areas and from year to year on the same area.

Hatchability Of 316 eggs found in successful nests on the Northern Area during the 3-year period, 287 or 91 per cent hatched (Table 23b). Per cent hatchability (eggs hatched divided by total eggs) of 67 eggs on the Middle Area was 94 per cent and of 135 eggs on the Southern Area, 82 per cent (Tables 24b and 25). (The lower per cent hatchability recorded on the Southern Area was due mainly to two atypical nests in which only two eggs hatched.) This compared closely with the 88 per cent hatchability found on the Winnebago Area by Klonglan (1955b), but was somewhat higher than the 83 per cent observed by Baskett (1947).

Of the 29 (9%) eggs in hatched nests which failed to hatch on the Northern Area during the 3 years, 13 were infertile, 14 contained dead embryos, one was destroyed by a mammalian predator and the cause of failure of one was undetermined. Baskett (1947) found that an average of 1.8 (16%) eggs per nest did not hatch, and Klonglan (1955b) reported an average of 1.1 eggs per nest (12%) was unsuccessful. Bolstad (1962) reported an overall per cent hatchability of about 96 per cent on the three Central Iowa Areas in 1961.

Hatchability of eggs reported in other studies ranges from 74 per cent to 90 per cent (Table 27). Thus, during the 3 years hatchability on the Northern Area and on the Central Iowa Areas in general, was apparently slightly higher than in most other area.

Fertility During the 3 years fertility of eggs (eggs containing

Table 26. Fertility of eggs as determined from successful and completed nests, Central Iowa Areas, 1962-1964

	Year			
	1962	1963	1964	1962-1964
Northern Area				
Total number eggs	145	165	113	423
Number infertile	5	13	3	21
Number fertile	140	152	110	423
Per cent fertile	97	92	97	95
Middle Area				
Total number eggs	21	37	20	78
Number infertile	1	0	1	2
Number fertile	20	37	19	76
Per cent fertile	95	100	95	97
Southern Area				
Total number eggs	48	30	67	145
Number infertile	4	2	8	14
Number fertile	44	28	59	131
Per cent fertile	92	93	88	90

embryos divided by total eggs) as determined from successful nests was 96 per cent on the Northern Area. Egg data added from completed nests in which fertility could be determined changed the per cent fertility only slightly to 95 per cent (Table 26). The per cent fertility of eggs recorded on the Middle and Southern areas during the same period, as determined from both successful nests and completed unsuccessful nests was 98 per cent on the Middle Area and 90 per cent on the Southern Area (Table 26). There appeared to be no important difference in fertility among the 3 years on the Northern Area, ranging only from 92 per cent

Table 27. Hatchability and fertility of eggs in successful and completed nests

Study	Total eggs	Per cent hatched	Per cent fertile	Location of study
Hamerstrom (1936)	723	82	93	Iowa
Romanoff <u>et al.</u> (1938)	15,010		94	Hatchery
Randall (1940)	<sup>a</sup>	90	94	Pennsylvania
Baskett (1947)	1,319	83	92	Iowa
Einarsen (1942)	261	79	90	Washington
Stokes (1954)	6,372	76	91	Pelee Island
Stokes (1954)	5,935	74	87	Pelee Island
Linder <u>et al.</u> (1960)	781	77	90	Nebraska
Klonglan (1962)	1,335	84	95	Iowa
Present study				
Northern Area	316	91	--	Iowa
	423	--	95	

<sup>a</sup>Not given.

in 1963 to 97 per cent in 1964. Per cent fertility of eggs on the Middle and Southern areas appeared to vary more from year to year, but this could be expected due to the small number of eggs upon which fertility was based each year.

Bolstad (1962) in 1961 on the Central Iowa Areas found 95 per cent of 221 eggs in 23 nests were fertile. Fertility rates of 97 per cent, 93 per cent and 96 per cent were recorded on the Northern, Middle and Southern areas, respectively. Baskett (1947) reported 1167 eggs out of 1268 total eggs from which fertility data could be obtained were fertile, for an average rate of fertility during the 3 years of 92 per cent. The variation in per cent fertility was slight; highest was 93 per cent in 1939, and lowest, 92 per cent in 1941. Klonglan (1955b) reported 619

eggs or 95 per cent of 653 eggs fertile in 1954 on this same area.

Rates of fertility recorded in other nest studies range from 87 per cent to 96 per cent, with most percentages between 90 and 94 per cent (Table 27). Fertility rates on the Central Iowa Areas, with special reference to the Northern Area, were therefore very similar to those reported by Baskett (1947) and Klonglan (1955b) on the Winnebago Area. In turn, the per cent fertility recorded both on the Central Iowa Areas and the Winnebago Area are in the upper range of fertility rates as determined from other investigations.

Embryo mortality During the 3-year period on the Northern Area a total of 14 eggs (4%) in successful nests contained dead embryos (Table 23b). On the Southern Area 10 eggs (10%) which did not hatch contained dead embryos (Table 25). No dead embryos were found in successful nests on the Middle Area (Table 24b). Of 518 eggs in 49 successful nests from all Central Iowa Areas, 27 eggs or 5 per cent contained dead embryos.

Baskett (1947) reported a mean of 4 per cent of the eggs in successful nests contained dead embryos on the Winnebago Area during the 3 years of his study, ranging from 6 per cent in 1939 to 3 per cent in 1940. Klonglan (1955b) found approximately 6 per cent of all eggs in successful nests on this area in 1954 contained dead embryos.

Linder et al. (1960) reported 13 per cent of 781 eggs in 72 successful nests in Nebraska failed to hatch due to the death of the embryo. In southwestern Iowa approximately 6 per cent of the 636 eggs in 92 successful nests reported by Klonglan (1962) contained dead embryos. Thus, the percentage of eggs in successful nests on the Northern Area and Central

Iowa Areas which failed to hatch due to the death of the embryo was, in general, very similar to the percentage reported in the other Iowa studies.

Progression and distribution of hatching

Although theoretically the calculation of the distribution of the hatch should be based on data from hatched nests, several factors prevented such a practice. The relatively low pheasant populations characteristic of the Middle and Southern areas, the lack of personnel to search for nests in some years and the loss of time accrued due to the distance between areas, all contributed to the lack of a larger sample of hatched nests being obtained during any single nesting season. Since there were only 18 hatched nests in 1962 and 16 and 24 successful nests found in 1963 and 1964, respectively, it was apparent that no meaningful hatching distributions could be constructed for any one of the 3 years. Furthermore, some of these nests had been disturbed by predators, crushed by farm implements or were so badly weathered that the date of hatching could not be determined with certainty. Therefore, on the Central Iowa Areas the hatching distribution for each of the 3 years was computed from brood observations obtained during early morning roadside counts on the 21-mile routes previously described on page 39. Routes were limited to 21 miles because this particular length was the longest possible which would permit thorough coverage yet prevent repeating any part of the route, and at the same time restrict the course of the route to the area boundaries on the north and south, and not more than 1 mile from the east or west boundaries of the areas. (However, on the Southern Area because of fewer section roads the route in part of its length was

as much as 2 miles west of the area itself.) Restricting the route in this manner was necessary in such an area of rapidly changing pheasant populations, since data collected at distances greater than described could result in erroneous conclusions based on populations not representative of those resident on each study area. Since the number of broods observed on the Middle and Southern areas was too small to permit construction of meaningful hatching curves for each area, these data were combined with those obtained from counts on the Northern Area and a single hatching curve was constructed for the Central Iowa Areas. The Winnebago Area route was 30 miles long and consequently ranged farther from the study area than did the central Iowa routes, but because the density of pheasants appeared to be about the same in this general region, the distance of the route from the area presented no problem.

The collection of data from roadside brood observations for use in the construction of hatching curves appeared subject to only one major source of error. Although there was possibility for error in estimating the age of broods, the use of photographs and detailed descriptions of known-age young pheasants undoubtedly reduced the error due to this source. However, the leading bias in roadside observations was the probability that early-hatched broods were counted more often than late-hatched broods. Birds in older broods were large and active, and therefore readily observed at the start of the counts in July and throughout August and September. Young broods, however, at the starting date for counts in mid-July were difficult to see in heavy cover due to their small size and secretive behavior. Therefore, for the early part of the

counting period these late-hatched broods probably were not observed in proportion to their true numbers in the population; nevertheless, the number missed probably was not great enough to have caused any important change in the recorded distribution of the hatch.

The distribution and progress of the hatch on the Central Iowa Areas was distinctive during each of the 3 years. The hatch in 1963 was about 4 weeks earlier than in 1964, and the 1962 hatch was intermediate (Figure 12). In addition, the percentage of the total hatch which occurred each year during the peak followed the same pattern, being highest in 1963, low in 1964 with 1962 showing an intermediate position. Thus, the major portion of the hatch in 1963 was compressed into a relatively short period in late May and early June, while in the other 2 years the hatching season was considerably more protracted.

Baskett (1947) and Klonglan (1955b) reported that hatching peaks on the Winnebago Area occurred in the last half of June during the period 1939-1941 and in 1954, and the hatching curves constructed in 1962, 1963 and 1964 for this same area seemed to substantiate this as the normal pattern (Figure 13). It thus appears from a comparison of the hatching peaks on the Central Iowa Area and the Winnebago Area for the entire 1962-1964 period that the peak on the Central Iowa Areas was typically at least a week, or possibly 2 weeks earlier on the average (Figure 15). Since the 228 broods observed on the Central Iowa Area in 1964 compared to the 80 broods in 1962 and 71 broods in 1963 resulted mainly from an increase in the number of counts, not any important increase in pheasant numbers, the data from 1964 contributed disproportionately to the hatching

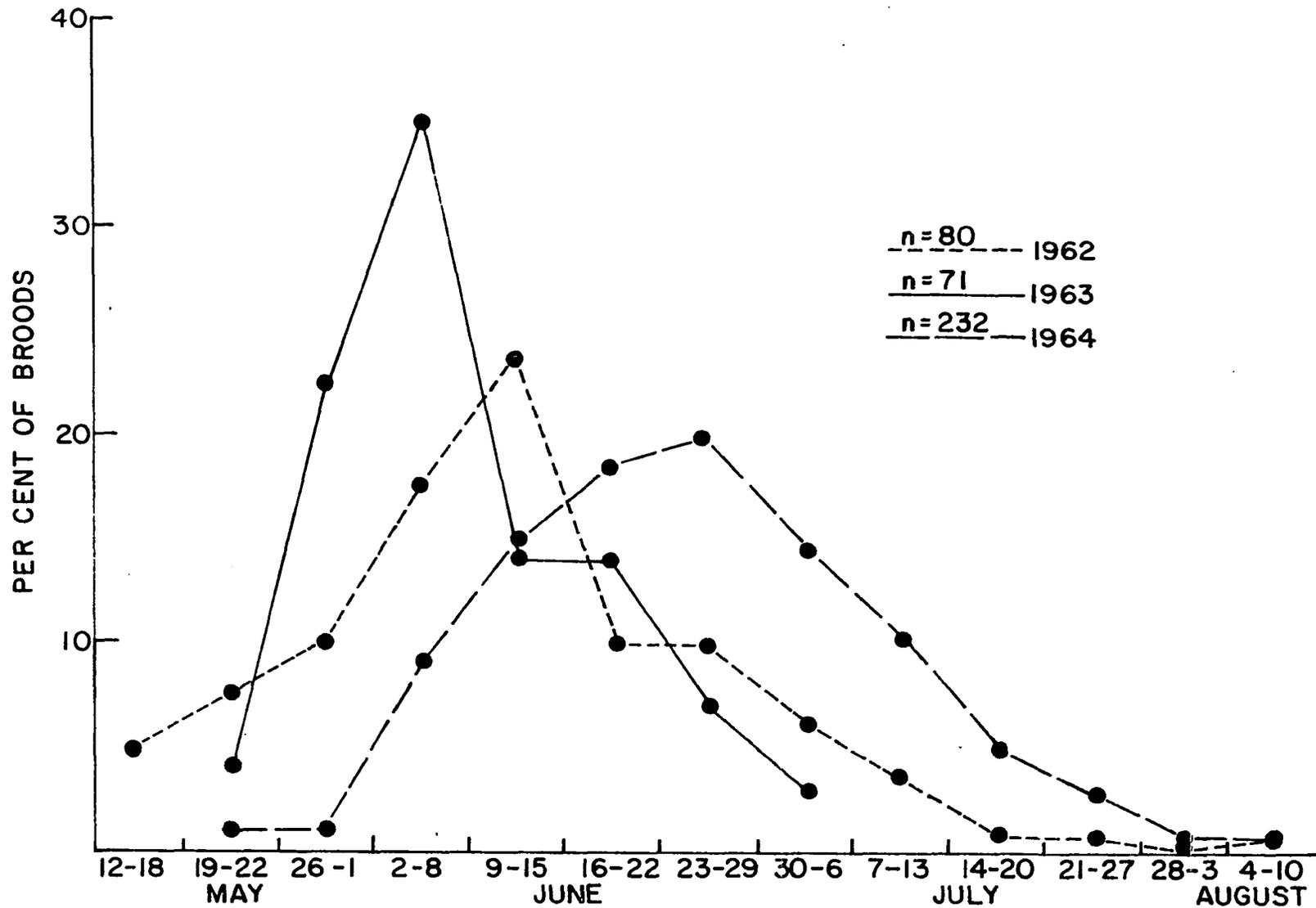


Figure 12. Comparison of hatching distributions on the Central Iowa Areas, 1962, 1963 and 1964

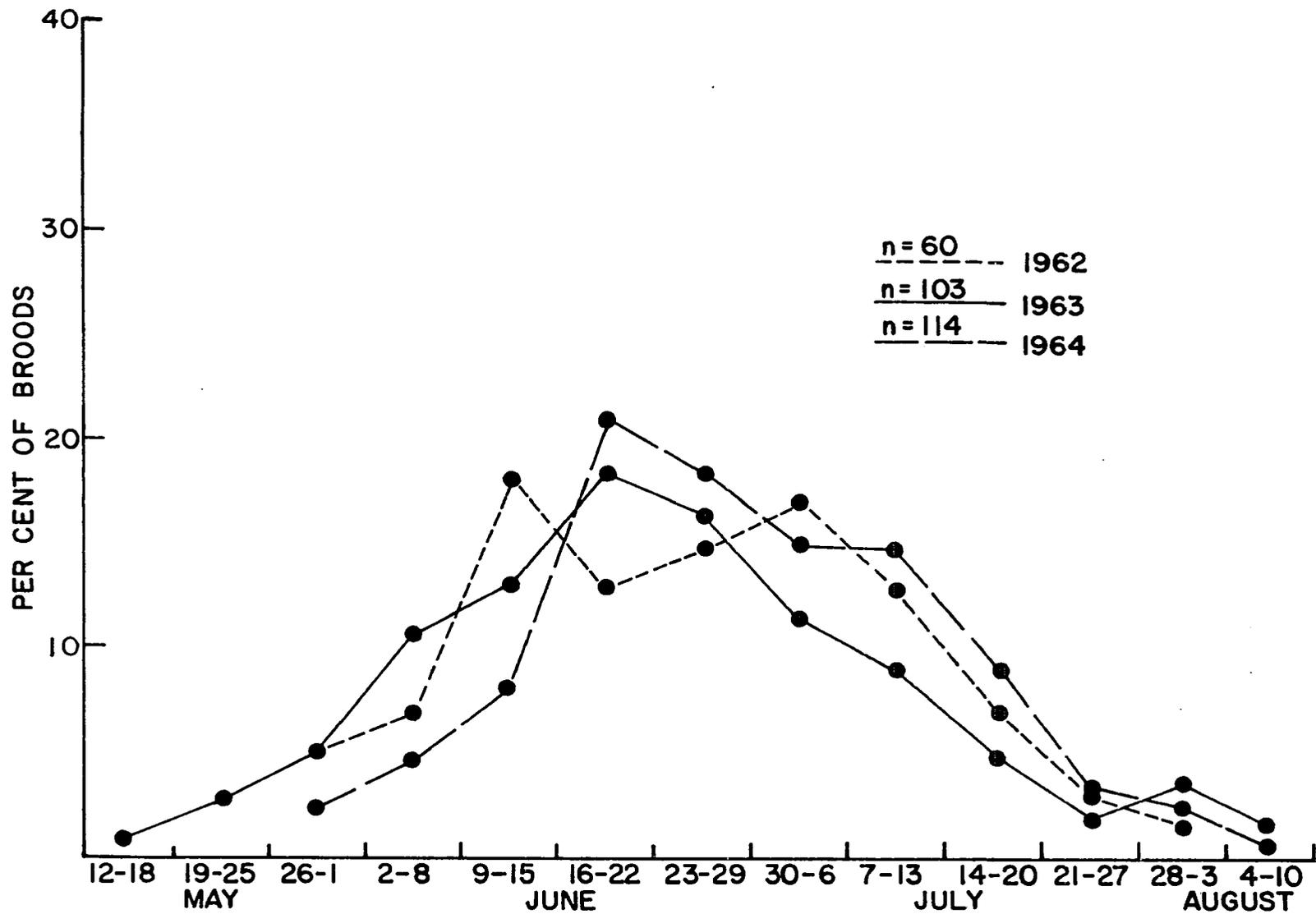


Figure 13. Comparison of hatching distributions on the Winnebago Area, 1962, 1963 and 1964

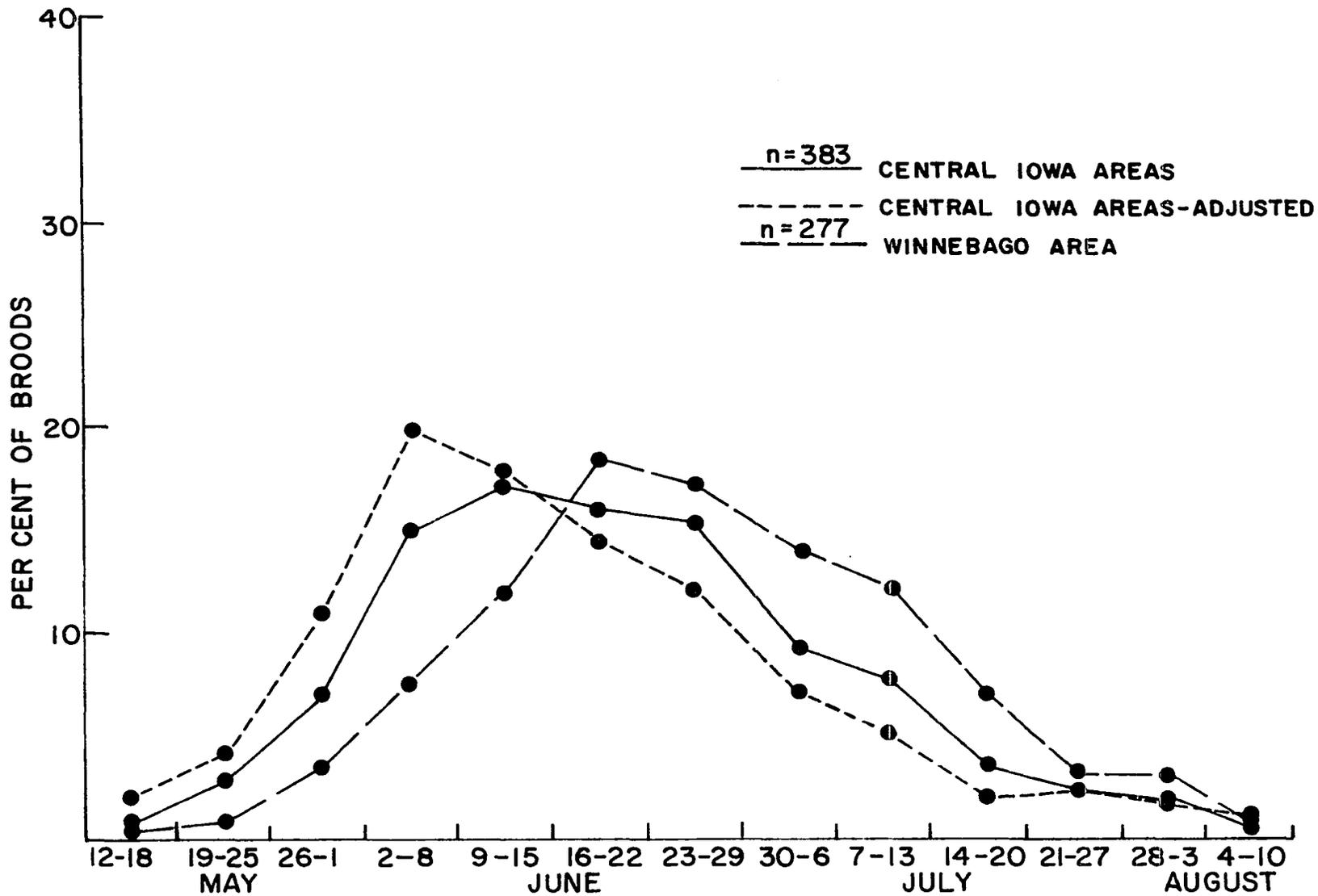


Figure 14. Comparison of hatching distributions on the Central Iowa and Winnebago areas, 1962-1964

distribution constructed from the combined data for the 3-year period. To compensate for the tendency of the 1964 brood data to overweight the combined hatching distribution, a second adjusted hatching curve for the Central Iowa Area was constructed on a percentage basis, each year contributing 33.3 per cent to the total, no matter what the actual number of broods observed yearly on each area (Figures 12, 14 and 15). Thus, each year's data shared proportionately in the hatching distribution computed from the combined data. The earlier hatching peak of the adjusted curve in relation to the unadjusted Central Iowa and Winnebago area curves is apparent (Figure 14) and undoubtedly represents a more accurate picture of the distribution and pattern of the hatch during this period.

Further comparisons between hatching curves from the Central Iowa and Winnebago areas in the 1962-1964 period revealed that while the peak of hatching occurred at an earlier date on the Central Iowa Area, on the average about the same proportion of the hatch on both areas took place prior to the peak (Table 28 and Figure 15). By the beginning of June about 12 per cent of the hatch had occurred on the Central Iowa Area, or almost 18 per cent according to the adjusted curve, while less than 6 per cent of the hatch had been completed on the Winnebago Area. Similarly, the earlier hatching curves from the Winnebago Area indicated that less than 3 per cent of the hatch had been completed before June 1 (Table 28). However, if the 1962-1964 hatching curve for the Winnebago Area is displaced one week earlier, it then agrees fairly well with the central Iowa distribution. More convincingly, however, a shift of the

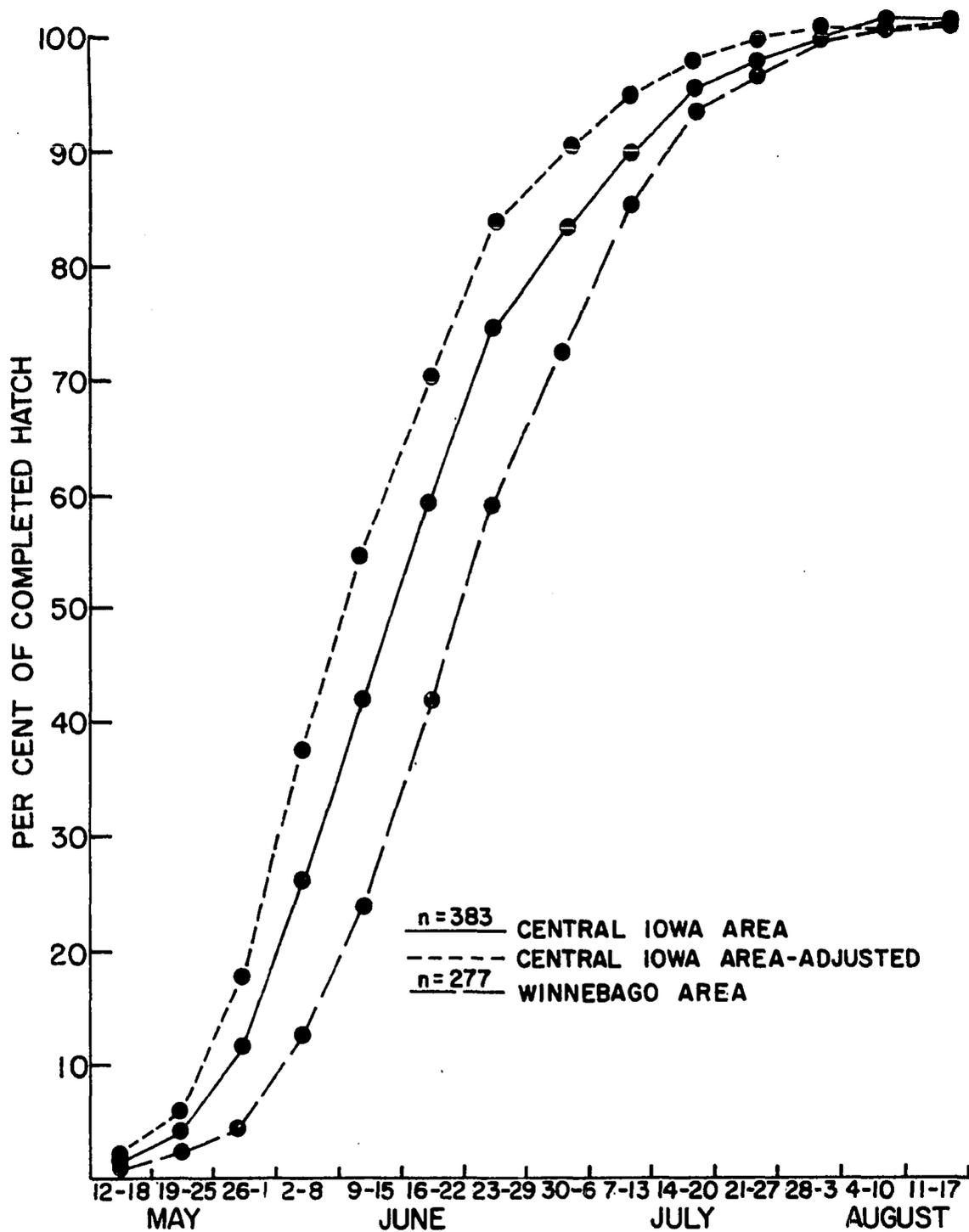


Figure 15. Comparison of cumulative hatch of pheasant broods on the Central Iowa and Winnebago areas, 1962-1964

Table 28. Comparison of cumulative hatching distributions on the Central Iowa and Winnebago areas

	Central Iowa Areas			Winnebago Area			Winnebago Area			Winnebago Area		
	1962-1964			1962-1964			1939-1941 <sup>a</sup>			1954 <sup>b</sup>		
	Number of broods	Per cent of broods	Cumulative per cent	Number of broods	Per cent of broods	Cumulative per cent	Number of broods	Per cent of broods	Cumulative per cent	Number of broods	Per cent of broods	Cumulative per cent
<b>May</b>												
1-15	5	1	1	1	0	0	0	0	0	0	0	0
16-31	39	10	12	13	5	5	3	2	2	1	2	2
<b>June</b>												
1-15	122	32	43	54	20	25	31	23	25	8	19	21
16-31	120	31	75	98	35	60	40	29	54	15	36	57
<b>July</b>												
1-15	66	17	95	73	26	86	31	23	77	13	31	88
16-31	22	6	99	27	10	96	21	15	93	3	7	95
<b>August</b>												
1-15	5	1	99	11	4	100	8	6	99	2	5	100
16-31	4	1	100				2	2	100	0	0	100
Total	383			277			136			42		

<sup>a</sup>Baskett (1947).

<sup>b</sup>Klonglan (1955b).

Winnebago curve 2 weeks earlier results in a still better fit. Thus, although the normal peak of hatch appeared to occur earlier on the Central Iowa Area, the distribution of the hatch in relation to the peak appeared much the same on both areas.

The occurrence of the early and prominent hatching peak on the Central Iowa Area in 1963 seemed well supported by correlative evidence from the nesting study. The phenology of crop growth that year throughout the state was about 2 weeks earlier than usual due to above normal rainfall and extremely warm temperatures in April. As a result nest establishment was probably somewhat earlier in hay and oats than usual; however, the height and density of oats appeared affected more favorably by this combination of weather factors than did hay, so that the quality of cover provided by oats for nesting in relation to hay was unusually good. Consequently, both the number and proportion of nests in oats in 1963 was greater in comparison with the other 2 years. Moreover, because nests in oats were relatively free from disturbance by farming operations compared to those in hay, the success of nests in this type was high. Conversely, the earlier growth of hay proved to be no advantage, since the abnormally warm but very dry conditions which prevailed through all but the end of June were ideal for mowing of hay and resulted in a somewhat earlier than usual and greatly contracted mowing period (Figure 11). Thus, it appeared that the early and accentuated peak of hatching in 1963 was probably the direct result of conditions which allowed more successful nesting earlier in the season than usual. Over 4 inches of rain

during the last week of April might possibly have destroyed or caused desertion of some nests, so that the start of the hatch was delayed proportionately until mid-May (Figure 12); however, no weather disturbances of any importance occurred during May, June or early July, and therefore hatching apparently continued undisturbed throughout this period.

In contrast, the peaks of hatching in 1962 and 1964 were 1 to 3 weeks later than in 1963. In 1964, the approximately 2 1/2 inches of rain which fell in the interval May 19-25 may have caused a dip in the hatching curve during this interval and secondarily prevented a sharper peak 3 to 4 weeks later (Figure 12), but the reason for the substantial delay in the hatch compared to 1963 was not known. A much larger proportion of the nests was established in hay in 1964 than in 1963. The period of hay mowing, however, was greatly protracted (Figure 11) due to the occurrence of frequent rain showers during mid-June, yet few hatched nests were found even in those hayfields cut late. Apparently, therefore, a large proportion of hay nests in 1964 were renests, and the protracted and flattened hatching curve for this year suggested that renesting in other cover types beside hay must also have been extensive. In 1962 the peak of hatching was intermediate to the 1963 and 1964 peaks, but the reason for this was not clear. No important weather disturbances during the nesting season could be directly related to the progression and distribution of the hatch. The distribution of hatching in relation to the peak in 1962 showed more resemblance to the 1964 hatching distribution than to the distribution in 1963 (Figure 12). If the 1962 curve is displaced one week later, the fit with the 1964 curve is fairly close,

although a higher proportion of the hatch occurred prior to the peak in 1962 than in 1964.

The hatching distributions constructed for each year of the 1962-1964 period on the Winnebago Area appeared to bear little resemblance to their counterparts on the Central Iowa Area (Figure 13). In 1962 the dip in the interval June 16-22 could not be related to any known weather factors; however, even though the number of broods upon which the distribution was based was small, it is difficult to believe that such a distinctly abrupt decline was due to sampling variation alone. Although no information on nesting was available from the Winnebago Area, it was possible that a larger proportion of the nests were established in hay than usual. Consequently, if the peak of mowing had occurred during middle or late June as usual, its coincidence with the anticipated probable peak of hatching in this type could have caused the kind of double-peaked distribution which occurred in 1962; however, this is pure speculation.

Of the three yearly distributions of the hatch on the Winnebago Area, the one in 1964 agreed most closely with its obverse on the Central Iowa Area. The hatching peaks on both areas fell approximately within the same interval even though a larger proportion of the hatch apparently occurred later in the season on the more northern area (Figures 12 and 13). Nesting in 1964 appeared to get off to a later start than in the other years, possibly because rainfall in April was almost four times normal.

The 1963 distribution of the hatch for the Winnebago Area seemed entirely out of phase with the same year's distribution from the Central

Iowa Area (Figures 12 and 13). Whereas rainfall on both areas was about normal during May, June and early July, the Winnebago Area experienced several damaging hail storms during May, June and July, the most severe which occurred on May 8 along with 2 1/2 inches of rain. Hail stones as large as golf balls were reported by farmers residing on the area. Under these circumstances, therefore, it could not be expected that hatching distributions on the two areas would show much similarity.

### Reproduction

Production of young During the 3 years a total of 385 nests containing 3207 eggs were estimated to have been established on the Northern Area (Table 29). Approximately 24 per cent of these were successful, resulting in the production of 773 chicks, an average of 129 chicks per section. The greatest production occurred in 1963 (149 chicks per section) and the lowest (109 chicks per section) in 1962 (Tables 30 and 31). Over 78 per cent of all chicks were produced in oats and hay; more than 90 per cent were produced in oats, hay and roadside.

In this portion of central Iowa a large part of the total production during the period 1962-1964 occurred in oats, especially in 1963. With the exception of 1963, density of nests in this type was comparatively low, but since few nests were lost to farming operations, success of nests and consequently production of chicks, was high. In addition, in 1963, due to the special set of circumstances of weather and crop phenology described earlier on page 90 in the section on location of nests, density of nests was also high, resulting in over 71 per cent of the total chicks

Table 29. Estimated average yearly production of chicks on 2 square miles of the Northern Area, 1962-1964

Cover type	Calculated <sup>a</sup> number of nests	Calculated <sup>a</sup> number of eggs	Per cent eggs successful	Calculated chick production	Per cent	
					of total chicks	Chicks per 100 acres
Hay	173.3	1449.7	17	241.1	31	55.6
Oats	144.1	1191.9	30	362.7	47	46
Roadside	40.3	338.1	28	95.8	12	155.3
Pasture	13.4	110.8	37	40.4	5	17.0
Waste areas	13.9	116.2	28	32.5	4	86.2
Totals	385.0	3206.7		772.5		
Means	128.3	1068.9	24	257.5		49.8

<sup>a</sup>Data from 1962 reduced to a basis of 2 square miles.

Table 30. Estimated production of chicks on 4 square miles of the Northern Area, 1962

Cover type	Calculated number nests	Calculated number eggs	Per cent eggs successful	Calculated chick production	Per cent	
					of total chicks	Chicks per 100 acres
Hay	120.0	996.0	24	239.0	55	90.9
Oats	33.8	246.7	31	77.5	18	15.4
Roadside	10.0	83.0	46	38.4	9	90.9
Pasture	26.7	221.6	36	80.7	19	40.5
Waste areas	10.0	83.0	0	0.0	0	0.0
Total	200.5 (100.3) <sup>a</sup>	1630.3 (815.2) <sup>a</sup>		435.6 (217.8) <sup>a</sup>		
Mean			27			41.8

<sup>a</sup>Data from 1962 reduced to a basis of 2 square miles.

Table 31. Estimated production of chicks on 2 square miles of the Northern Area, 1963 and 1964

Cover type	Calculated number nests	Calculated number eggs	Per cent eggs successful	Calculated chick production	Per cent of total chicks	Chicks per 100 acres
1963						
Hay	33.3	279.7	14	38.9	13	27.8
Oats	101.8	855.1	25	213.8	72	79.4
Roadside	13.9	116.8	20	23.4	8	113.6
Pasture	0.0	0.0	0	0.0	0	0.0
Waste areas	4.6	38.6	55	21.2	7	208.3
Total	153.6	1290.2		297.3		
Mean			23			58.1
1964						
Hay	80.0	672.0	12	82.7	32	50.5
Oats	25.4	213.4	52	110.1	43	41.8
Roadside	21.4	179.8	30	53.2	21	256.4
Pasture	0.0	0.0	0	0.0	0	0.0
Waste areas	4.3	36.1	32	11.4	4	105.3
Total	131.1	1101.3		257.4		
Mean			23			49.3

being produced in this type (Table 31). Lowest chick production in oats occurred in 1962; even though nest success was high, density of nests was lower than in the other 2 years (Table 30).

Hay ranked equally with oats as an important cover type for chick production. Although success of nests on the average was much lower than in oats, such a large number of nests was established in hay during the 3 years that 31 per cent of all chicks were produced in this cover type (Table 29). In 1962 and 1964 almost 55 per cent and 31 per cent, respectively, of the production occurred in hay; however, in 1963 hay accounted for only 13 per cent of the production, reflecting the large contribution to production made by oats.

Roadsides comprised less than 4 per cent of the nesting cover on the Northern Area, yet due to the high density of nests in this type, 12 per cent of the total production occurred in roadsides during the 3 years (Table 29). The probable principal reason roadsides assumed this importance was the presence of residual cover remaining from the previous year which was available for early nesting. In 1962, following a winter with record snow depths, cover in roadside was completely flattened and prostrate, and thus did not offer attractive nesting sites. In 1964, however, the general absence of snow in the winter preceding the nesting season probably resulted in much early nesting in roadsides, thus resulting in a larger proportion of the hatch occurring here than in the 2 previous years (Table 31).

Waste areas and pastures were not important in production. Although nest densities and success of nests in these types were sometimes relative-

ly high, the small per cent of the total nesting acreage in these types precluded any significant contribution to production.

Baskett (1947) reported successive increases in production each year during the period 1939-1941 on the 1520-acre Winnebago Area; the number of chicks hatched was 352 in 1939, 478 in 1940 and 954 in 1941 for a mean during the 3 years of about 250 chicks. As computed from Baskett's data this was equal to 148, 201 and 401 chicks per section produced on the Winnebago Area in 1939, 1940 and 1941, respectively. Klonglan (1955b) in 1954 on this same area reported a production of 345 chicks, or about 145 chicks produced per section.

Randall (1940) reported 776 chicks (296 chicks per section) produced on a 1675-acre sample tract in typical first-class pheasant range in Pennsylvania. On Pelee Island, Ontario, where pheasant populations by comparison with most other areas are exceptionally high, production of chicks was estimated at 62,483 in 1949 and 60,401 in 1950, or about 3964 and 3833 chicks per section, respectively (Stokes 1954). Linder et al. (1960) in what is considered poor to fair pheasant range in Nebraska, reported an average of only 496 chicks produced on seven sections during a 5-year period, or approximately 70 chicks per section. Highest production was in 1958 with 93 chicks per section and the lowest in 1955 when only 48 chicks were hatched per section. In Iowa's presently best pheasant range in a restricted area in southwestern Iowa, Klonglan (1962) in 1957 and 1958 estimated chick production at 447 and 471 chicks per section, respectively. Thus, production of chicks on the Northern Area in central Iowa during the period of the present study was low on the average compared

to estimates of chick production from most other areas reported in the literature, with the exception of the Nebraska study. The production which occurred on the Northern Area in 1963, however, equaled that reported by Baskett (1947) in 1939 and Klonglan (1955b) in 1954 on the Winnebago Area.

During the 3 years on the Northern Area the number of nests per hen in the breeding population ranged from 0.8 in 1962 and 1964 to 1.6 in 1963, with a mean of 1.0 (Table 32). The average number of eggs and chicks produced per hen averaged 8.7 and 2.1, respectively. Approximately 25 per cent of the hens in the spring population on the average were estimated to have been successful in bringing off a brood.

On the Winnebago Area, as computed from the data of Baskett (1947), on the average about 1.9 nests were established and 4.3 chicks were produced per each hen in the spring breeding population during his 3-year study (Table 33). The lowest number of nests per hen recorded was 1.3 in 1939, but as the population continued to increase, proportionately more nests were established per hen. The number of chicks produced per hen generally increased during this same period, reaching a high of 4.8 in 1941. The per cent of hens in the spring population which were successful in bringing off a brood also increased during this period, beginning at 40 per cent in 1939 and reaching a high of 54 per cent in 1941. Computations of these same indices from the data of Klonglan (1955b) indicated that reproductive success in 1954 was somewhat lower than during the 3 years of Baskett's (1947) study (Table 33). Computations of these indices from other studies where permitted by the data are presented in Table 33

Table 32. Indices of production, Northern Area, 1962-1964

	Year			
	1962	1963	1964	1962-1964
Nests per hen	0.8	1.6	0.8	1.0
Eggs per hen	6.8	13.7	7.0	8.7
Per cent hens successful	22	38	16	25
Chicks per hen	1.8	3.0	1.6	2.1
Chicks per successful hen	8.1	8.1	9.4	8.5

Table 33. Indices related to production as indicated in reported investigations of pheasant reproduction

Reference	Year	Index				
		Nests per hen	Eggs per hen	Per cent hens successful	Chicks per hen	Chicks per successful hen
Baskett 1947	1939	1.3		40	4.2	8.7
	1940	1.6		41	3.7	9.1
	1941	2.4		54	4.8	8.6
Randall 1940	1939			45	3.8	8.5
Stokes 1954	1949			85		8.7
	1950			77		8.3
Klonglan 1955b	1954	1.9	11.5	32	2.7	8.2
Linder <u>et al.</u> 1960	1955-1959	2.9	22.9	44	3.4	7.8
Klonglan 1962	1957			43	4.1	9.5
	1958			42	4.0	9.5

along with those from the early Iowa studies.

Certain indices obtained during the present study appeared considerably lower on the average than those from the other studies, particularly the number of nests and chicks per hen and the per cent of hens successful (Tables 32 and 33). However, it seemed likely that the reduced nature of these indices was in large part the result of overinflated censuses of breeding populations, especially those made during the late winter in 1962 and 1964. Two large concentrations of pheasants containing almost 200 birds each were located on the perimeter of the census area during both years and apparently included in addition to resident birds pheasants from adjoining sections which did not normally remain to nest on the study area. Consequently, indices based on such counts would erroneously indicate poorer reproductive success than that which actually occurred. By contrast, in 1963 estimates of the breeding population were obtained from a total count of territorial cock pheasants in conjunction with spring sex ratios, and thus, judging by the larger production indices for that year (Table 29) this census appeared less subject to this source of bias. Even in 1963, however, the indicated indices were slightly lower than would be expected on the basis of the same indices calculated from other investigations, particularly the average number of chicks produced per hen (Table 30). It therefore appears that chick production for the 3 years may have been slightly underrated; the number of nests missed each year may have been somewhat higher than first estimated. In 1964, especially, the production of chicks was probably underrated. The number of juvenile pheasants per mile from roadside counts in 1964 on the Northern

Area was 2.5, about the same as in 1963 (Table 31). Similarly, winter counts in late February, 1965 on this area revealed a population of 102 pheasants per section, the same as recorded in the breeding population of 1964. Thus, it is likely that chick production in 1964 was also about the same as in 1963, and not down slightly as previously indicated.

A comparison of the average number of young birds observed per mile during brood counts on the Northern Area and the Winnebago Area in relation to the late winter populations on each area additionally points to exaggerated counts of the pheasant breeding population as the main reason for the lower production indices on the Northern Area (Table 31). Even though the estimated population of breeding hens on the Northern Area was only 17 per cent less than on the Winnebago Area the average number of young birds per mile from roadside brood counts in the late summer of 1962 on the Northern Area was 60 per cent fewer than on the Winnebago Area. Similarly, despite the poor rate of reproduction on the Winnebago Area in 1963 compared to the Northern Area, the average number of young birds per mile was over 32 per cent greater on the Winnebago Area, even though the difference between the breeding population of hens between the two areas was only 22 per cent. It was possible that the observability of young birds may have varied on the two areas due to possible differences in behavior of young, arrangement and patterning of cover, phenology of the hatching season or other unknown causes, but it seemed unlikely that this could have accounted entirely for the apparent disagreement in the ratio of the young birds-per-mile index to the breeding hen population on the two areas (Table 31).

During the 3 years the apparent primary factor responsible for variations in the rate of production of chicks was the per cent of hens which were successful in bringing off broods (Figure 16). The number of chicks produced each year, in turn, appeared to be the major factor determining the following year's breeding population of hens (Figure 17). In 1962, an indicated 22 per cent of the hens were successful, resulting on the average in the production of 1.8 chicks per each hen in the breeding population, while in 1963, 38 per cent of the hens were successful and an average of 3.0 chicks were produced per hen. Similarly, in 1964 a reduction in the number of hens successful resulted in a corresponding decrease in the chicks per hen index; however, a secondary factor, the number of chicks per successful hen (average number of eggs hatched per successful nest) also appeared to influence production in 1964. In both 1962 and 1963, the number of chicks produced per each successful hen was 8.1, but in 1964 an average of 9.4 chicks was produced, resulting in the production of approximately 16 per cent more chicks than would have been expected that year had the average number of chicks per successful hen been 8.1 as in the other 2 years.

Linder et al. (1960) during a 5-year study of pheasant reproduction in southcentral Nebraska, reported considerable variation between years in the tendency of hens to reneest. During years when breeding populations were low, the average number of nests recorded per each hen in the population was also low, but as the population increased each successive year during the 5-year period a corresponding increase in the number of nests established per hen was noted. Even though the number of nests per hen

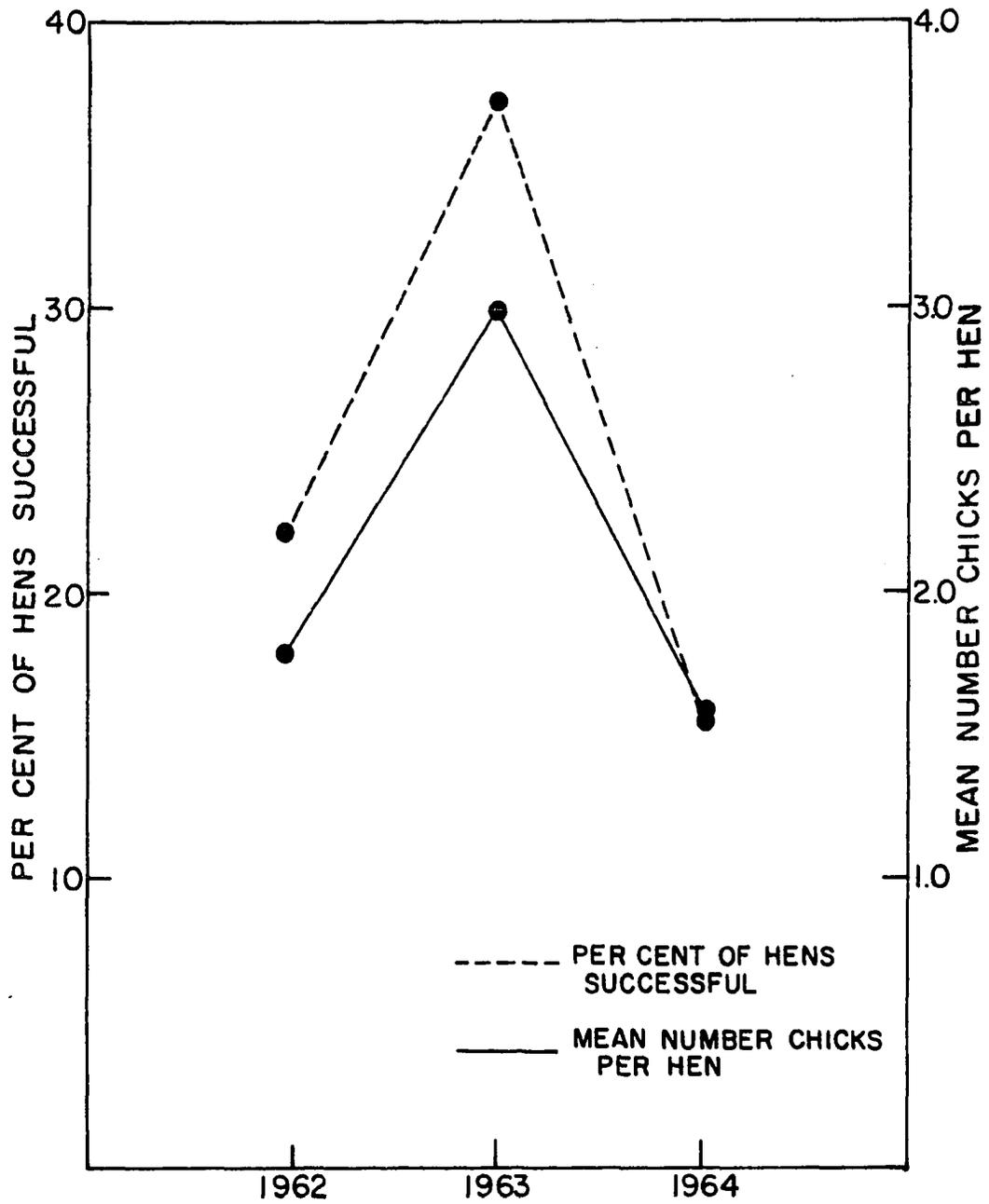


Figure 16. Relationship of per cent of hens successful and rate of chick production on the Northern Area, 1962-1964

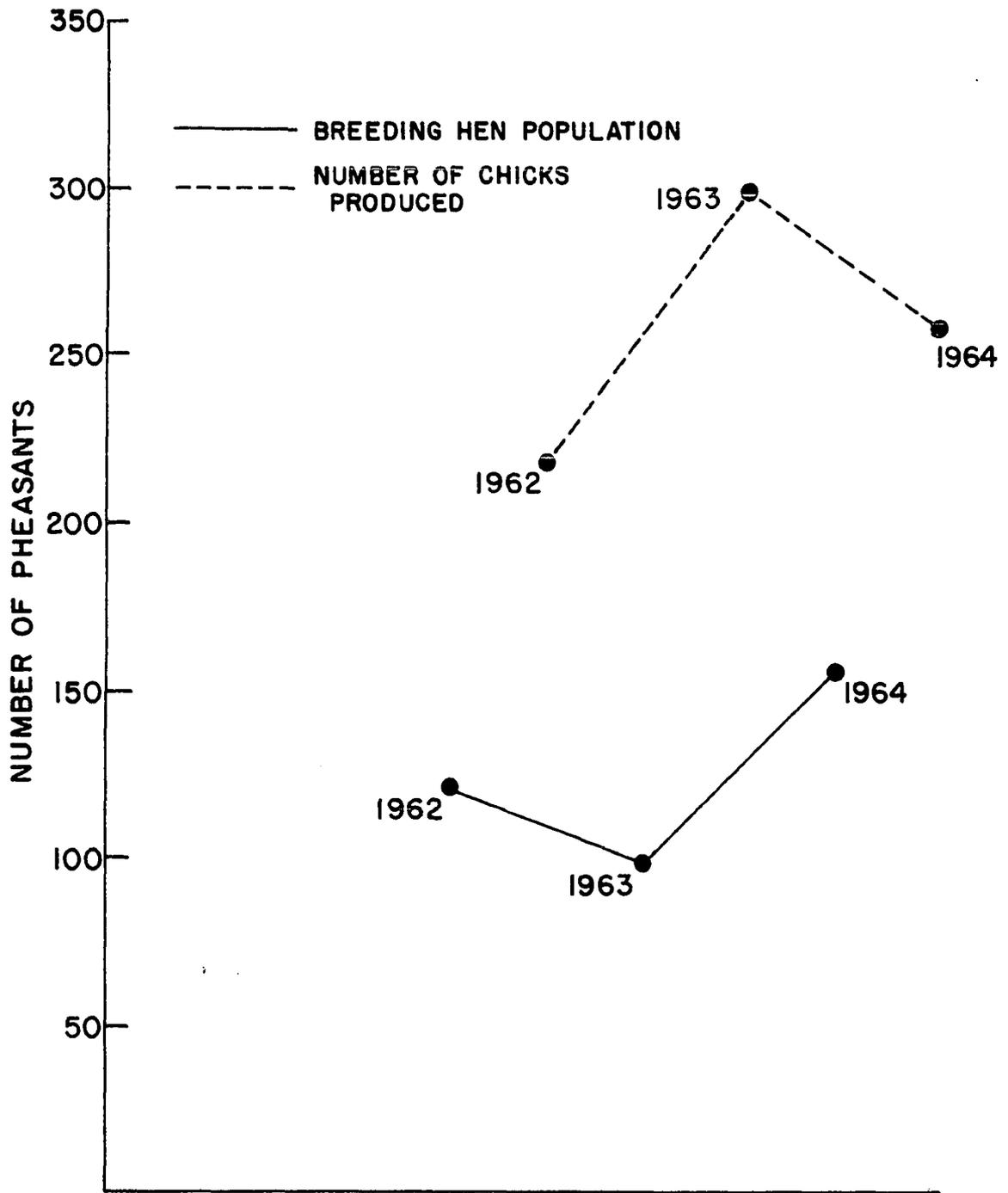


Figure 17. Relationship of chick production and number of hens in the breeding population, nesting study portion of the Northern Area, 1962-1964

increased, however, the average number of eggs per nest declined and the total number of eggs laid by each hen each year remained almost constant. The authors thus suggested that the larger number of nests established in years of high breeding populations reflected a greater incidence of voluntary abandonments which the hen made no attempt to incubate, and therefore indicated that in years of higher population less actual effort was spent in incubation even though more nests were laid. The data of Baskett (1947) indicate that a somewhat similar relationship between population and number of nests per hen existed on the Winnebago Area during the 3 years of his study (Table 33), although the successive yearly increases in both the per cent of hens successful and the number of chicks per hen indicate that greater persistence in nesting and incubation, rather than less, was the major probable reason for the increase in the number of nests per hen. In the present study, however, the opposite relationship appeared to hold true; the highest average number of nests per hen was recorded in 1963, the year with the lowest breeding population (Table 32). Conversely, in 1962 and 1964, years with comparatively high populations, the number of nests per hen was only one-half that of 1963. Moreover, the average number of eggs per nest was about the same during the 3 years, and the average number of eggs per hen in the breeding population decreased as the breeding population increased. Therefore, it appeared that during the period of the study, the years of higher population were characterized by low nesting effort but with about the same attention to incubation as in years of lower population.

Indices of reproductive success      Several indices of reproductive success such as average brood size, per cent young-of-the-year, young per hen, young per adult, young birds per mile and per cent of hens with broods are obtainable from summer roadside counts, but only two of these-- the average number of young per mile and the per cent of hens with broods-- have in practice been found useful.

Theoretically, each of these two indices should provide a measure of the year-to-year changes in the success of nesting, but each is subject to various biases, some of which have already been discussed in the section on progression and distribution of the hatch. Other biases, however, are specific for each index. The amount of dew present during the roadside counts apparently is the major factor influencing the number of pheasants observed on or near the road. Klonglan (1955a) demonstrated a strong correlation between dew and the mean number of pheasants seen during early-morning summer roadside counts in northcentral Iowa. If his findings can be projected to other areas, then it is apparent that the proportion of the total roadside counts after all counts have been secured, which fall within each of the various categories of dew density will influence the mean number of birds observed. Thus, to be able to directly compare this index from different areas, the proportion of counts within each category must be approximately equal, or only those counts which were obtained under the same conditions of dew should be compared. However, comparisons of counts from areas separated spatially or from areas differing in land usage must be made with caution, since despite similar dew readings, the observability of pheasants may differ significantly between

Table 34. Young-pheasants-per-mile index from roadside counts of heavy and moderate dewfall in relation to breeding populations on the Northern and Winnebago areas, 1962-1964

	Year		
	1962	1963	1964
Northern Area			
Breeding hen population(a)	239	196	320
Young birds per mile	1.2	2.3	2.4
Young per mile x 100(b)	120	230	250
Ratio: $\frac{b}{a}$	0.5	1.2	0.8
Winnebago Area			
Breeding hen population(a)	285	252	209
Young birds per mile	3.0	3.4	4.3
Young per mile x 100(b)	300	340	430
Ratio: $\frac{b}{a}$	1.1	1.4	2.1

areas due to differences in pheasant behavior, cover conditions and climatic factors.

The per cent of hens with broods index is subject, also, to various potential sources of bias. Data from South Dakota showed that the weekly observed per cent of hens with broods increased during the summer (Kimball et al. 1956), and thus the time during which the counts are made will influence the data obtained. Therefore, for this purpose counts taken during widely separated time periods during the summer cannot be directly compared. Also, as Kimball et al. (1956) pointed out, very young birds are not always seen with the hen due to their small size and greater dependency on camouflage and concealment rather than flight. Occasionally,

the reverse is also true. Hens usually seek cover more quickly than young birds when approached by a moving vehicle, so that occasionally the hen may not be seen with the brood, particularly if heavy escape cover is available nearby. Probably the most important potential sources of bias, however, stem from possible differences in the behavior of successful hens, unsuccessful hens and those still incubating. As Kimball et al. (1956) pointed out, at the time of the counts some hens may still be incubating and thus will not be seen. Unsuccessful hens have begun to molt and probably are more secretive, retiring into heavier cover and not appearing readily along roads. Such sources of bias would thus cause the counts to indicate a higher per cent of hens successful than was actually true. However, so little is known about hen behavior during this period that conclusions cannot be drawn concerning the influence of this factor on the per-cent-of-hens-with-broods index.

In light of Klonglan's (1955a) findings regarding the influence of dew on the numbers of birds observed during roadside counts, in the present study four arbitrary classifications of dew density were established: heavy, moderate, light and none. Since in practice this type of count is secured only under optimal or near optimal conditions of dew to permit the acquisition of a large number of observations, only counts in the High and Moderate categories were used in calculating the young-birds-per-mile index. There was no reason to believe, however, that the per-cent-of-hens-with-broods index would be similarly affected by dewfall and consequently, counts in all dew density categories were used in the

calculation of this index. To minimize the problem of increasing percentage of observed hens with broods during the course of the summer mentioned by Kimball et al. (1956), only counts obtained after the end of the third week in July were used.

During each of the 3 years on the Northern Area, the young-birds-per-mile index seemed to offer a fairly reliable basis for predicting both chick production and the number of birds in the breeding population the following year (Table 35). In 1962, the young-birds-per-mile index of 1.2 was followed by a decrease in the spring hen population from 239 in 1962 to 196 in 1963. A sharp increase in production in 1963 was reflected in a corresponding increase in the birds-per-mile index to 2.3. The index of 2.4 young pheasants observed per mile in the summer of 1964, however, as previously mentioned indicated that the estimate of production for that year was too low; the equally high breeding populations in 1964 and 1965 appeared to confirm this. A similar but weaker relationship appeared to exist on the other Central Iowa Areas as well (Table 35).

On the Winnebago Area, however, the change in the average number of young birds observed per mile during roadside counts from year to year did not seem to correspond to changes of the same magnitude in the breeding population (Table 35). In 1962, the recorded index of 3.0 young per mile preceded a decline of 22 per cent in the spring breeding population from 404 pheasants to 316 in 1963. In 1964, an index of 3.4 reflected another but lesser decrease in the population of 18 per cent. The index of 4.3 young per mile in 1964 was followed by a breeding population in 1965 only equal to that of 1964. Thus, on the Winnebago Area

Table 35. Relationship of young-birds-per-mile index and per-cent-of-hens-with-broods index to production estimates and breeding population of the following year, Central Iowa and Winnebago areas, 1962-1964

Year	Young-birds-per-mile-index	Number counts providing data	Calculated chick production	Per cent hens with broods	Number counts providing data	Breeding population following year
Northern Area						
1962	1.2	13	217	49	12	249
1963	2.3	5	297	57	5	407
1964	2.4	13	257	62	14	408
Middle Area						
1962	0.4	13		56	13	61
1963	1.1	3		64	4	114
1964	0.7	9		59	14	112
Southern Area						
1962	0.2	4		34	6	58
1963	0.7	7		77	6	73
1964	0.7	10		53	11	75
Winnebago Area						
1962	3.0	4		71	4	316
1963	3.4	4		65	5	258
1964	4.3	6		75	6	260

the young-birds-per-mile index during each of the 3 years for unknown reasons did not appear to offer a method for predicting year-to-year changes in pheasant production. However, the number of counts on which this index was based was small. Perhaps more counts would have provided a more reliable index figure. Also, since the Winnebago brood route was as much as 4 miles from the 4-section census area, it is possible that the data collected may not have been representative of study area itself.

The per-cent-of-hens-with-broods index showed no apparent relationship to changes in the level of the breeding population (Table 35). An increase in this index on the Northern Area from 1962 to 1963 paralleled a corresponding increase in both chick production and the breeding population the following year; however, in 1964 the per-cent-of-hens-with-broods index was about the same as in 1963, but because the breeding population in 1964 was almost 39 per cent greater than in 1963, a corresponding increase in the young-birds-per-mile index should have been expected. Instead, chick production, as indicated by this latter index, was about the same as in 1963. Thus, if the per cent of hens with broods indices can be trusted, a considerably greater mortality of adult hens must have occurred prior to nesting in 1964. The per cent of hens with broods indices from the Middle and Southern areas showed even less relationship to changes in the levels of the breeding populations on those areas (Table 32), but this may have been partially attributable to the small number of observations obtained per count.

Similarly, no consistent relationship between this index and breeding populations was noted on the Winnebago Area. Even though the breeding

population steadily decreased from 1962 through 1964, finally leveling off in 1965, the per cent of hens with broods remained about the same during this same period (Table 32). Thus, it appeared that due either to sources of bias inherent in the counts themselves, or to yearly differences in adult hen mortality, the per cent of hens with broods index was of little value for predicting the yearly changes in the level of the breeding populations.

#### Causes of nest failure

The cause of nest failure in any given instance often could not be assigned with certainty to a specific agent, and thus the importance and role of particular agents in nest destruction were difficult to determine. Destruction of nests in hay, for example, was most often attributed to mowing, but since mowing activities often caused crushing and scattering of nests and eggs, it was frequently impossible to determine the proportion of such nests which might have been abandoned or deserted or destroyed by predators prior to mowing, particularly if a few days had elapsed between mowing and a search of the field for nests. Nests in other cover types, especially in a non-agricultural type such as roadside, were subject to high rates of predation, and yet it was not possible to determine if some of these nests had not first been abandoned or deserted and only secondarily disturbed by predators. Furthermore, in most cases it was not possible to determine which species of predator was responsible for the destruction of a nest. Nest destruction by predators was most common in roadsides and waste areas, usually during the early part of the

nesting season. Since in some years it was not possible to search some roadsides until mid-July, many of the nests found were fragmentary and well-weathered. Although destroyed nests attributed to predation had obviously been molested by predators, there was no assurance that they had not been deserted or abandoned first.

Stokes (1954) distinguished between abandonment and desertion. Abandoned nests he defined as those unincubated nests which had been voluntarily vacated, while deserted nests by definition were all nests incubated or unincubated, which hens left after first having been disturbed by a predator or some other agent. This differentiation was not made in the present study since it was felt that no useful distinction could be made as to whether a hen had left a nest "voluntarily" or "involuntarily." Furthermore, it seemed of little importance whether a nest had been incubated; it appeared likely that hens might leave a nest voluntarily during incubation as well as during laying and therefore "desert" or abandon for the same reason.

Of the 275 nests found during the 3 years on the Central Iowa Areas, including nests found through supplemental searching and nests reported by farmers as well as those found on sample plots, 213 (78%) were unsuccessful (Table 36). The principal factor in nest failure was farming operations, which accounted for 144 (52%) of all nests. The remaining nest failures were due to predation (20%), abandonment or desertion (3%), trampling by livestock (1%) and flooding (< 1%). The cause of failure for four nests (2%) could not be determined.

Farming operations

Farming activities, mainly mowing of hay, were

Table 36. Fate of nests on the Central Iowa Areas, 1962-1964

Cover type	Total nests found	Successful nests	Abandoned or deserted nests	Undetermined	Destroyed nests					
					Predation			Farming operations	Flooding	Live-stock
					Mammal	Bird	Total			
Hay	170	28	0	3	6	1	7	131	0	1
Oats	38	13	4	0	13	0	13	8	0	0
Roadside	49	16	3	1	23	0	23	5	1	0
Pasture	8	3	0	0	3	0	3	0	0	2
Waste areas	10	2	0	0	8	0	8	0	0	0
Totals	275	62	7	4	53	1	54	144	1	3
<i>Per cent of nests</i>		23	3	2	19	<1	20	52	<1	1
<i>Per cent of unsuccessful nests</i>			3	2	25	<1	25	68	<1	1

the most important single cause of nest destruction (Table 33). Approximately 52 per cent of the total nests and 68 per cent of the unsuccessful nests were attributable to this cause. Within this category, hay mowing accounted for approximately 48 per cent and 62 per cent of the total nests and unsuccessful nests, respectively. Combining operations in oat-fields and infrequent mowing of roadsides accounted for the remaining 13 nests.

Bolstad (1962) reported that of all unsuccessful nests found on the Central Iowa Areas in 1960, approximately 63 per cent could be attributed to hay mowing and oat harvesting. Of these, hay mowing accounted for over 57 per cent.

Baskett (1947) found almost 41 per cent of all nest failures were due to man's agricultural activities during the period 1939-1941 on the Winnebago Area, and Klonglan (1955b) 13 years later reported that over 61 per cent of all nest failures were due to mowing and combining operations in hay and oats. The destruction of the majority of these nests (approximately 60%) were attributed to hay mowing.

Other studies of pheasant nesting indicate similar proportions of nest failures due to man's agricultural activities. Hamerstrom (1936) reported approximately 26 per cent of the total nests and 38 per cent of the unsuccessful nests attributable to mowing activities or other farm-work. Randall (1940) in Pennsylvania recorded more than 45 per cent of all nests and almost 57 per cent of the unsuccessful nests destroyed by agricultural activities, including mowing of hay. Knott *et al.* (1943) in Washington state found that failure of nests due to farming activities

accounted for 35 per cent of the total nests found and almost 80 per cent of the unhatched nests. Similarly, in the Willamette valley in Oregon, Eklund (1942) found that approximately 37 per cent of all nests and 71 per cent of the unsuccessful nests were attributable to farming operations. Linder et al. (1960) reported over 37 per cent of the total nests established during a 5-year period were destroyed by farming activities, including about 22 per cent by alfalfa-mowing operations. During 6 years of pheasant investigations in Wisconsin, Buss (1946) found that approximately 40 per cent of the total nests and over 60 per cent of the unhatched nests failed because of agricultural activities, largely hay mowing. Klonglan (1962) assigned 28 per cent of the unhatched nests to a classification comprising nests destroyed by farming activities; however, if the nests which were deserted due to seed stripping operations in bluegrass pastures grown for seed were included, nearly 34 per cent of all nest failures were traceable to man's farming activities. Stokes (1954) and Shick (1952), however, reported much less nest destruction due to this factor. Shick (1952) on the Prairie Farm in Michigan found less than 20 per cent of all unsuccessful nests accountable to man's agricultural operations, while Stokes (1954) recorded less than four per cent of all nest failures in this category. Both these studies, however, were conducted in areas in which pastures, waste areas, sloughs, ditches and roadbanks constituted most of the nesting cover, and thus little nest destruction from this factor in such non-agricultural nesting types would be expected. Thus, the magnitude of nest destruction on the Central Iowa Areas due to farming activities, especially hay mowing, was well

within the range of that reported both for the Winnebago Area by Baskett (1947) and Klonglan (1955b), and in other studies conducted throughout the pheasant range in which destruction of nests has been tabulated.

The loss of nests from mowing activities on the Central Iowa Areas showed little variation between 1962 and 1963 (Table 37); however, in 1964 the proportion of the nest failures due to this factor increased sharply to over 76 per cent. This difference was the direct result of the large number of nests established in hay in 1964 compared to the other 2 years.

Predation Next to farming operations, predation was the most important single cause of nest destruction on the Central Iowa Areas (Table 37). Approximately 20 per cent of the total nests and 25 per cent of the unhatched nests were attributed to predation, almost all of which was mammalian predation. Bolstad (1962) reported that of all unsuccessful nests found on the Central Iowa Areas in 1960, 22 per cent failed as a result of predation. The rate of destruction from this cause in both Bolstad's (1962) study and the present study was somewhat lower than the 38 per cent nest failure recorded by Baskett (1947) for the Winnebago Area. In contrast, Klonglan (1955b) on the same area found only 13 per cent of the unsuccessful nests failed because of predation. However, as Klonglan (1962) pointed out, it is possible that the population of predators on the Winnebago Area had declined considerably during the 14-year interval between the two studies, since a substantial decrease in the amount of favorable habitat, particularly sloughs and native meadows, had occurred during this period. Furthermore, it appeared likely that

Table 37. Fate of nests on the Central Iowa Areas, 1962, 1963 and 1964

Cover type	Total nests found	Successful nests	Abandoned or deserted nests	Undetermined	Destroyed nests					
					Predation			Farming operations	Flooding	Live-stock
					Mammal	Bird	Total			
1962										
Hay	43	11	0	2	3	1	4	26	0	0
Oats	9	4	1	0	3	0	3	1	0	0
Roadside	7	4	0	0	2	0	2	1	0	0
Pasture	7	3	0	0	3	0	3	0	0	1
Waste areas	2	0	0	0	2	0	2	0	0	0
Totals	68	22	1	2	13	1	14	28	0	1
Per cent of nests		32	2	3	19	2	21	41	0	2
Per cent of unsuccessful nests			2	4	28	2	31	61	0	2
1963										
Hay	43	7	0	0	3	0	3	33	0	0
Oats	19	5	1	0	8	0	8	5	0	0
Roadside	16	4	1	0	9	0	9	1	1	0
Pasture	1	0	0	0	0	0	0	0	0	1
Waste areas	5	1	0	0	3	0	3	1	0	0
Totals	84	17	2	0	23	0	23	40	1	1
Per cent of nests		20	2	0	27	0	27	48	1	1
Per cent of unsuccessful nests			3	0	34	0	34	60	2	2

Table 37. (Continued)

Cover type	Total nests found	Successful nests	Abandoned or deserted nests	Undetermined	Destroyed nests					
					Predation			Farming operations	Flooding	Livestock
					Mammal	Bird	Total			
1964										
Hay	84	10	0	1	0	0	0	72	0	1
Oats	10	4	2	0	2	0	2	2	0	0
Roadside	26	8	2	1	12	0	12	3	0	0
Pasture	0	0	0	0	0	0	0	0	0	0
Waste areas	4	1	0	0	3	0	3	0	0	0
Totals	124	23	4	2	17	0	17	77	0	1
Per cent of nests		19	3	2	14	0	14	62	0	1
Per cent of unsuccessful nests			4	2	17	0	17	76	0	1

the lack of early nesting in 1954 contributed to the lower proportion of nests destroyed by predators that year, since the earlier nests usually suffered the highest predation losses.

Other studies conducted throughout the continental pheasant range show considerable variation in the proportion of nest failures ascribed to predation. Hamerstrom (1936) in Iowa found that 15 per cent of the total nests and over 19 per cent of the 343 unsuccessful nests found failed because of predation. Randall (1940) accredited 25 per cent of all nests and 31 per cent of the unhatched nests to predation. Eklund (1942), however, recorded a much lower proportion of nest failures due to this factor; less than 9 per cent of the unsuccessful nests and 6 per cent of the total nests failed because of predation. Similarly, Knott et al. (1943) attributed only 7 per cent of all nest failures to predation. In Wisconsin, Buss (1946) recorded a slightly higher rate of predation, finding 12 per cent of the total nests and over 20 per cent of the unhatched nests failed as a result of predation. Stokes (1954) and Shick (1952), conducting pheasant investigations in "atypical" pheasant range where nesting cover was largely non-agricultural, found predators were responsible for 17 per cent and 21 per cent, respectively, of all nest failures.

Such a wide spread in the apparent importance of predation, however, should be viewed with caution. Since no measure is possible of the number of nests destroyed by predators before "destruction" by farming activities, particularly hay mowing, it is probable that farming activities mask the true importance of predation in agricultural nesting types. Also, a

small percentage of nest destruction attributable to predation may merely indicate heavy destruction or failure of nests by some other agent, since nests in all categories are represented on a percentage basis. Furthermore, a high rate of predation does not necessarily indicate a poor rate of production; renesting may eventually compensate for the failure of earlier nesting attempts. For example, on Pelee Island (Stokes 1954) and on the Prairie Farm (Shick 1952) the indicated rate of nest predation was fairly low. On Pelee Island mammalian predators were rare and avian predation was not considered important; however, nest abandonment was exceedingly high when compared to other studies. Incidence of predation on pheasant nests on the Prairie Farm likewise was low, but here, too, abandonment and desertion were high even though predators were common. Perhaps the exceptionally good nesting cover typical of the Prairie Farm prevented the discovery of abandoned and deserted nests by predators, thereby resulting in the assignment of a larger proportion of such nests to an "abandoned" or "deserted" category than occurs in most other studies.

In any event, the percentages of nests destroyed each year on the Central Iowa Areas were well within the limits of normality as judged by the studies previously reviewed (Tables 36 and 37). No important difference in rate of predation was noted between 1962 and 1963. In 1964, however, the per cent of all nests destroyed by predators decreased to approximately 17 per cent, reflecting the large number and high rate of destruction of nests that occurred in hay that year.

The number and species composition of predators residing on the Central Iowa Areas was not known. Also, as pointed out previously on

page 150 of this section, the particular mammalian species responsible for the destruction of many nests could not be determined due to the condition of the remaining evidence when the nest was found. As a result, no attempt was made to specify the particular predator responsible for the destruction of a nest except to differentiate between mammalian and avian predation. However, mammals thought to be most important in nest destruction were the striped skunk (Mephites mephites), badger (Taxidea taxus) and feral house cat (Felis domesticus). Thirteen lined ground squirrels (Citellus tridecemlineatus) were known to infrequently carry eggs from nests, and occasionally the destruction of a nest could be attributed to racoons (Procyon lotor), particularly on the Middle Area where a heavily-wooded stream valley bordered the southern portion of the area on the west. Surprisingly, during May, June and July crows seemed to be uncommon in the area. Although these birds were occasionally seen in freshly-cut hayfields, only one destroyed nest during the 3 years could definitely be attributed to crow predation. Bolstad (1962), in contrast, had reported that 6 out of 11 predator-destroyed nests were traceable to predation by crows.

Abandonment and desertion Abandonment and desertion of nests on the Central Iowa Areas were recorded only in oats and roadside. These nests accounted for less than 3 per cent of the nests found during the 3 years (Table 36). Bolstad (1962) reported that over 14 per cent of 49 nest failures on these areas in 1960 were attributable to either abandonment or desertion; however, one of these nests was deserted only after repeated visits to the nest, and consequently probably should not have

been included in this classification. Baskett (1947) during his 3-year study recorded approximately 20 per cent of the unsuccessful nests in this category, although the inclusion in this category of nests at which either the hen, nest or cover had been disturbed by agricultural activities makes direct comparison of this figure with those from other studies somewhat difficult. The impression is gained from his data, however, that losses due to abandonment or desertion were *not noticeably* different from those reported in other studies. Klonglan (1955b) reported that over 18 per cent of the nests found on the Winnebago Area in 1954 had been abandoned or deserted. In this latter study, however, dump nests comprised almost 30 per cent of the abandoned and deserted nests, while in Baskett's (1947) study only 12 per cent of the nests in this category were dump nests. Klonglan (1962) attributed this difference to the unusually late nesting season on the Winnebago Area in 1954.

The abandonment or desertion of nests reported in other studies shows considerable variation, ranging from 2 per cent (Hamerstrom 1936) to 39 per cent (Stokes 1954) under field conditions, and as high as 64 per cent in pen studies (Buss et al. 1951). However, classifications of abandonment and desertion are frequently defined so differently that direct comparisons between studies are often meaningless. A few of these studies, however, are especially interesting because of the unique opportunity they offer for a more thorough understanding of the role of abandonment in pheasant nesting ecology. Stokes (1954) attributed the high rate of abandonment to the extremely high populations characteristically found on Pelee Island, and he postulated that eventual control

of the population might be a rate of abandonment so high that nesting success would barely compensate for annual mortality. Furthermore, by comparing rates of abandonment in several of these studies to the density of the nesting hen population he showed that, in general, abandonment increases with breeding density. Klonglan (1962) lent support to this hypothesis by showing that the number of hens per section in the breeding population on the Winnebago Area and another pheasant research area in Union and Adair counties in southwestern Iowa was closely correlated with the per cent of nests abandoned each nesting season. It is also interesting to note in this connection that the highest rates of abandonment have been reported in pens (Buss et al., 1951 and Seubert 1952), under conditions where birds were forced to live at densities never attained in the wild.

During the 3 years on the Central Iowa Areas, only seven nests were found which could with certainty be claimed as being deserted or abandoned, and thus little could be concluded about the importance of this type of nest failure in the different years. It is worth recounting, however, that abandoned and deserted nests were found only in oats and roadside. Even though no such nests were recorded in hay, judging by the two former cover types it was likely that similar nests in hay were not recorded because of the complications introduced by destruction of nests and eggs as a result of mowing. If the same proportion of abandoned or deserted nests was present in this type as had occurred in oats and roadside, perhaps as many as from 20 to 30 such nests may have been located in hay during the 3 years. This would have raised the losses of nests due to

abandonment or desertion to a level more in keeping with that reported in most of the other studies.

Causes of nest destruction in the present study other than those already discussed were of no importance, at least during the 3 years of the study. The loss of only a single roadside nest was ascribed to flooding, even though the bottoms of some ditches were temporarily flooded each spring (Table 33). Trampling of nests by livestock in pastures was recorded only rarely, but since some early nests in this type were probably not found, this cause of destruction may have been more common than recorded. One nest was destroyed in hay by a sow which had wandered into a hayfield after escaping from a feedlot.

#### Juvenile mortality

A knowledge of juvenile mortality is fundamental to a thorough understanding of the population dynamics of the pheasant or any other game species, and yet this remains perhaps the most evasive statistic in all population studies of upland game birds. Unfortunately, in the late summer and early fall at the time such data are collected, cover is both plentiful and luxuriant, and chicks are so extremely secretive and adept at self-concealment that making periodic complete censuses of young birds during this period is not practicable; therefore, other means of obtaining estimates or indices of juvenile mortality must be employed. In the past some investigators have used decrease of brood size from hatching to some designated age as a measure of juvenile mortality. By knowing the average number of hatched eggs per nest and observing the progressive shrinkage in brood size with time, the mortality rate over the period of

observation can be estimated. Because this method permits securing a relatively large number of brood observations, it was adopted for use in the present study.

Observations of broods were made while driving along designated routes at sunrise (Figure 6), and during the performance of other daily field activities. An attempt was made to flush all broods, the surrounding area being searched as thoroughly as possible to make certain all chicks in the brood had been seen. Most observations of brood were obtained in this manner. Some birds were counted as they fed undisturbed along fence-rows and field borders, and in most cases accurate counts were obtained; however, counts also included other broods which were sighted in hayfields and oat stubble, sometimes at considerable distances from the vehicle. Although attempts were made to flush these birds to obtain a complete count, under such circumstances it was inevitable that some birds escaped detection and were not counted.

This method, however, was subject to a number of biases, some serious and of undeterminable magnitude. Young hens over 10 or 11 weeks of age had attained near-adult size and were usually indistinguishable from adult hens, particularly if no juvenile cocks were present in the brood. Furthermore, it is believed by pheasant biologists that some chicks may become independent of the hen by as early as 10 or 11 weeks of age so that broods older than this may not have contained all members of the brood at the time of observation.

Very young broods, under 4 weeks of age, also presented problems in counting. As Kimball et al. (1956) pointed out, young broods are not

always seen with the hen, so that many of these are probably overlooked. Even if a brood of this age is sighted, however, because such young chicks cannot fly or do so only poorly, they tend to depend solely on hiding for protection; consequently it was often not possible to locate all chicks in the brood. In addition, as Klonglan (1962) postulated, it is probable that young broods, because they lack mobility, do not appear along the road as regularly as older broods and therefore tend to be counted in less than their true proportion in the population.

All of these above potential sources of bias associated with brood behavior, since they are of importance mainly in regard to either very young or old broods, could be satisfactorily avoided simply by omitting them from the analysis. Thus, in the present study only broods older than 3 weeks of age but less than 12 weeks of age were used for computing juvenile mortality. However, other sources of bias are more important and more difficult to avoid. Broods belonging to different hens and those which have become independent of the hen because of her death or other reasons, tend to intermingle, thus resulting in the counting of larger "broods," especially if the young of each brood are of the same or nearly the same age and difficult to tell apart. Conversely, broods which leave the hen voluntarily or are forced into independence prematurely by the death of the hen may also tend to disperse due to possible loss of direction, orientation and group cohesion caused by the absence of the hen. Data involving such scattered individuals would indicate smaller "broods" and lead to underestimates of the true size of broods, unless these chicks in turn join other broods. These two sources of error are

therefore in some measure compensating, but the degree of compensation in the present study was not known. In addition, the degree of independence of broods from the hen may vary from year to year. Stokes (1954) found that at high population levels pheasant chicks became independent of the hen at younger ages than normal, some broods leaving the hen as early as 8 weeks of age. Also, annual differences in the degree of independence from the hen could also be expected due to variation in the amount of adult hen mortality during the summer, since the death of a larger proportion of the hen population during this period would result in a larger percentage of "hen-less" broods.

It is also possible that broods hatched at different dates during the hatching season but recorded at the same age might show significant differences in average size due to differential exposure to weather factors or various agricultural practices, or because of seasonal differences in clutch size. This in turn would tend to mask the effects of mortality on brood size. This type of bias could be eliminated by securing a sample of brood observations large enough to classify broods not only by age but by week of hatching as well. Such large numbers of observations could be obtained only in areas with very high pheasant populations and were therefore not possible in the present study.

Other probable sources of error include not being able to estimate the number of entire broods that have been lost and the possibility that large broods are more easily observed than smaller ones. It is apparent, therefore, that this method of estimating juvenile mortality is only approximate, but it was the only method presently available which permitted

a large number of observations of broods in a limited amount of time. Furthermore, comparison of data from the present study with that obtained in a similar manner in other studies, should permit meaningful and relative comparisons regarding the amount and importance of juvenile mortality.

During the 3 years on the Central Iowa Areas, the average size of broods showed a steady decline from hatching to 12 weeks of age, with an overall mean brood size of 5.7 (Table 38). Mortality during this same period was estimated at approximately 41 per cent. Most of the mortality apparently occurred before chicks reached 4 weeks of age (Table 39). On these areas in 1960, Bolstad (1962) recorded an average brood size of 5.0 based on observations of 29 broods along a designated 30-mile route. The shrinkage in brood size from 8.9 at hatching to 5.0 therefore indicated a mortality of about 45 per cent.

Baskett (1947) on the Winnebago Area reported a mean brood size of 5.7 for broods 7 weeks of age and younger. Although he made no estimate of juvenile mortality during this period, based on the average number of eggs hatched per successful nest and the subsequent shrinkage in brood size, the mean juvenile mortality up to 8 weeks of age was approximately 35 per cent. Kozicky (1951) on this area estimated a loss of juvenile pheasants of approximately 30 per cent from hatching to 11 weeks of age, and Klonglan (1955b) 5 years later reported a loss of 2.3 chicks per brood or nearly 30 per cent, approximately the same figure reported by Kozicky (1951).

Other studies have indicated a similar rate of juvenile mortality.

Table 38. Relationship of mean brood size to age of brood on the Central Iowa and Winnebago areas

Age in weeks	1962		1963		1964		1962-1964	
	Number broods	Mean size	Number broods	Mean size	Number broods	Mean size	Number broods	Mean size
Central Iowa Areas								
2-3	2	1.0	4	6.5	13	5.5	19	5.3
4-5	7	7.0	10	6.7	39	6.2	56	6.4
6-7	12	6.9	22	6.4	62	5.7	96	6.0
8-9	20	4.8	19	6.4	51	5.4	90	5.6
10-11	25	5.1	17	6.2	34	4.4	76	5.2
Total	66		72		199		337	
Mean		5.4		6.4		5.5		5.7
Winnebago Area								
2-3	3	5.0	2	3.5	5	5.0	10	4.7
4-5	11	5.5	9	6.7	22	6.4	42	6.2
6-7	18	5.4	25	5.8	33	6.7	76	6.1
8-9	22	6.5	31	4.3	35	6.5	88	5.7
10-11	7	4.1	18	4.3	15	5.9	40	4.9
Total	61		85		110		256	
Mean		5.7		5.0		6.4		5.8

In Iowa, Errington and Hamerstrom (1937) observed a progressive shrinkage in size of broods of a magnitude which indicated a mortality of approximately 46 per cent by nine weeks of age. Stokes (1954) using a similar method on Pelee Island reported that chick mortality was about 36 per cent from hatching to 8-10 weeks of age. In southern Iowa, Klonglan (1962) demonstrated a steady decline in size of broods from hatching to 12 weeks of age during the period 1957-1959. An average of 2.9 chicks per brood, or about 31 per cent of the number that left the nest reportedly perished within less than 2 to 3 months after hatching.

Table 39. Mean size of broods at hatching and at 4 through 11 weeks of age on the Central Iowa Areas, and per cent mortality from hatching to 8-11 weeks of age

Year	Number of success- ful nests	Mean number of eggs per hatched nest	Age in weeks					Per cent mortality
			4-5	6-7	8-9	10-11	8-11	
1962	20	9.1	7.0	6.9	4.8	5.1	5.0	45
1963	17	8.8	6.7	6.4	6.4	6.2	6.3	28
1964	22	9.2	6.2	5.7	5.4	4.4	5.1	45
Mean	19.7	9.1	6.4	6.0	5.6	5.2	5.4	41

During the 3 years on the Central Iowa Areas, juvenile mortality as indicated by shrinkage in brood size was of similar magnitude in 1962 and 1964 but decidedly less in 1963. The reason for this was not known with certainty, but several interrelated factors appeared to be involved. As indicated in the section on the progression and distribution of the hatch, a much larger proportion of the hatch occurred during the peak of hatching in 1963 than in 1962 and 1964, and thus a greater percentage of the juvenile population was comprised by those broods hatching near or at the peak of the hatch. Therefore, if by chance no important adverse weather occurred during the interval of peak hatching, a much larger proportion of the juvenile population than usual would have passed through the vulnerable 1-4 weeks-old period when many normally die, without having been exposed to the well-known decimating affects of excessive moisture and/or cold temperatures. This, in fact, is what appeared to have occurred.

The peak of hatching occurred in the first week of June, and during the remainder of June and early July precipitation was almost 3 inches below normal; temperature, however, was more than 3 degrees above normal. Conversely, in 1964 the period of hatching was greatly protracted. Thus, a lower percentage of the juvenile population was comprised of broods hatching near the peak, and therefore a greater percentage of chicks in the 1-4 age group were subject to the frequent and periodic thunderstorms which occurred throughout June and July that year and resulted in precipitation which exceeded the normal during these two months by over 3 inches. The difference between the 2 years in the distribution of the hatch in conjunction with the distinctive temperature and rainfall patterns which occurred in each year may therefore have partially accounted for the apparent discrepancy in mortality rates (Table 39). The peak of hatching in 1962 was intermediate between 1963 and 1964 in relation to the proportion of the total hatch occurring at the peak, but more closely resembled the 1964 curve (Figure 12). Consequently, the similarity in mortality rates in these 2 years possibly may be partially explained on this basis.

Another factor which may possibly have influenced the better survival of chicks in 1963 was the earliness of the hatch. Stokes (1954) reported that chicks hatched early in the summer on Pelee Island showed better survival than those from late nests, and Wagner (1961) indicated that chicks hatched late in the season in Wisconsin may have suffered greater mortality than early-hatched chicks. In 1963 the peak of hatching on the Central Iowa Areas occurred at least 1 week earlier than in 1962 and 4

weeks earlier than in 1964. Also, as previously indicated, a larger proportion of the total hatch occurred at the peak in 1963, so that a larger percentage of the juvenile population classified as "early" compared to the other two years. Thus, for these reasons alone juvenile survival in 1963 may have been somewhat higher than usual.

No nest studies were in progress on the Winnebago Area during the same 3 years of the central Iowa studies, and thus, since the average number of chicks per hatched nest during that period was not known, no direct estimates of juvenile mortality could be made. However, judging by the similarity in overall mean brood size between the Winnebago and Central Iowa areas, and the shrinkage in size of broods from 4 weeks to 12 weeks of age (Table 38), the mean rate of juvenile mortality during the 3-year period was also probably quite similar on both areas, even though yearly differences in mortality and mean brood size between the two areas were apparent. In any event, individual yearly differences notwithstanding, it was evident that the rate of juvenile mortality recorded on the Central Iowa Areas had not differed significantly from that recorded on the Winnebago Area during the period of the present study or as reported earlier in the studies of Baskett (1947), Kozicky (1951) and Klonglan (1955b).

#### Soil Analyses

Not all factors determining pheasant populations are known. Factors such as kind of soil, quantity and type of nesting cover, winter cover and certain agricultural practices, however, which have been established

as affecting population levels, appeared the same throughout the fall-off area in southern Hamilton and northern Story counties. Since most of the above factors other than effects of soil had been investigated on the Central Iowa Areas and had appeared to vary insignificantly within the fall-off area (Bolstad (1962), the need for a preliminary investigation into the possible effects of soil was indicated.

Thus, in addition to calcium, a host of other soil nutrients was also determined, including phosphorus, potassium, magnesium, manganese, iron, boron, copper, zinc, strontium, molybdenum, cobalt, aluminum and sodium. Of these, all but boron, strontium and aluminum have been found essential for the maintenance of animal health. Determination of other elements considered essential but not included in the analysis would have been desirable, but the soil testing laboratory which carried out the determinations was equipped to handle only these elements first mentioned.

Detailed examination of the physical, chemical and vegetational soil interrelationships was beyond the scope of the present study. To define the problem more precisely, soil samples were taken only from the top 9 inches of the soil, the approximate depth to which mineral nutrients would be available to pheasants through direct ingestion of the soil itself, not including grit. It was realized that plant materials were undoubtedly important in providing sources of these minerals for pheasants, but the inclusion of this potential nutrient source in the analyses would have involved plot studies and eventually extensive use of bio-assay methods, both of which were beyond the scope of the study. Also, quantity

of each element from the soil determinations was reported as the amount readily available to plants; this undoubtedly is not the amount which would be "available" to pheasants in the same sample. Still, however, the information obtained from the analyses of the soil samples should be of value for comparing concentrations of soil elements among the three Central Iowa Areas. In brief, this approach at best would permit the detection of obvious differences in the concentrations of various soil nutrients in surface soils between areas. Conversely, however, due to the small number of soil samples involved, even if no such differences were indicated, undetected real differences may still exist. In an attempt to minimize the well-known variation in soil mineral nutrients which occurs among different soils, samples were collected only from the Nicollet series, which in the entire Clarion-Webster Soil Association comprises approximately 16 per cent of all soils. Thus, although level of soil nutrients may vary between soils, any conspicuous differences in concentration of soil elements which might occur between areas were assumed to be equally distributed throughout all soil series and therefore could be detected irrespective of the series chosen for collection of the samples.

No conspicuous differences in concentrations of soil elements were apparent among the samples from the Central Iowa Areas (Tables 40 and 41). The low level of iron in the samples from the Southern Area appeared at first glance to indicate a real difference in the concentration of this element compared to the other two areas. That the indicated difference was due to chance variation, however, is revealed by the extremely large standard deviations associated with the iron determinations from all three

Table 40. Quantity of selected available mineral elements in ten soil samples from Nicollet soils collected from each of the Central Iowa Areas

	p.p.2m. <sup>a</sup>											
	Ca	Mg	Mn	Fe	Cu	Zn	Mo	Na <sup>b</sup>	B	Al	Sr	Co
Northern Area												
Mean	7748.0	1274.0	31.2	66.8	1.6	4.3	0.95	2817	4.5	25.6	37.5	0.46
Range	5300- 10440	760- 1820	17- 53	4- 238	1- 2	3- 10	0.9- 1.0	2480- 3160	4- 5	15- 46	26- 46	0.3- 0.7
Standard deviation	1737.6	334.0	12.9	36.5	1.6	2.5	0.04	62.4	0.5	18.9	6.6	0.15
Standard error	549.5	105.6	4.1	11.5	0.5	0.8	0.01	19.7	0.2	6.0	2.1	0.05
Middle Area												
Mean	8100.0	1298.0	22.1	87.0	2.2	6.9	0.98	2770.0	5.1	49.8	32.4	0.39
Range	5560- 14180	880- 1880	5- 34	6- 250	2- 3	3- 12	0.9- 1.1	2600- 3140	5- 6	13- 137	22- 40	0.3- 0.8
Standard deviation	2430.9	273.3	9.1	101.9	1.3	4.3	0.08	174.2	0.3	47.2	6.0	0.17
Standard error	768.8	86.4	2.9	32.2	0.4	1.4	0.03	55.1	0.1	14.9	1.9	0.06
Southern Area												
Mean	8777.0	1232.0	18.1	18.4	1.5	3.3	0.95	2876.0	4.8	25.0	37.0	0.45
Range	6240- 14880	880- 1700	2- 43	3- 62	1- 2	2- 9	0.9- 1.1	2480- 3160	4- 5	15- 56	16- 53	0.2- 0.7
Standard deviation	2654.8	300.9	11.5	16.8	1.6	2.1	0.06	223.5	1.3	12.6	9.3	0.14
Standard error	839.6	95.2	3.6	5.3	0.5	0.7	0.02	70.7	0.4	4.0	2.9	0.04

<sup>a</sup>Determined by extraction with 1N NH<sub>4</sub>AOc, pH 7.0 and extract subjected to analysis by an emission spectrograph.

<sup>b</sup>Quantity as reported appears extremely high--decimal point should probably be moved one place to left.

Table 41. Quantity of available phosphorus and available potassium, and pH and lime requirement in 10 soil samples collected from Nicollet soils on each of the Central Iowa Areas

	Lime required (tons per acre) <sup>a</sup>	pH	Phosphorus p.p.2m. <sup>b</sup>	Potassium p.p.2m. <sup>c</sup>
Northern Area				
Mean	4.6	5.7	40.2	296.4
Range	2.0-7.0	5.2-6.1	23.0-54.0	198.0-342.0
Standard deviation	1.5	0.9	9.6	53.9
Standard error	0.5	0.3	3.0	17.1
Middle Area				
Mean	2.5	6.2	50.7	262.2
Range	0.0-4.0	5.5-7.7	4.0-100.0	204.0-324.0
Standard deviation	2.6	0.6	35.7	48.2
Standard error	0.8	0.2	11.3	15.2
Southern Area				
Mean	3.8	5.9	33.2	264.6
Range	0.0-5.5	5.2-7.6	6.0-67.0	210.0-318.0
Standard deviation	2.2	0.7	18.0	38.6
Standard error	0.7	0.2	5.7	12.2

<sup>a</sup>< 1.5 = very low, 1.5-2.0 = low, 2.5-3.0 = medium, > 3.0 = high.

<sup>b</sup>Determined by extraction with 0.03N  $\text{NH}_4\text{F}$  in 0.025 N hydrochloric acid and extract subject to analysis by a spectronic colorimeter.

<sup>c</sup>Determined by extraction with  $\text{NH}_4\text{OH}$  and extract subject to analysis by a flame photometer.

areas, particularly the standard deviation from the Middle Area samples which is larger than its mean (Table 40). Moreover, the concentration of not only iron but other elements as well demonstrated extreme variation; manganese, copper, zinc and aluminum all showed standard deviations larger than 50 per cent of their mean. Also, with the exception of manganese, the trend in the sample means of elements did not vary from area to area in accordance with the known decrease in pheasant populations which occurs from the Northern Area to the Southern Area. Whether the trend shown by the sample means of manganese indicates real differences in soil concentrations of this element among areas is not known, but as judged by the analyses of the samples, this element was the only one of all tested which appeared to deserve further study.

Similarly, there appeared to be no conspicuous or clear-cut differences in the quantity of nitrogen, phosphorus and potassium and in the lime needs of the soils from the four counties in which each of the Central Iowa Areas and the Winnebago Area are located, as determined from soil samples collected in these counties and analyzed by the Iowa State University Soil Testing Laboratories (Tables 42 and 43). There was little difference in the nitrogen levels found in the soils of the three Central Iowa Areas, but the samples from Winnebago County indicated less need for nitrogen in the soils of this county than in central Iowa. Similarly, phosphorus appeared to be present in equal quantity in the soils of Boone, Hamilton and Story Counties; however, soils from Winnebago County showed a slightly greater need for phosphorus (Table 42). By contrast, potassium in soils of Hamilton County appeared high compared to levels in the other

Table 42. Levels of nitrogen, phosphorus and potassium in soils of Boone, Hamilton, Story and Winnebago counties<sup>a</sup>

County	Number of samples	Classification of soil nutrient level by per cent of soils tested			
		Very low	Low	Medium	High
Nitrogen					
Boone	1316	12	63	21	4
Hamilton	698	6	63	24	7
Story	1245	6	61	26	7
Winnebago	177	3	38	44	15
Phosphorus					
Boone	3705	29	49	18	4
Hamilton	1666	23	50	22	5
Story	4056	20	49	24	7
Winnebago	804	40	41	16	3
Potassium					
Boone	3705	6	65	22	7
Hamilton	1666	2	41	34	23
Story	4056	2	65	24	9
Winnebago	804	12	41	41	6

<sup>a</sup>Based on data from Iowa State University Agricultural Extension Service (1956).

Table 43. Lime requirements in soils in Boone, Hamilton, Story and Winnebago counties<sup>a</sup>

County	Number samples	Lime requirement (tons/acre)					
		None	Slightly acid	1.5-2.0	2.5-3.0	3.5-4.0	74.0
Per cent of county samples							
Boone	3705	32	26	19	13	9	1
Hamilton	1666	38	30	12	14	6	0
Story	4056	34	32	17	11	5	1
Winne- bago	805	48	30	11	15	7	1

<sup>a</sup>Data from Iowa State University Agricultural Extension Service (1956).

three counties.

In any event, there is little evidence to suggest either from soil samples individually collected from the Central Iowa Areas or from those analyzed by the Iowa State University Soil Testing Laboratories, that differences in concentrations of the various soil elements investigated are responsible for or related to the known differences in pheasant densities both between each of the Central Iowa Areas or between these areas and the Winnebago Area. Judging by the variation in the concentration of specific elements in the central Iowa samples, a very large number of samples would need to be collected before real differences in the concentration of elements between areas could be identified with confidence.

#### Pheasant Movements

Relatively few studies of pheasant movements have been undertaken since investigations of this important game bird began over 50 years ago. Apparently, since distances traveled by pheasants were early found not to be extensive, the problem of egress and ingress as it affected the welfare of pheasant populations may not have been considered important. Although in general this assumption was probably valid for populations found in the heart of the pheasant range, the importance of movements in populations located in submarginal range or at the edges of the major continental pheasant range has not been determined. The Central Iowa Areas, because they straddle an area of extremely abrupt decline in pheasant numbers, presented a unique opportunity to determine the importance of movement in pheasant populations in such an area and at the

same time compare findings with those of other studies of pheasant movement. Weston (1954) and Grondahl (1953) conducted previous investigations of pheasant movements in Iowa; however, both studies were carried out in prime pheasant habitat in northcentral Iowa and well within the boundary of the established Midwest pheasant range. Both studies, furthermore, were primarily concerned with movements of adult birds during winter and spring dispersal. Not to be ignored, also, is the fact that these studies were conducted over 10 years ago. Since then, if the continued general trend in loss of permanent cover throughout the Midwest pheasant range is any indication, the forfeiture of winter cover to increasingly intensive agricultural operations has undoubtedly occurred in both northcentral Iowa and on the Central Iowa Areas, so that the importance of this loss to pheasants as reflected in movement should be evaluated.

In the winter of 1961-1962 pheasants were trapped by means of a slightly modified version of the Ohio wire trap first described by Hicks and Leedy (1939). Trapping began in late December and continued through to late March when birds dispersed from winter concentration areas. With few exceptions, traps were checked daily during this period, usually in the evenings. Captured birds were placed in burlap sacks, each sack holding up to eight birds. The birds were subsequently taken to a heated vehicle where they were banded, tagged and released.

All birds were banded with numbered aluminum, butt-end type bands furnished by the Iowa State Conservation Commission, and most were back-tagged. Twice, however, the catch was unsuspectedly large and consequently not enough tags were available to mark all birds trapped. Since

facilities were not available for holding birds overnight on location, some were released without tags.

Each back-tag was painted with a distinctive red symbol so that individual birds could be recognized with the naked eye or with the aid of binoculars. In addition, differently-colored tags were used at each trap-site, and thus upon observation of a tagged bird in the field the color of the tag alone disclosed the original field of capture.

All trapping took place on the Northern Area, since the lower populations on the other two Central Iowa Areas precluded capturing enough pheasants from which to obtain a meaningful sample of movement records. During the winter of 1961-1962 three traps were kept in continual operation. Two of these traps (traps A and B) were located on the Northern Area itself; one in a fencerow in the NW 1/4 sec. 19, the other in a plum thicket in the SW 1/4 sec. 31. The remaining trap (trap C) was placed in a 60-yard long hedgerow bordering a farmstead located about one-fourth mile due east of the southeast corner of section 30. Trap A was located approximately 2.7 miles from trap B and 2.3 miles from trap C. Trap B and trap C were located about 1.6 miles apart.

During the other 2 years of the study, winters were very mild and with so little snow that pheasants could not be baited into traps. In these years pheasants did not bunch up in winter concentration areas as usual due to the absence of snow cover, and in addition, the resulting general availability of waste corn and weed seeds precluded baiting birds to trap-sites. However, during the late summer of 1963 and 1964 pheasants

were captured at night in oat stubble, soilbank fields and uncut hayfields by means of the spotlighting method previously described on page 51. Captured birds were retained in a specially-constructed two-tier holding bag consisting of two burlap sacks held against a flat wooden surface. The opening of each sack was guarded by a doorspring woven into the mouth of the bag to prevent birds escaping. After a field had been thoroughly searched, all captured pheasants except very young birds were affixed with a leg band and back-tag and released in the same field where captured.

Records of pheasant movements were obtained from four sources:

(1) recaptured pheasants; (2) reobservations of tagged pheasants; (3) tagged or banded pheasants shot by hunters; (4) bands or tags recovered in the field by personnel and farmers. Birds in the first category were termed recaptures, and those in the second category were called reobservations. Movement records obtained from birds found dead or from tags and bands found loose in the field were termed recoveries, and those secured from pheasants shot by hunters were designated as returns. Movement was recorded to the nearest 0.1 mile from either the winter trap-site or the center of the field of original capture to the point the pheasant was again caught, reobserved or killed, or the band or tag recovered.

All of the above sources of movement records were subject to biases of varying degree which tended to make computed mean distances moved by pheasants for each category somewhat smaller than that which probably occurred. Since data on movements were obtained mainly incidental to the performance of other field duties on the area, or during spotlighting activities, records from the area itself were more likely to be obtained than from areas immediately adjacent. Undoubtedly, some of the longest

records of movement would probably have been obtained from these bordering areas, but little additional time was available for off-area activities. Recaptures and reobservations especially were subject to this type of bias. Records of pheasant movements obtained from tags, bands or dead birds on the area found by myself or assisting personnel while in the field were also subject to this bias. Records in this same category obtained from farmers, however, were somewhat less subject to bias since farmers from immediate surrounding areas were to some extent aware of the trapping program and its purpose, and therefore would probably have been as likely to report a recovered tag or band as resident farmers. The records secured from banded or tagged birds shot during the hunting season were by comparison the least biased. During the hunting season hunters in this general area appeared to be fairly evenly distributed, and thus marked birds which had left the area probably possessed about the same probability for being shot as those that remained. Furthermore, each year during the opening weekend of the season, hunters' bags were checked for marked birds, both on the area and for 1 mile outward in all directions. There probably existed, however, a greater tendency for farmers whose farms were greater than 1 mile from the area not to report bagged marked cocks, because many were not familiar with the project. However, the absence of records as great or greater than this distance obtained from the area itself indicate that this type of bias probably was not important.

During the 3 years, 281 pheasants representing 258 individual birds were trapped using the described methods. Twenty-three of these birds

were subsequently retrapped. Of these, 19 were retrapped once and four birds were retrapped twice. Two cocks retrapped once during the late summer were subsequently shot by hunters in November. A hen, trapped at trap C during the winter of 1961-1962 was later recaptured 0.3 miles from the original trap-site location during spotlighting activities in 1964, almost 2 years and 8 months later.

From these 258 pheasants, 89 records of movement were secured; 27 recaptures, 32 reobservations, 25 returns and 5 recoveries (Table 44). Recoveries showed the greatest mean movement and birds recaptured during winter the least movement. The longest record of a single movement was 4.9 miles. To further facilitate comparison with other studies, movements were grouped according to the season in which they were recorded, irrespective of source (Table 45). Thus, the winter movements recorded during the period mid-December through early April corresponded to a similar period in two previous studies of pheasant movements in Iowa and two in Wisconsin. The period extending from mid-April through June (spring movements) conformed to the period of "spring dispersal" in the other studies. Movements recorded during the interval July through November were designated as "late summer and fall movements."

#### Winter movements

All records of winter movements were obtained during the winter of 1961-1962. Forty-one such movements averaged 0.2 miles with a range of 0.0-4.9 miles (Table 45). Without the individual record of 4.9 miles, however, the mean distance of winter movements was only 0.1 miles; the next longest such movements were three of 0.4 miles each.

Table 44. Records of 88 pheasant movements obtained on the Central Iowa Areas, 1962-1964, grouped according to source of record

	<u>Recaptures</u>			<u>Reobservations</u>	<u>Returns</u>	<u>Recoveries</u>	Overall mean	Total
	Winter trapping	Spotlighting	Both methods					
Number	18	9	27	32	25	5		88
Mean miles moved	0.0	0.2	0.1	0.3	0.4	0.8	0.3	
Maximum miles moved	0.0	0.3	0.3	4.9	1.5	1.5		
Range in miles moved	--	0.0-0.3	0.0-0.3	0.0-4.9	0.0-1.5	0.2-1.5		

Table 45. Pheasant movements on the Central Iowa Areas, 1962-1964, grouped according to season

	Winter movements <sup>b</sup>	Spring movements <sup>c</sup>	Late summer and fall movements <sup>a</sup>			
			Adults	Juven-iles	Age unknown	All ages
Number	41	4	9	29	6	44
Mean miles moved	0.2	0.9	0.3	0.4	0.2	0.3
Maximum miles moved	4.9	1.5	0.8	1.5	0.4	1.5
Range in miles moved	0.0-4.9	0.1-1.5	0.0-0.8	0.0-1.5	0.0-0.4	0.0-1.5

<sup>a</sup>July through November.

<sup>b</sup>Mid-December through early April.

<sup>c</sup>Mid-April through June.

The winter of 1961-1962 was extremely adverse, with temperatures averaging 5.1 degrees below normal during the months of January, February and March. In addition, snow depths averaged between 10 and 18 inches during this same period, and the number of consecutive days of snow on the ground was the highest on record in central Iowa since the winter of 1935-1936. Towards the end of February and in early March, birds which had died from starvation were found occasionally at trap-sites A and B, and many other birds too weak to fly normally, were also observed. Birds at trap-site C did not starve due to the close proximity of a small unpicked cornfield. Probably because of these adverse weather factors, pheasant movements were restricted during this period. Birds trapped

and marked at one trap-site were never recaptured at another, but since traps were located no less than 1.6 miles and as far as 2.7 miles from each other, extensive movement between trap-sites was not expected. However, there were few large concentrations of birds on or near the area other than those located at the three trap-sites. One small group of wintering pheasants was located about 0.7 miles east of trap-site B and two other groups, one of about 18 birds and the other of approximately 25 birds were located about 0.9 and 0.5 miles, respectively, from trap-site A. No marked pheasants were observed at these locations, and periodic counts of these outlying groups revealed almost no fluctuation in the number of pheasants in each concentration, indicating that both ingress and egress to and from these concentration areas were limited. The extreme movement record of 4.9 miles was obtained during a winter pheasant census on the northernmost section of the Middle Area, but judging by the restricted movements of other pheasants, a movement of such magnitude was atypical.

Weston (1954) in 1949 and 1950 conducted an investigation of the winter-spring movements of pheasants on two state-owned marshes in northern Iowa. During the 2-year period, based on 162 marked pheasants recorded off the areas, winter movements averaged approximately 0.5 miles, ranging from 0.0 miles to 2.1 miles. During 1949, out of 21 pheasants observed off the areas, only two were farther from the areas than 0.5 miles, and of 141 similar sightings in 1950, all but one were less than 1 mile from the areas. The one exception, a cock, was observed 2.2 miles from the location where originally trapped. Thus, the winter move-

ments recorded in Weston's (1954) study were slightly more extensive than those recorded on the Northern Area in central Iowa.

Grondahl (1953) in the winter of 1950-1951 investigated the winter movements of pheasants on the Winnebago Pheasant Research Area in north-central Iowa. Based on 119 roadside and field observations of marked birds, the mean movement recorded was approximately 0.4 miles. One hundred and eight (91%) of these were observed within 0.75 miles of the location where marked. Eight other records of marked birds of up to 2 miles were not included because it was believed these were permanent winter movements and would therefore erroneously increase the mean distance of the observed daily cruising radius.

Further information on winter movements was provided by 33 retrapped marked birds. Fourteen of these birds were recaptured at the same site at which they were marked, and 19 others were taken in two other traps, both which were located 0.4 miles from the site of the original capture. Thus, the winter movements recorded in Grondahl's (1953) study were only slightly more extensive than those recorded on the Northern Area in central Iowa.

Several factors may have contributed to the seemingly more restricted movements in central Iowa compared with those in northern Iowa. The extremely adverse winter weather conditions which occurred in central Iowa in the winter of 1961-1962 were not approached in severity by the conditions prevailing during the studies of Weston (1954) and Grondahl (1953), particularly in the former study. As a result, pheasants were probably less confined and restricted in their movements and cruised

greater distances from concentration points. Secondly, Grondahl (1953) reported considerable movement between traps located as little as 0.4 miles from each other, indicating that unlike the Northern Area, concentration areas were in some instances quite close together. As a result, the mere presence and easy availability of such parcels of cover probably encouraged more movement between them. Conversely, the rarity of similar proximate areas of winter cover during the winter of 1961-1962 on the Northern Area may have prevented greater and more frequent movements than those recorded.

In any event, the magnitude of winter movements in all three of the Iowa studies did not appear extensive. This agrees closely with a study of winter movements of pheasants in southcentral Wisconsin in which no movement of 876 marked birds was recorded between two known winter concentration areas separated by only 1.25 miles of cultivated farmland (Buss 1946).

#### Spring movements

Only four records of spring movements were obtained during the entire 3 years of the study. The mean of these movements was 0.9 miles, with a range of 0.1 to 1.5 miles (Table 45). Two of the recorded movements, however, were over 1 mile.

Weston (1954) in 1949 and 1950 recorded the movement of 707 pheasants during the period March 6 to June 8 on the Birge Lake and Grass Lake areas in northern Iowa. The mean distance of movements recorded within this period was approximately 0.9 miles; however, in each year the great-

est movements were recorded in the latter part of this period after the main dispersal had been completed. Thus, the mean distance recorded in both years during the interval March 6 to 31 was only approximately 0.5 miles, but almost 1.5 miles during the period May 1 to June 8. Four movements of 7 miles each were the longest recorded during spring dispersal.

Grondahl (1953) reported the mean distance of spring dispersal was approximately 0.6 miles, based on observations of 87 marked birds during April and May. The longest record of spring dispersal was 1.85 miles. No difference in the mean length of movements occurring in the early part of this period and the latter part could be demonstrated, and thus he concluded that "the maximum observed mid-winter movement of birds can be expected to approach or even exceed the distance of mean observed spring dispersal."

It therefore appears that the average distance of spring dispersal recorded by Weston (1954) was somewhat greater than that observed on both the Winnebago Area in 1951 and during the 3 years of the present study. However, as pointed out by Grondahl (1953), the longer distance of spring dispersal observed by Weston probably was attributable to the greater size of the wintering area. Such large areas as the Birge Lake and Grass areas harbored large concentrations of pheasants and therefore must have attracted birds from greater distances. Probably for the same reason, movements during spring dispersal from a large tract of winter cover used traditionally by pheasants in Wisconsin (Buss 1946) were somewhat more extensive than those recorded in the study of Grondahl (1953) and in the present study. Although the majority of movement records in

the Wisconsin study were less than 0.5 miles, five (15%) were greater than 1 mile. Also, in South Dakota in an area where winter cover was entirely restricted to the Missouri River bottomlands, movements of up to 10 miles have been recorded from winter to summer range, based on crowing intensity samples (Kimball 1949).

#### Late summer and fall movements

During the 3 years 44 movement records were obtained from nine adult and 29 juvenile pheasants retrapped in late summer or reobserved or shot during the hunting season. The mean of these movements was 0.3 miles, with a range of 0.0 to 1.5 miles (Table 45).

Weston (1954) reported that of 13 cocks shot by hunters during the pheasant season, nine were killed on the Birge Lake and Grass Lake areas. Three of the remaining four were reported bagged over 5 miles from the area on which they were banded. However, since all birds reported had been trapped during previous winters, many of these movements may have occurred during spring dispersal and therefore were not representative of true summer or fall movements.

Records of pheasant movements in the Sutter Basin of California during the period 1952-1958 (Malette and Bechtel 1959) probably are more comparable to movements recorded in late summer and fall in central Iowa than are those obtained by Weston (1954). As in the present study, pheasants were trapped by use of the spotlighting method and records of movement were secured from recaptured birds and cocks shot during the hunting season. (Hunting regulations in California also permitted shooting

of hen pheasants.) The movement of 601 cock and hen pheasants of all ages retrapped during the same year of banding averaged 0.5 miles. Records of movement obtained from 347 cocks and 46 hens shot during the hunting season indicated that on the average hens tended to move greater distances than cocks, and juveniles greater distances than adults. Mean movement of hens and cocks was 1.6 miles and 1.3 miles, respectively. Mean movement of juveniles was 1.3 and of adults, 1.1. The authors attributed this greater movement by adult hens and juveniles during late summer months to disturbance by crop rotation and double cropping practices which continued throughout the hatching and brooding period, resulting in loss of habitat and an inadequate food supply for hens and broods.

In the present study, however, there was no clear indication of greater movements by juveniles (Table 45), and too few records of hen movements during late summer and fall were obtained to allow meaningful comparisons between distances moved by hens and cocks. It is apparent, therefore, that in light of the above individual comparisons of the movements of pheasants in central Iowa and those recorded in the other studies, there appeared to exist no detectable differences in the length or type of pheasant movements on the Central Iowa Areas compared to other areas within the heart of the pheasant range in the Midwest which might have an important bearing on the welfare of these central Iowa populations.

## DISCUSSIONS AND CONCLUSIONS

A comparison of the ecological factors affecting pheasant production among three pheasant populations of varying density in central Iowa and a traditionally higher population in northcentral Iowa, revealed that few conspicuous differences were apparent. As a result, the factors responsible for the differences in density levels among these populations remain unidentified. Even where the data do indicate apparent dissimilarities in the ecology of production, such differences are slight and of questionable importance, and therefore difficult to evaluate on the basis of a field study alone. The final evaluation of the importance of the factors determining the population level of each of these areas must await accompanying complementary evidence from both long-term studies of pheasant populations and studies of the physiology of the pheasant. Information from studies emphasizing reproductive physiology in relation to natural environmental conditions is especially needed. However, a more thorough treatment of the indicated differences found in the present study is warranted.

Perhaps the most clear-cut difference between the Central Iowa Areas and the Winnebago Area was the apparent earlier hatching peak (and by implication an earlier nesting peak) in the central Iowa populations. During the 3 years the peak of hatching on the Central Iowa Areas was between 1 to 2 weeks ahead of that on the Winnebago Area. Similarly, Klomglan (1962) reported that the peak of nesting and hatching in an area of high pheasant populations in Union and Adair counties in southern Iowa during 1957 and 1958 was about 2 1/2 weeks in advance of that on the

Winnebago Area during the same period. Klonglan (1962) also attributed the higher rate of nesting success in hayfields on the former area to this phenomenon; though the nesting pattern was earlier, the phenology of mowing apparently was no earlier than on the Winnebago Area, and therefore more time was available for eggs to hatch. On the Central Iowa Areas, however, it was not clear during the years of the study whether the earlier hatching distribution was accompanied by an earlier phenology of mowing or if the average dates of mowing were the same on both the Central Iowa and Winnebago areas. However, an indication of this relationship may be gained by comparing the mowing dates on the Winnebago Area during the time of Baskett's (1947) study and Klonglan's (1955b) study with those recorded in the present study. The average range in dates of mowing as recorded by these investigators was approximately June 15 to July 3 compared to June 1 to 20 in the present study (Table 19). If these dates of hay mowing on the Winnebago Area are fairly typical for that area, it therefore appears that the earlier hatching peak on the Central Iowa Areas is accompanied by a correspondingly advanced phenology of mowing, and thus no advantage would be gained because of the early nesting pattern. This appears to be borne out by the apparent similarity in success of nests revealed by a comparison of nesting success in hay on the Winnebago Area during 1939-1941 and 1954, and the Northern Area during the period of the present study.

There appears also to be a tendency toward a larger clutch size of completed nests of about one-half egg to one egg on the Central Iowa Areas as judged by similar data on completed nests obtained by Baskett

(1947) and Klonglan (1955b), but the importance of this difference in clutch size as a regulatory factor in some measure responsible for the traditional differential in populations on these two areas is open to question (see page 103 under Clutch size). The indicated difference between these areas in average clutch size of completed nests is subject to at least two interpretations. Since many workers have shown that clutches of eggs of renesting birds average smaller than those of initial nesting attempts, the larger clutch size recorded for the Central Iowa Areas may indicate higher success of first nests in central Iowa than on the Winnebago Area, and therefore less need for renesting. Conversely, however, the same data interpreted differently could suggest less tendency to renest per se, and thus imply individual hens were less persistent in attempting to hatch a clutch on the Central Iowa Areas than on the Winnebago Area. Which of these interpretations is most likely correct is not known, but the average per cent of hens which successfully bring off broods on the two areas must be determined before final solution of this problem can be achieved. Should the per cent of hens successful prove the same for these two areas, the acceptance of the first interpretation would then be indicated. Conversely, a lower percentage of successful hens on the Central Iowa Areas would require recognition of the second interpretation. If the first interpretation proved correct, the greater clutch size of completed nests on the Central Iowa Areas could then be dismissed as a factor responsible for the differential in population levels, since populations on the Winnebago Area have traditionally been higher.

On the Central Iowa Areas no clear-cut differences in the ecology of pheasant production between individual areas could be detected. However, the low populations characteristic of the Middle Area and Southern Area prevented meaningful comparisons with the Northern Area, so that even if true differences exist they may not have been detected. Differences in success of nests between the Central Iowa Areas was suggested by the data, with a rate of success each year inversely proportionate to the density of the breeding population (Tables 10, 11 and 12). This same apparent tendency was previously noted by Wright and Otte (1962) during a nesting study on the Central Iowa Areas in 1961. However, whether this difference is real and consistent is not known; a larger sample of nests obtained over an additional period of years would be necessary to judge the importance of this phenomenon. However, if it appears that in the final analysis this indicated tendency is borne out, then higher nesting success also may be disregarded as a determinant in the maintenance of the higher population on the Northern Area, since of the three Central Iowa Areas the populations on this area have been consistently higher.

#### Temperature

Although temperature was not investigated in the present study as a factor which might be important in the regulation of pheasant populations, it is almost certain that this factor is of no consequence in regard to the present differential in pheasant densities on the Central Iowa Areas. Temperature differences between areas located only a few miles apart could not possibly be of sufficient magnitude to effect any

differences in pheasant numbers. However, assuming for the moment that temperature might be important in determining populations, we would expect it to operate in reproduction, most likely by increasing mortality of embryos, and thereby decreasing the number of young produced. If this were true, however, increasingly larger numbers of unhatched eggs in successful nests would be expected to occur in nests from the Winnebago Areas southward to the Southern Area, where proportionately the largest number of unhatched eggs should be found. However, there was no suggestion of this either between the individual Central Iowa Areas or between these areas and the Winnebago Area based on the findings of the present study and those of Baskett (1947) and Klonglan (1955b, 1962).

There appears to be considerable doubt, furthermore, that temperature is a limiting and regulating factor of pheasant populations in any part of the pheasant range in the United States. Klonglan (1962) in southwestern Iowa found a slightly higher number of unhatched eggs in successful nests and dead embryos in incubated nests than on the Winnebago Area, but because the average clutch size was larger, the number of eggs hatched per clutch and young raised per brood was higher than on the Winnebago Area.

Furthermore, the relationship of high temperature and low pheasant populations is not convincingly close on a national basis. East of the Mississippi River the southern range limit of the pheasant is approximately a straight line running from southern New York and Pennsylvania across central Ohio and Indiana to central Illinois, but west of the river it dips far south into the panhandle of Texas, southern New Mexico

and southern California (Aldrich and Duvall (1955). Yeatter (1950) suggested that the presence of established pheasant populations in southern California might be explained on the basis of the probable southern Asian origin of the birds originally released in this area, yet the well-established populations in southern Kansas, northern Texas and southern New Mexico probably did not arise from introductions of this origin.

If high temperature is the factor limiting pheasant populations along the southern edge of the range in the United States, it would be likely to expect a general reduction in pheasant densities the closer we approach the southern edge of the range, rather than the abrupt drop-off in numbers which apparently occurs. Although unfortunately, little evidence is available on this point, it is known, for example, that some of the highest densities in Kansas are often found in extreme southwestern sections of that state where populations frequently exceed 100 hens per section in the fall (Robert Wood, Kansas Forestry, Fish and Game Commission, Pratt, Kansas, pheasant populations in Kansas, 1962, private communication), even though this area is near the southern range limit for the species.

If temperature is regarded as a density-independent factor, then theoretically we could expect a low population to react to the adverse affects of high temperature in the same fashion as a high population. Thus, we should artificially be able to increase a low population by releasing large numbers of wild pheasants into the original population,

with the result that the population could be expected to proceed through normal year-to-year fluctuations but at the newly-created density level. That many attempts to artificially increase some of these southern populations have repeatedly failed is mute testimony that factors other than high temperature are involved.

It could be argued that increasingly higher temperatures southward cause nesting habitat of comparable quality in the southern portion of the range to be less suitable in comparison to the same quality and types of habitats in the northern portion of the range. However, because populations in southern areas are often low, even if the best nesting sites were preferred and actively sought out by nesting hens, it seems probable that adequate sites would remain unutilized throughout an entire nesting season. If, however, the choice of nesting sites is on a non-selective basis, simply by chance it appears likely that excessively high temperatures occurring in successive springs and resulting in destruction of eggs and embryos by overheating, would completely decimate a population by reducing production of young. At least, if this did not occur such temperature effects would probably result in large year-to-year fluctuations in population; however, there appears to be no evidence that such unusually large fluctuations occur. On the contrary, it seems probable that population fluctuations in southern areas of the range are of no greater magnitude than in northern areas. Instead, populations in these two widely separated portions of the range probably fluctuate together at least part of the time.

Yeatter's (1950) suggestion that poor nest success and small average brood size are indicative of populations which are limited by high tempera-

tures is not necessarily valid. In southern Nebraska, for example, nest success averaged only about 15 per cent during a 5-year period (Linder et al. 1960). Even though nest success was low, however, more nests were produced per hen than in most other studies, those of Baskett (1947), Klonglan (1955b) and the present study included, and thus about the same number of young was produced per hen.

Admittedly, high temperatures reduce hatchability of pheasant eggs, but whether this occurs in the wild more frequently in some areas than others has not been established. As previously mentioned, such was not indicated in any of the Iowa studies. Even assuming this does occur more frequently in southern areas, many other facets of the population dynamics of the species would need investigation before high temperature could be concluded as a factor limiting and regulating pheasant populations.

#### Calcium

It is also improbable that low calcium levels are responsible for the existing differences in population levels between each of the Central Iowa Areas and between these areas and the Winnebago Area. As suggested by results of soil tests completed by the Iowa State University Soil Testing Laboratories and those from the present study, there appear to be no important differences in calcium levels in the same kinds of soils throughout the soil association area. In addition, although levels of calcium are sometimes insufficient for proper plant growth on some of these soils, too high calcium levels are frequently equally troublesome. Most soils of the Webster series possess sufficient calcium for optimum crop growth, and therefore, lime is not ordinarily needed on these soils,

and may even depress crop yields (Riecken and Smith 1949). Scattered throughout the Webster soils are areas with calcareous surfaces which are known as "high lime" spots and can be recognized by the presence of snail shells or shell fragments on the soil surface. Similarly, as with Webster soils addition of lime on these areas depresses crop yields. Thus, pheasants on any of the Central Iowa Areas or the Winnebago Area have easy access to calcium from these sources alone, so that it is difficult to imagine egg production of pheasants becoming depressed from a lack of this element in the diet.

Furthermore, the importance of calcium as a factor limiting pheasant populations anywhere within the continental pheasant range is questionable. The Nebraska Sandhills are an area extremely deficient in calcium and yet populations exceeding 50 to 75 pheasants per section may exist in stream valleys and around the edges of cultivated areas (Sharp and McClure 1945). Recently, east northcentral Iowa has supported some of the highest pheasant populations in that state even though limestone needs of the soils in this area are quite high (Klonglan 1962). Similarly, a locally restricted population of pheasants often exceeding 400 birds per section in the fall is found in southwestern Iowa in Union and Adair counties even though there appears to be no measurable difference in calcium content of soils in this area and those immediately adjacent (Klonglan 1962). Soils in this general area are relatively mature and much less fertile than soils in northern regions of the state where populations of similar density occur. Thus, the presence of high populations in such relatively calcium-deficient areas would seem to prevent

definite statements favoring the acceptance of calcium as a factor limiting pheasant populations.

Another major stumbling block preventing the acceptance of the calcium hypothesis is the discovery that pheasants possess the ability to find and utilize calcium sources (Sadler 1961, and Korschgen 1964). The conclusions reached by Dale (1954, 1955) and McCann (1961) are apparently based on the assumption that ingestion of calcareous material occurs largely by chance and on a non-selective basis. Dale (1954) suggested that the success of pheasants in the Nebraska Sandhills was possibly due to the absence of cultivated grain crops and the greater dependency of pheasants on more calcium-rich weed seeds. Recent studies, however, indicate that calcium is sought by pheasants on a highly-selective basis, and therefore there appears to be no adequate explanation for the absence or scarcity of pheasants in many relatively calcium-deficient areas even though the main diet of birds in such areas may consist largely of cultivated grains.

There is no doubt that pheasants need calcium to maintain a calcium level within the body sufficient to carry on normal physiological processes. However, the main point to be brought out is the fact that high densities or not, birds in populations presently found in any given area must be meeting their calcium requirements or they would not exist. Therefore, because populations in the southern edge of the range are usually low, and recognizing that calcium levels in these areas are adequate to maintain the present population, it is difficult to imagine the existence of many areas in the southern portion of the range which are so extremely deficient in calcium that if they presently support, for example, 10 birds per

section, cannot support 30 birds per section. This is particularly true considering that pheasants actively seek out calcareous material.

Recent evidence from field studies further discredits low calcium levels as a factor limiting pheasant populations. The studies of Greeley (1962), Ellis and Anderson (1963), Harper and Labisky (1964), Anderson (1964) and Korschgen (1964) all indicate no apparent relationship between high pheasant populations and status of soil or surface calcium (see Review of Literature, page 8).

#### Soil Elements Other Than Calcium

The importance of soil elements other than calcium in the welfare of pheasant populations is entirely unknown. Since calcium probably seemed the most likely element to influence pheasant reproduction, most investigators have concerned themselves with this element with the result that others have gone unstudied. However, as mentioned previously, both the Central Iowa Areas and the Winnebago Area are within the Clarion-Webster Soil Association Area, so that it is difficult to understand how important differences in concentrations of various soil elements, including trace elements, would occur. Furthermore, apparently no soil deficiencies or toxicities affecting plant growth other than nitrogen, calcium, phosphorus and potassium deficiencies are known from Iowa (Thompson 1957). That soil microelements have not been studied in Iowa suggests that apparently they are presently considered unimportant in preventing proper crop growth in this state. Although many trace elements are known to be needed for the proper function of body processes of birds, they are

needed in such small quantities that it is difficult to understand pheasants not obtaining sufficient amounts in the normal daily diet. Furthermore, if as in the case of calcium, food items containing high concentrations of trace elements are sought out by pheasants, the unlikelihood of these elements serving as factors limiting pheasant populations is increased.

If soil elements are limiting for pheasants, it might be expected that birds exhibiting the effects of deficiencies or toxicities would occasionally be noted, but to my knowledge reports of such findings have not been received from any part of the continental pheasant range. It is true that if the deficiency resulted in body deformation or other physically disabling characteristics such individuals would be quickly eliminated from the population by predators and other agents, but still the probability is high that individuals exhibiting such diagnostic symptoms of deficiencies or toxicities would eventually be noted. On the other hand, if the effects of deficiencies or excesses were not directly and immediately detrimental physically, they might be more easily overlooked. However, since individuals in such a state would probably reproduce substandardly or not at all, the population would exhibit reduced reproductive thrift. Obvious and consistent indications of poor reproductive success in low populations, however, have not been reported.

The mechanism by which deficiencies or toxicities of soil elements would control ceilings on population levels is difficult to comprehend. To illustrate the extreme situations, deficiencies or toxicities distributed randomly or evenly throughout areas, either in soils or foodstuffs might cause the appearance of symptoms in all members of a population. Converse-

ly, concentration of essential elements in localized areas or in certain food or grit items might permit acquisition of sufficient quantities by every member of the population if each possessed the ability to actively select for particular elements. If, however, birds lack powers of selectivity, only those individuals who by chance happened to secure sufficient quantities would survive. In this latter situation such wholesale losses would be pointed up in censuses of winter and spring populations, and brood and production indices when compared to similar indices from healthy and thriving populations; however, apparently no such consistent differential in indices from high-population and low-population areas have been noted. Thus, it is not difficult to understand how deficiencies or toxicities of elements in soils and foodstuffs could prevent establishment of pheasant populations, but more difficult to determine how they could act to regulate populations already established.

#### Relationship of Pleistocene Geology and Pheasant Distribution in Central Iowa

Four major ages of glaciation are recognized in Iowa. Materials deposited during the earliest, the Nebraskan, originally covered the entire state, but these subsequently have been buried by materials deposited in later periods of glaciation, so that nowhere in the state do they form extensive surface features (Ruhe in press). Similarly, materials deposited during the second period, the Kansan, do not form extensive surface features in the state, with the exception of the southcentral part where streams have incised deeply enough so that Kansas till is

exposed in many places on the lower valley slopes (Figure 18).

Materials deposited during the third period, the Illinoian, are found only in extreme southeast and southwest Iowa where they occur as glacial till and Loveland loess, respectively. In both areas Illinoian materials have been buried by later deposits and are exposed on the surface only where slopes and summits have been eroded (Ruhe in press).

Materials deposited during the fourth and last period, the Wisconsin, presently cover all of Iowa. Glacial drift blankets approximately the northern one-half of the state, but elsewhere Wisconsin loess deposits continuously mantle all of the state except on eroded slopes and summits where continuous loess was not deposited. These Wisconsin till and loess deposits are the materials in which the present soils of Iowa are formed, and thus are the materials which are directly related to crop growth and all animal life found on them.

Four tills of Wisconsin age are currently recognized in Iowa (Ruhe in press). The Iowan drift, the oldest, occurs on the surface in extreme northwestern and northeast central Iowa on slopes where overlying younger Wisconsin loess deposits have been stripped away by erosion. The Cary and Mankato substages, the most recently deposited tills, occur as the "Des Moines lobe" and cover northcentral and central Iowa (Figure 18). Originally this lobe was considered as one substage--the Mankato--with four major morainal systems decreasing in age northward (Kay and Graham 1943), but later the area between the oldest moraine, the Bemis, and the Altamont moraine was designated as Cary, and the remaining portion of the lobe from the margin of the Altamont moraine inward as Mankato (Ruhe 1952).

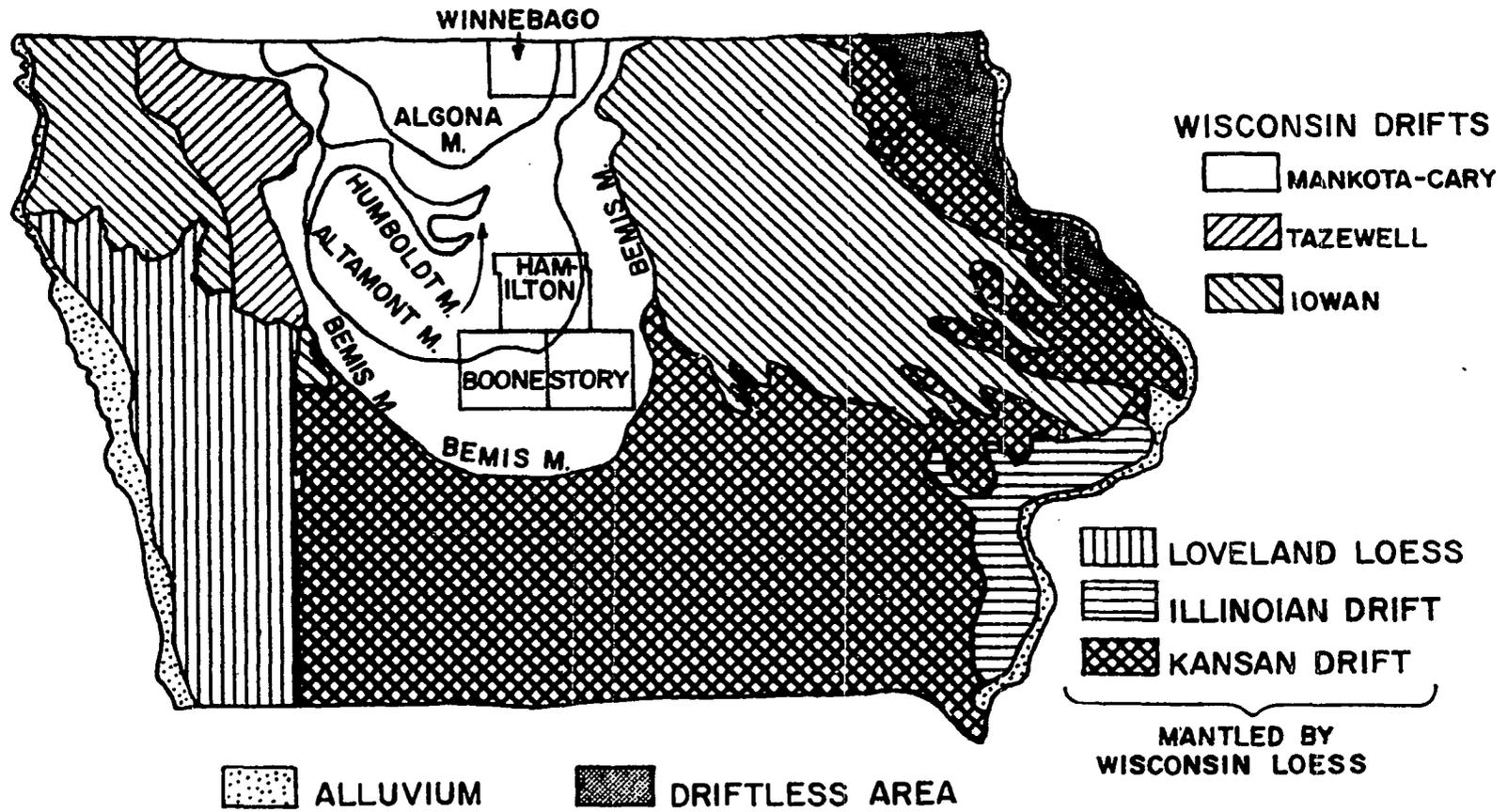


Figure 18. Location of Central Iowa and Winnebago areas in relation to Pleistocene geology of Iowa (based on Ruhe in press)

Upon first examination of the distribution and density of pheasant populations in central Iowa, one is struck by the apparent relationship whereby high pheasant populations occur north of the margin of the Altamont moraine and low populations south of it, with the margin of the moraine itself approximately defining the drop-off area in pheasant numbers in central Iowa (Figure 18). Especially interesting is the observation that the Altamont moraine marks the approximate line of demarcation between the Northern Area and the Middle Area in extreme southcentral Hamilton and northwest Story counties, with both the Middle and Southern areas lying south of the moraine in the Cary, and the Northern Area located within the Mankato lobe. However, more recent evidence regarding Pleistocene geology in central Iowa indicates that the Mankato and Cary lobes are probably of the same age. Radiocarbon dates from the base of the Cary lobe averaged 14,000 years (Ruhe and Scholtes 1959), and dated outwash material 13,000 years old from the Algona moraine (Figure 18) near the Minnesota border buried a forest (Ruhe in press). Therefore, as Ruhe (in press) pointed out such radiocarbon dates require that glacial ice retreated 107 miles from the city of Des Moines to near the Minnesota border in approximately 1000 years. Since these dates predate the previous supposed age of the Mankato lobe, the whole Des Moines drift lobe was reclassified as Cary (Ruhe and Scholtes 1959) and Mankato was reassigned to that part of the lobe north of the margin of the Algona moraine (Figure 18). Thus, it appears that the correspondence of the margin of the Altamont moraine and differences in pheasant densities in central Iowa north and south of it may be the result of chance alone, with no assur-

ance of a cause and effect relationship.

#### Predation

Since the factors known to affect pheasant population densities such as certain agricultural practices, weather conditions and food appear similar on the Central Iowa Areas and Winnebago Area as well, to be the factor responsible for the differences in population levels among these areas, the density of the predator population on each area might be expected to be inversely proportional to the density of the pheasant population. Thus, following this line of reasoning the Winnebago Area, which traditionally has supported the highest pheasant populations would sustain on the average the lowest population of predators, and conversely, the Southern Area would support the highest predator populations. However, there is no evidence to indicate such an inverse relationship between predator populations and pheasant populations. Factors governing predator populations are in some measure the same ones known to regulate pheasant numbers, including land use patterns and amount of undisturbed cover. On this basis the predator populations on each of these areas could also be expected to be similar. Although no estimates were made of predator numbers, there was no evidence to suggest that predator populations on these areas were noticeably different. Following this line of reasoning, if differences in predator populations did exist, they might be expected to parallel differences in pheasant distribution. For example, the greater amount of nesting cover on the Union-Adair Area in southwestern Iowa compared to the Winnebago Area, cited by Klonglan (1962) as one

factor probably responsible for the high pheasant populations on this area, was probably also one reason for the larger predator population on this area.

This is not to suggest, however, that in the absence of predators the pheasant populations on the study areas would remain at their present level. Errington (1946) believed that in many prey species predation is an ineffective mechanism in controlling and limiting their numbers, since he felt predation as well as many other types of population losses are largely intercompensatory; an individual that misses death from one agency eventually dies from another, so that such predation removes the "biological wastage" and therefore does not actually depress the prey population. However, as Errington (1963) recognized, "nature's way is any way that works," and that pat answers should be avoided when interpreting effects of predation on particular prey species. Thus, in light of such high pheasant populations on relatively predator-free islands such as Pelee Island and Old Hen Island as described by Stokes (1954) and on Protection Island in the Pacific Northwest as recorded by Einarsen (1942), it is tempting to postulate that lack of predation is the major factor which has allowed these populations to reach their present high levels. However, all these islands support various densities of avian predators such as certain hawks, owls and crows, and in addition, Pelee Island supports other predators such as dogs, cats, rats and snakes, so that predation is probably not without some effect. At the same time, however, disturbance of nesting cover by agricultural practices is either absent or reduced. Since where similar undisturbed cover of high quality appears

on mainland areas, high pheasant populations also occasionally occur, the net effect of predation on pheasant populations on these islands is difficult to separate from other influences. It is entirely possible, however, that in some parts of the continental pheasant range predation may be one factor among many which tends to depress pheasant populations. As Klonglan (1962) pointed out, the effect of predation on low populations could be considerably more than on high populations. Even though the death rate in low populations may be low in numbers, proportionately it may be high, and thus an individual pheasant might possess a greater chance of falling victim to predation than one in a high population. Populations would thus be relatively vulnerable to predation unless they could increase their numbers above a certain threshold of survival where predation would be relatively ineffectual. On the Central Iowa Areas and Winnebago Area, however, because of the probable similarity of predator numbers on all the study areas, the Winnebago Area included, predation is difficult to imagine as the "threshold preventative" which is maintaining both the pheasant populations on the Southern and Middle areas in a continually depressed state below those of the nearby Northern and Winnebago areas.

Thus, the factor or factors responsible for the maintenance of the present pheasant population differentials on these study areas remain unknown. What must be kept in mind is that if it can be shown that despite contrasts in densities, high populations and low populations are fluctuating in time but at different density levels, then either reproductive and mortality rates are identical in the two populations, or within one population higher mortality rates are compensated for by

higher reproductive rates, or vice versa. This also applies if the fluctuations in each of the two populations over a period of years are out of phase but of proportionately the same average magnitude relative to base population levels in each area. For example, since the Northern and Middle areas retained the same differential in breeding populations each year during the 3 years, the rates of reproduction and mortality on these two areas were probably the same each year. It seems probable, therefore, that over long periods many populations, including those on the Central Iowa Areas, exhibit similar reproductive and mortality rates irrespective of density. Thus, the factor or factors which control density levels in these populations seem to set an imposed ceiling above which the populations cannot increase unless one or more of the factors are corrected. As Klonglan (1962) pointed out, there probably is no single factor which determines pheasant population levels, but rather a host of factors including some which are unknown. That some such mechanism of regulation exists is indicated by the situation existing in central Iowa where populations differ in density despite apparent similarities in all factors known to affect pheasant population levels. Possibly the lack or imbalance of one or more of these "unknown ingredients" results in suppression of the population below its threshold level. The work of Ellis and Anderson (1963) and Anderson (1964) indicating that mortality of adult pheasants and not poor reproduction was responsible for the continued decline of pheasant releases in southern Illinois, suggests that up to the present perhaps too much attention has been given to investigation of factors thought important in limiting reproduction rather than those influencing mortality.

## SUMMARY

1. The present study was undertaken as a logical step in the identification of the factors responsible for the abrupt decrease in pheasant populations which occurs over a 20-mile north-south gradient in central Iowa.

2. Limited data were available which indicated no differences in topography, agricultural land usage or cover distribution among areas located north, south and within the "fall-off" area.

3. Results of censuses of breeding populations during the 3 years, 1962-1964, showed that pheasant populations fluctuated noticeably on each of the Central Iowa Areas. Populations on the Northern Area (high-density population) and Middle Area (medium-density population) fluctuated in phase, first decreasing from 1962 to 1963, then recovering and reaching their highest point in 1964. On the Southern Area (low-density population) populations showed a steady increase during the 3 years. In contrast, populations on the Winnebago Area in northcentral Iowa decreased steadily during the same period.

4. About 82 per cent of the nests from all three Central Iowa Areas were estimated to have been located in areas considered as agricultural. Of these, 45 per cent were in hay, 37 per cent in oats, 11 per cent in roadsides and 4 per cent each in pastures and waste areas. However, 49 per cent of the hatched nests were in oats while only 27 per cent were in hay. These percentages were similar to those obtained in 1939-1941 and 1954 on the Winnebago Area.

5. During the 3 years the average overall clutch size on the

Northern Area was  $8.4 \pm 3.7$  eggs per nest, and on the Middle and Southern areas was  $8.7 \pm 1.9$  eggs and  $8.9 \pm 1.4$  eggs, respectively. Mean clutch size for completed nests during this same period on the Northern Area was  $10.5 \pm 2.1$  eggs. This was about 0.5 of an egg larger than reported earlier for the Winnebago Area; however, mean clutch size of all nests recorded on the Central Iowa Areas was almost one egg smaller.

6. Hatchability of 316 eggs on the Northern Area was 91 per cent. On the Middle Area, 94 per cent of 64 eggs hatched, and on the Southern Area 82 per cent of 135 eggs hatched. Fertility, as determined from successful nests and completed unsuccessful nests was 95 per cent on the Northern Area, 98 per cent on the Middle Area and 90 per cent on the Southern Area. Similar rates of fertility were recorded by Baskett (1947) and Klonglan (1954) on the Winnebago Area.

7. The distribution of the hatch, as determined from data collected during roadside brood counts, appeared to be 1 to 2 weeks earlier on the Central Iowa Areas than on the Winnebago Area; however, the percentage of the total hatch occurring before the peak of hatching was about the same on both areas. In 1963, the hatch on the Central Iowa Areas appeared to be earlier than in 1962 and 1964, presumably because a much higher proportion of the nests were established in oats in 1963 than usual.

8. On the Northern Area during the 3 years an average of 129 chicks was produced per square mile. Over 78 per cent of all chicks were estimated to have been produced in oats and hay; more than 90 per cent were produced in oats, hay and roadside.

9. Of two indices obtained from roadside brood counts to measure

the success of production, the per cent of hens with broods and the number of young observed per mile, the latter index appeared the most reliable and best suited for this purpose.

10. Farming operations, particularly mowing of hay, were the most important single cause of nest destruction. Approximately 52 per cent of the total nests and 68 per cent of the unsuccessful nests were attributed to this cause. Predation and abandonment were other important causes of nest failure, accounting for 25 per cent and 3 per cent, respectively, of all hatched nests.

11. Juvenile mortality from hatching to 8-11 weeks of age, as determined from data obtained during roadside brood counts, averaged 41 per cent during the 3-year period. Similar decreases in mean brood size with age on both the Central Iowa and Winnebago areas indicated that juvenile mortality on these areas was probably also similar.

12. No differences were detected on each of the Central Iowa Areas in concentration of various soil elements from soil samples collected from the Nicollet soil series and analyzed by the Ohio Agricultural Experiment Station, Wooster, Ohio. Similarly, there appeared to be no clear-cut differences in the quantity of nitrogen, phosphorus and potassium and in lime needs of soils from the four counties in which the Central Iowa Areas and the Winnebago Area are located, as determined from soil samples collected in these counties and analyzed by the Iowa State University Soil Testing Laboratories.

13. Average of 41 winter pheasant movement records was 0.2 miles, with a range of 0.0 to 4.9 miles. The average of 4 spring movement

records was 0.9 miles. Forty-four records of movement obtained during late summer and fall averaged 0.3 mile, with a range of 0.0 to 1.5 miles.

14. The effect of temperature, Iowa Pleistocene geology, predation, soil calcium and other soil elements on the distribution of pheasant populations in central Iowa was discussed.

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**APPENDIX**

NEST RECORD

Area \_\_\_\_\_ Date \_\_\_\_\_

Location within plot \_\_\_\_\_

Nest cover. Constituents (%) \_\_\_\_\_

Height: Max. \_\_\_\_\_ Min. \_\_\_\_\_ Average \_\_\_\_\_

Density (% canopy) \_\_\_\_\_

Stage of clutch when found: (1)Incomplete\_\_ (2)Incubated\_\_ (3)Unknown\_\_

Visits to Nest

Date \_\_\_\_\_

Hen present? \_\_\_\_\_

Hen flushed? \_\_\_\_\_

No. eggs \_\_\_\_\_

Final Visit

Date \_\_\_\_\_

Successful Nests:

Eggs hatched \_\_\_\_\_

Eggs infertile \_\_\_\_\_

Eggs with dead embryos \_\_\_\_\_

Stage of development \_\_\_\_\_

Eggs with delayed live embryos \_\_\_\_\_

Eggs destroyed \_\_\_\_\_

Undetermined \_\_\_\_\_

Hatching date unknown \_\_\_\_\_

Hatching date:

Estimated \_\_\_\_\_

Known \_\_\_\_\_

Unsuccessful Nests:

Eggs destroyed \_\_\_\_\_

Eggs with dead embryos \_\_\_\_\_

Stage of development \_\_\_\_\_

Eggs fertile \_\_\_\_\_

Eggs infertile \_\_\_\_\_

Projected hatching date \_\_\_\_\_

Cause of destruction:

Hen killed? \_\_\_\_\_

