HUNGARIAN PARTRIDGE

in NORTHCENTRAL MONTANA

by
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JOB FINAL REPORT

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VITA

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ABSTRACT

Population characteristics and seasonal ecological requirements of a Hungarian partridge population were determined on a 54 mi^2 area in northeast Teton County, Montana during January, 1969-April 1974. A total of 2,873 observations and 17,736 partridge were recorded. Cereal grains were major food items with green plant materials and forbs taken in high frequencies but low volumes. Dandelions were the major forb species eaten. Partridge fed in early morning and late evening, the latter being most important. Pairs were the basic population unit; pairing began annually 7-18 February and was complete by 1 March. All observed, marked females and 81-83 percent of males paired. Surviving previous-year pairs remained paired and all adults tended to pair within coveys; 67 and 69 percent of subadult males and females, respectively, paired outside their winter coveys. The peak week of nesting was 13-19 May and 29 percent of all broods hatched during the peak week, 19-25 June. Mean brood sizes decreased 18 percent from time of hatching to observation in July, 21 percent July-August, and 7 percent August-September. Positive correlations between mean brood sizes and numbers of adults accompanying broods was attributed to increased chick survival. Spring densities were significantly, positively correlated with percent females with young and inversely with mean brood size in August. Winter trapped birds averaged 17 percent adult males, 41 subadult males, 9 adult females and 33 subadult females. Observed winter sex ratios averaged 131 males per 100 females. Winter coveys were autonomous; only minor mixing of members occurred. Eighty-six percent of marked birds moved ≤ 660 yd from winter trap-sites during their lifetime. Data suggested all adult males and subadult females returned to initial winter ranges in succeeding winters; 74 and 50 percent of subadult males and adult females returned, respectively. Subadult males were the most mobile segment and subadult females were the least. Annual mortality was 73 percent with hunters taking 3 percent, 12 percent were victimized by accidents and the remainder were taken by predators. Life expectancy was 1.8 yr for adults, 0.9 for subadult males and 0.8 for subadult females. Maximum longevity was 4 yr for adults and subadult males and 3 for subadult females. Three habitat classes were identified with optimal seasonal areas including 34-52 percent grain, 20-26 fallow, 15-29 rangeland, 4-12 hayland, 4-5 agriculturally idle areas and 2 miscellaneous areas. Idle areas were critical components in all seasons; hayfields seemed least important. Diversity of habitat used by partridge was greatest in winter and least in summer. Pair-habitat components changed continuously in March and April but were similar in May and June. Brood habitats changed monthly, July-September, while adults-only habitat remained similar during this period. Ninety-five percent of partridge were within 77 yd of three different land uses/sub-uses, 389 of a grain field, 983 of woody cover and 1,000 of a winter range.

INTRODUCTION

The Hungarian or European gray partridge *(Perdix perdix* L.*)* has been listed as one of three successful game bird introductions into the United States; attempts have been made with 35 species or subspecies (Bump 1970). All three successful species, Hungarian partridge, ring-necked pheasant *(Phasianus colchicus)* and chukar partridge *(Alectoris graeca)* are members of the family Phasianidae.

In Montana, Hungarian partridge presently inhabit all but the forested, mountainous habitats. They persist primarily in ring-necked pheasant and sharp-tailed grouse *(Pediocetes phasianellus)* range and overlap into sage grouse *(Centrocercus urophasianus)* and blue grouse *(Dendragapus obscurus)* summer habitats.

Intensive cultivation of extensive dryland areas and increased numbers of domestic livestock, primarily beef cattle, on irrigated crop and rangelands have resulted in a decrease in the quality and quantity of habitats requisite for pheasants (Weigand and Janson 1976) and sharptails (Brown 1966). To satisfy current and future demands for farmland game bird hunting in Montana, additional hunting pressure may be focused on the third farmland species, the Hungarian partridge. This species had not previously been intensively studied in Montana and only general interpretations could be extracted from extensive production and harvest chronology data which were available.

Recognition of the necessity for refined data needed to manage Hungarian partridge resulted in initiation of the present study in northcentral Montana in 1969. Purposes of this study were two-fold: to determine the population characteristics of Hungarian partridge on a study area basis; and, to determine the seasonal ecological requirements of partridge in relation to agricultural land uses and their attendant management practices.

The study area was selected in December, 1968 and preliminary trapping and marking of partridge occurred during January and February, 1969. Intensive field studies were conducted July, 1969 through September, 1972. Observations of partridge groups were continued during the summer, 1973 and winters of 1972-73 and 1973-74. Partridge were also trapped and marked during the winter of 1973-74.

METHODS

Population Analyses

Hungarian partridge, recorded along four observation routes, provided trend information on the study area's population (Fig. 1). Routes ranged in length from 12.3 to 19.5 mi (19.6 to 31.4 km) and were traversed by vehicle, traveling at 15-20 mph (24-32 kmph). Attempts were made to survey each route a minimum of three times per month or nine times each season; fewer surveys occasionally resulted in winter due to snow-drifting and closing of roads. Data from each route were combined into seasonal route indices and study area indices were derived by pooling route results for each season. Two indices, numbers of observations per mile and numbers of partridge per mile, were obtained each season; in summer, numbers of broods per mile were also determined. Seasons were designated as: spring, March-May; summer, June-August; fall, September-November; and winter, December-February.

Routes were regularly surveyed in early morning, starting 1/2-hr before sunrise each season except summer when surveys began at sunrise. Late morning, midday and evening (begun 1-hr before sunset) surveys were also conducted. Respective indices were compared statistically (x^2, P .10) between each of the applicable survey periods; non-significance permitted pooling of sample data for a given period,

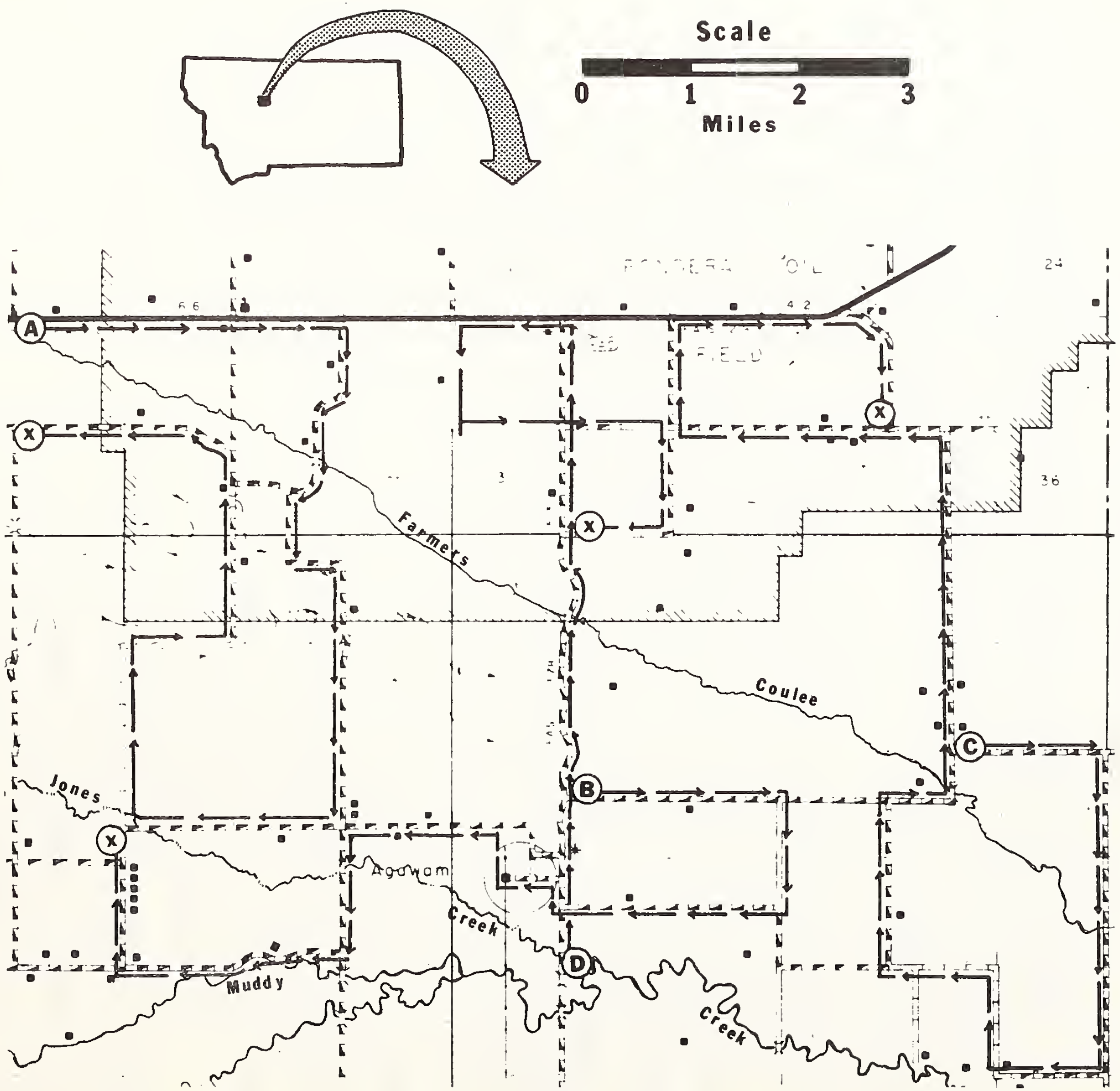


Figure 1. Location of four observation routes on the Agawam Study Area, Teton County, Montana.

route or the entire study area. Only early morning survey data were used in plotting trends unless otherwise specifed.

The sex and age of each partridge observed was recorded, whenever possible. Birds were flushed when heavy vegetation prevented complete counts. Bird activity, location by study area grid code and vehicle odometer readings were also recorded for each observation. Prevailing weather conditions (current temperature; percentage cloud cover; wind velocity and direction; atmospheric conditions and percent of ground covered by, and depth of, snow) were recorded at each observation site as well as at the beginning and end of each survey.

Partridge observed during other study activities, and similarly recorded, supplemented route observation data.

Route B was surveyed each week between completed winter-covey dissolution and anticipated commencement of egg hatching, 1970, to record numbers of calling partridge. Surveys began 30 to 45 minutes before sunrise on mornings having wind less than 12 mph (19.3 kmph). Since calls were heard up to an estimated 0.5 mi (0.8 km), individual calling partridge were counted during a 2-minute period at 0.5-mi intervals along the route. Paired male partridge did not call when the observer was within 50 yd (46 m) of the bird but were included as calling birds. Partridge observed during each survey were classified as previously described. The survey was a modification of the bobwhite

(Colinus virginianus) summer whistle count survey (Kabat and Thompson 1963).

A 2-mi^2 (5.2 km^2) area in the southcentral portion of the study area was intensively searched for partridge nests in 1970. Searches were conducted once each month during April, May and June. The area was searched by various combinations of one man and one dog to three men and two dogs. The area was again searched intensively for nests by the author, an assistant and 20 boy scounts on 30 May 1971. Records were kept of all partridge and each flushing site was searched for nests. Nest searches in various vegetation types were conducted during June and July, 1970 and 1971, elsewhere on the study area. A golden retriever was used by the author and an assistant in all nest searches.

Although sexes of partridge may be identified by covert color patterns (Saunders 1899; Yeatter 1934; and McCabe and Hawkins 1946), the technique is limited to use with birds in hand or to birds at extremely close range and no references to its accuracy were located. Saunders (1899), Ogilvie-Grant (1911/1912) and Westerskov (1949:16) presented a general technique which utilized plumage color patterns on the head and face for field-sexing partridge. This method has not been tested for accuracy and apparently has not been used to its potential in North American field studies; Ogilvie-Grant's (1911/1912) precautionary note about a possible "eclipse plumage" in males, July-August, may have contributed to non-use of this criterion.

Details of facial-head techniques are presented below with anatomical nomenclature taken from Pettingill (1970:10-11).

Males possess rust-colored feathers on their orbital, malar and auricular regions; the forehead, crown and occiput are uniformly slate gray. No differentially-colored superciliary line was noted for males. Females exhibited buff-colored orbital and malar regions; these areas terminated at about the posterior edge of the eye. The auricular region characteristically showed mottled gray and white feathers extending posteriorly from the eye to the neck. The forehead and crown of females was also mottled gray and white, with a frequently distinct white superciliary line separating the dorsal from the orbital region (Fig. 2).

Age of dead partridge was determined by the presence or absence of a Bursa of Fabricius (Gower 1939). Live birds in hand were classified to age by the molt progression of primsary feathers (Petrides 1945). However, in summer and fall, presence of either one or both outer juvenile primaries with faded coloration and/or fraying of vane edges signified a yearling bird. The presence of adult primaries in No. 9 and 10 positions in summer indicated the bird was at least 2-years-old; presence of these feathers in fall and winter signified an unknown-age adult.

Color of tibio-tarsal region scales was also used in combination with primary molt progression to confirm bird age. Gray or gray-blue

Figure 2. Facial plumages of the male (left) and female (right) Hungarian partridge.

color indicated an adult bird while yellow or yellow-tan signified a juvenile bird (Witherby et al. 1944).

Weekly age-classes (through 14 weeks) were assigned to juvenile partridge observed in the field by colored photographs and descriptions provided by Willard (1973 and pers. conv.).

Food habits data were obtained by examining contents of crops. Crops were taken from partridge examined in hunter bags, from vehicle mortalities and predator kills, from systematic collections during 1973 and 1974 and from birds collected during a study of the effects of mercurial fungicides on partridge. Empty crops were so recorded. The aggregate percentage method (Martin et al. 1946) was used to tabulate and compare food items by month and season.

Trapping and Marking

Hungarian partridge were trapped and marked during winter and summer months to provide identifiable individuals for determining movements, life expectancy, longevity and population turnover; they were also an aid in interpreting social structure of coveys and of local populations.

Two types of grain-baited, walk-in, funnel-entrance traps were used during winter periods. Semi-portable traps (Fig. 3), modified from Hamerstrom (1942), were used at sites where two or more coveys occurred. Chicken wire was used to cover traps in 1968-69; this was replaced by 2x2-5/8-in (5.1x6.7 cm) vinyl-coated wire mesh to minimize injury to partridge in 1969. Modified "lily-pad" traps (Gullion 1961) (Fig. 4) were used in single-covey areas or where frequent movement of traps was required to capture several coveys. Detailed description of trap types are presented by Weigand (1970).

Figure 3. Semi-portable traps used to trap partridge in winter.

Figure 4. Portable trap used to trap partridge in winter.

To permit three trap-checks daily, no more than ten traps were activiated at any given time. Bait corresponded to nearest waste grain sources. Whole barley *(Hordeum distichon)* or wheat *(Triticum aestivum)*, and occasionally a mixture of both, was used throughout the winter. Grain and unset traps were placed in partridge feeding and roosting sites to precondition the birds for trapping. Only sites actively used by partridge were pre-baited.

Attempts were made to trap partridge broods during the summer of 1969 by dragging the lower edge of a mist net, suspended loosely between two conduits, over vegetation containing the birds (Weigand 1971b). Upon flushing of the first bird, the entire net was dropped onto the vegetation in the direction of their flight. Attempts were also made to flush partridge toward standard mist net settings (Low 1957) (Fig. 5).

Efforts were made to trap partridge broods in late August-early September, 1971-73, with a truck-mounted cannon net modified (Weigand 1973a) from Lacher and Lacher (1964).

During the first year of study a numbered, No. 10 aluminum leg gand was placed on one leg and a colored plastic, No. 5 leg bandette was placed on the other. In subsequent years an aluminum leg band was placed on each leg. Partridges were fitted with vinyl bibs (Weigand 1970), a modification of ponchose described by Pyrah (1970) which positioned the strip onto the bird's breast (Fig. 6). The use of nine

Figure 5. Standard mist-net set used in partridge trapping attempts in summer.

Figure 6. Mounted partridge displaying vinyl bib.

different bib colors, four symbol colors and 35 symbols permitted 525 readily identifiable combinations.

Nine female partridge, captured during January and February, 1974, were instrumented with radio transmitter, modified for Hungarian partridge from standard grouse units (Sidney L. Markusen, Electronic Specialties, Esko, Minnesota). The twelve frequencies used ranged from 150.815 to 150.890 mH_z and 151.010 to 151.085 mH_z at .015 mH_z intervals. Movements and activities of instrumented birds (Fig. 7) were monitored with a VHF tracking receiver (also Electronic Specialties) and a truck-mounted or hand-held antenna. The birds were monitored at 2- to 5-day intervals from time of release until they died or until signal transmission terminated.

Figure 7. A radio-instrumented female partridge.

Vegetational Analyses

Hungarian partridge habitat was defined by comparing individual land uses and vegetation types used by partridge with those which were available. Terminology used in the study was:

land use: grain, fallow, hay, rangelands, agriculturally idle areas and roads and borrow pits (roadside ditches);

land sub-use: the basic unit; e.g. = a winter wheat field, a fallowed field, an alfalfa field, an upland range, an irrigation ditch;

habitat: that combination of several land uses or sub-uses which, at that particular time, were available to a given partridge population.

Characteristics of habitats on the study area were subsequently determined from three progressively broadening aspects: land use and vegetation measurements at each bird observation site; land use and vegetation type mapping along observation routes; and, land use mapping of the study area from aerial photographs.

Vegetation types associated with partridge observations were measured at four locations: observation site (OS); nearest different land use (NLU); second-nearest different land use (2NLU); and, nearest woody cover (NWC). Land uses were recorded at the first three points because: (a) large numbers of observations on roads and in borrow pits were anticipated; these special land uses were not subject to agricultural management procedures nor changes to other uses; (b) agricultural land-use associations with partridge were requisite to evaluating land use preferences by the birds; and (c) information on severl land uses or vegetation types associated with partridge was desirable to detect preferred juxtapositions of these uses. "Different" was defined as that land use having compositions or conditions identifiable from the type in which the bird group was observed. Distances were measured to the NLU, 2NLU and NWC by pacing or by vehicle odometer. To avoid damage to growing crops or at distances exceeding 0.25-mi (0.40-km), distances were computed by triangulation.

Each vegetation type was classified by three criteria:

(1) composition: the dominant and one subdominant plant species were recorded in heterogeneous stands; in relatively homogeneous stands only the dominant plant species was noted;

(2) condition: referred to grain and hay crop phenology and harvest, to grazed (by livestock) vs. ungrazed and to other treatments of all vegetation types; and

(3) height: the mean height of vegetation was determined from measurements at five random sites within that vegetational type.

Woody cover was defined as woody vegetation containing sufficient area, height and density to deter capture by predators. It consisted primarily of tree and shrub plantings (i.e. shelterbelts), rose *(Rosa* spp.) snowberry *(Symphoricarpos albus)* or willow *(Salix* spp.) clumps, and cottonwood *(Populus deltoides)* groves.

Distances were also measured to the nearest winter range (NWR), an area of known-use by partridge in winter (primarily shelterbelts and/or buildings).

Vegetation characteristics were measured annually along each of the four routes in late July-early August. The length of each land-use adjacent to roads (excluding borrow pits) was determined by vehicle odometer readings interpolated to the nearest 0.025-mi (0.04-km). Land use-vegetation type availability when compared with use, yielded partridge preference indices for given land-uses and vegetation types.

Partridge habitat was defined by clustering and discriminant analyses of land uses/sub-uses of 16 - 40 a (16 ha) compartments centered about each partridge observation, 1969-72. Two variables, numbers of units and proportions of each compartment of each of 24 land uses/ sub-uses, were determined from 1 in:9,000 in (1 cm:9,144 cm) aerial photographs. Mean occurrence and proportions of individual land uses/ sub-uses were combined from the 16 compartments in a home range to provide single values for each land use/sub-use. Occurrence and proportion of each land use/sub-use were then summed to yield a single mean and standard deviation.

Samples of observations were selected from each season for further testing: every 4th observation in spring and summer; every other one in fall; and every 5th one in winter.

Initially, clustering procedures searched a season's sample observations, by switching and joining, to reveal "best-fit" of habitat variables (Hartigan 1975, Ward and Hook 1963). The 3-cluster level was deemed appropriate for distinguishing among partridge habitat classes on this study area. Values of habitat variables resulting in these clusters were subjected to discriminant analysis and re-clustered where necessary (Anderson 1958; Dixon 1973). Unsampled observations were then individually assigned to clusters according to their land use/sub-use variable values. The step-wise discriminat analysis also indicated, by rank order, which land uses/sub-uses were decisive in placing a given observation in a given cluster.

Mean values for land use/sub-use variables were determined by month for pairs (March-June), broods (July-September) and adult-only groups (July-September). Each observation was centered within four 40 a compartments to detect more subtle differences among habitats utilized by these different social groups. All observations were used to describe habitats of these groups. Differences between habitats, by social group and month, were indicated from multivariate testing (Hotelling t^2, Anderson 1958). A source of error in these analyses could have resulted from associating habitat components from the 1972 aerial photographs to partridge observed during 1969-71.

Farming and livestock grazing activities were monitored along the four observation routes at weekly intervals from early May through early October, 1970-72 and at less frequent intervals during the same periods, 1973-74. Results of this sampling were interpreted as indicative of activities on the entire study area. Periodic survey results were supplemented by timely pre- and post-farming season route surveys and by random observations.

Utilization of grasses, grasslike plants and forbs by cattle was determined during the 1971 summer grazing season. Eight modified agronomy cages (Weigand, 1973b) were placed on separate ranges (one seeded, two upland and five lowland sites) prior to grazing (U. S. Forest Service 1963). Cages were placed a minimum of 50 yd (45.7 m) from fences (1 exception) and more than 100 yd (91.4 m) from any water sources (2 exceptions). Vegetation was clipped to within 0.5-in (1.3-cm) of ground level following removal of cattle from each range unit. Clippings were made from five to ten 0.96-ft^2 (0.09-m^2) loops inside, with a corresponding number outside, each cage. Outside loop sites were randomly selected 25-yd (22.9-m) from each cage. All clipped vegetation was separated into grass-and-grasslike plants and forbs. Separated samples were permitted to dry at room temperature for an average of 40 days (range, 23 to 56 days), then weighed to the nearest 0.5 gm.

Production and utilization of each plant group was obtained by comparing inside-cage with outside-cage vegetation weights.

Heights of 100 grazed and 100 ungrazed grass or grass-like plants were measured to the nearest 0.01-ft (0.3-cm) near each cage site. Plant measurements and determination of forage utilization were adapted from Cole (1958).

Scientific nomenclature for birds was from the A.O.U. Checklist of North American birds (1957), for mammals from Hoffman and Pattie (1968) and for vegetation from Booth and Wright (1959) and Booth (1972). Statistical methods were from Snedecor and Cochran (1967) unless otherwise indicated.

HISTORICAL BACKGROUND

Hungarian partridge and agriculture share relatively recent histories in Montana. Accounts of partridge introductions were compiled from minutes of Montana Fish and Game Commission meetings, and Department publications and biennial reports. Agricultural statistics were compiled from federal and state agencies responsible for these records.

Hungarian Partridge

Introductions of Hungarian partridge in North America have been widespread. Westerskov (1964) reported partridge were released in 46 states and all Canadian provinces except Newfoundland and Quebec. Although first introductions were made in the late 1700's (Oldys 1910, Phillips 1928), all attempts to establish the species were unsuccessful until the early 1900's (Taverner 1934).

The most successful introduction of partridge in North America occurred near Calgary, Alberta where a total of 800 birds were released by sportsmen in a limited area, 1908-1910 (Gordon 1935). By early November 1921, partridge were observed near Rutland, Saskatchewan, about 20 miles east of the Alberta border (Dexter, 1922). The average annual spread rate for these partridge was 28 miles for the 14-year period (Leopold 1933:80).

Based on Leopold's (1933) calculated average spread rate for Calgary birds, partridge could have reached Montana by 1914 (minimum distance of 125 mi or 201 km to Montana's northern border).

Coincidentally, the desirability of adding Hungarian partridge to Montana's list of upland game birds was first expressed by the Montana Fish and Game Commission in 1914 (Anonymous 1914). Marlowe (1922) reported partridge had drifted southward into Montana from Alberta by 1922; they were reported in the northern tier of counties and observed in the Sweetgrass Hills (in Toole and Liberty Counties), along the Milk River and as far south as the Marias River.

The Montana Fish and Game Commission authorized purchasing Hungarian "pheasants" in 1920 (Montana Fish and Game Commission 1920) and the first shipment was released about 1 May 1922 (Marlowe 1922). Approximately 1,000 birds from Europe were distributed to predetermined release sites in 45 of the existing 54 counties. Two thousand additional birds were imported in 1923, and in 1924 Jakways (1924) stated Hungarian partridge were "now a proven success in Montana. They are increasing rapidly in all parts of the state." Stocking of partridge imported from Czechoslavakia, Hungary and other central European countries (Anonymous 1929), continued up to about 1928-29; 2,000 were released in 1925, 1,000 in 1926, and a minimum of 600 after 1926 (Anonymous 1929). Marlowe (1926) indicated partridge had been released into every Montana county by 1926.

Construction of Montana's first Fish and Game Commission game farm was completed at Warm Springs in 1929. Hendricks (1929) stated it was then difficult to purchase good brood stock of partridge so wild birds were trapped in Deer Lodge County. Ten pairs of breeding stock were retained each year at the game farm until 1933 (Hendricks, 1932). In 1933, apparently the last year of game farm releases, three counties received a total of 52 partridge (Montana Fish and Game Department 1934).

The North Dakota Game and Fish Department released partridge from Czechoslavakia in 1923 (Upgren 1970). The same year, releases were made by the Wyoming Game and Fish Commission (Johnson 1960). It is possible that interchange of partridge occurred between Montana and both of these states.

Hungarian partridge were established in Montana by 1927 and sportsmen petitions for open and continued closed hunting seasons were received by the State Fish and Game Commission. Teton County residents asked for a hunting season on partridge in 1927 because of depredations on crops near Choteau. Since the Commission could legally regulate seasons only for native upland game birds, they could not authorize hunting of partridge, or ring-necked pheasants, without appropriate legislative action.

State legislative authorization was obtained and the first Hungarian partridge season in Montana, which included Teton County, was 24-28 November 1929. The daily limit was 3, with a possession limit of 6 after the first day; these limits could be comprised of partridge only or in aggregate with pheasant cocks. In the 44 succeeding years there were 7 years with closed seasons (1937-39, 1946-48 and 1950).

Hunting season lengths ranged from 5 (1929-32, 1940 and 1949) to 79 days (1974). Partridge hunting season dates coincided with those of pheasants through 1957. During 1958-73, partridge seasons ran concurrently with sharp-tailed grouse and pheasant seasons. Hunting of partridge during the double-season years ranged from 28.5 to 73.5 days. In 1974 partridge hunting opened with the grouse season and extended through the last day of the pheasant season.

Daily bag limits ranged from 2 (1953) to 6 partridge (1959-74). During 1929-33 daily limits applied to partridge, pheasant or any combination of the two species. Daily limits in 1953 applied to partridge, sharptails or 1 of each species. Possession limits during 9 of the 38 hunting seasons included a single day's limit; a 2-day limit comprised possession limits during the other years.

Annual hunting seasons and daily bag and possession limits for Hungarian partridge in Teton County are presented in Appendix I.

Harvest questionnaires were mailed to 6,656-18,585 licensed upland game bird hunters in Montana each year, 1958-74 (Weigand and Janson 1976). Completed and returned questionnaires from a mean 68 percent of the hunters revealed Hungarian partridge harvests ranged from a peak 163,760 in 1964 to a low 32,630 in 1972 (Table 1). They comprised a mean 14 percent of the total upland game bird harvest and ranked between third and fourth of eight species. Most of the Hungarian partridge harvest occurred in northcentral and northeast Montana.

Table 1. Total upland game bird[1] and Hungarian partridge harvests in Montana, 1958-74.

Year	Total Birds Harvested	Hungarian Partridge Harvested	Hungarian Partridge Percent of Total	Species with Greater Harvests[2]
1958	442,550	77,010	17.4	P,
1959	350,300	41,900	12.0	P
1960	401,100	49,400	12.3	P, BG
1961	422,400	37,470	8.7	P, RG, BG
1962	487,530	45,290	9.3	P, RG, BG
1963	727,750	111,490	15.3	P
1964	905,380	163,760	18.1	P
1965	358,790	40,520	11.3	P, RG, ST, BG
1966	700,230	123,530	17.6	P, ST
1967	433,860	70,620	16.3	P, ST
1968	373,750	70,160	18.8	P
1969	441,500	69,090	15.6	P, ST
1970	353,360	49,560	14.0	P, ST
1971	332,420	36,660	11.0	P, ST, SG
1972	339,400	32,630	9.6	ST, P, RG, SG, BG
1973	406,430	40,690	10.0	ST, P, BG, RG, SG
1974	339,620	45,190	13.3	ST, P, BG, RG

[1]Excludes Merriam turkey harvests.
[2]In order of harvest: P = pheasant; BG = blue grouse; RG = ruffed grouse; ST = sharp -tailed grouse; and, SG = sage grouse.

Agriculture

Settlement of Teton County began in the late 1800's (Giesecker et al. 1933:15) and there were 347 farms in the county by 1900 (U. S. Department of Commerce 1932). The high of 1,187 farms was reached by 1910, decreased to 1,032 farms by 1930, and remained relatively stable at about 1,050 until 1940. Mean farm size increased from an average of 541 a (219 ha) in 1920 to 1,019 a (413 ha) in 1940 (U. S. Department of Commerce 1936, 1942). Numbers of farms were not recorded by county after 1940.

Following the 1930 national census, Giesecker et al. (1933:17) reported: "The land not in farms is partly suitable and available for grazing, but much of it is wasteland with such scant vegetation that it has little or no value for grazing." The increased farm size through 1940 indicated additional acreages of previous rangeland were being cultivated for grain crops. The amount of land in farms increased from 613,506 a (248,470 ha) in 1920 to 1,101,500 a (446,108 ha) in 1940. Flax was an important crop on newly broken sod. Spring wheat was the principal cash-grain crop. Fall-planted rye was occasionally cultivated but winter-killed. Oats, barley and rye were grown and harvested principally for livestock forage; oats was the primary hay crop on some higher tablelands.

Horses and mules were the main power source for pulling farming implements during early settlement of the region. Mr. Paul Rice, a study area resident since 1910, stated the first mechanized grain thresher appeared in 1911; there were 695 tractors in Teton County by 1930 (Giesecker 1933:18). During the 1969-74 partridge study, all crop cultivation and hay mowing utilized self-propelled vehicles.

Grain crop acreages, numbers of livestock and livestock grazing-pressure means were determined for 5-year periods beginning with 1920-24. Grain crop acreage-means included acres harvested for barley, corn, flax, oats, rye, spring wheat and winter wheat. Acres of hay and numbers of livestock, by class, were available for individual years except during 1919-35 when 5-year interval figures only were recorded. Since numbers of livestock within the different types varied, livestock grazing-units were approximated using animal unit conversion factors (Range Term Glossary Committee (1964:7-8):

1 = 1 adult cow or cow plus calf;

0.2 = 1 adult sheep or ewe plus lamb; and

1.25= 1 adult horse.

Grain crop acreages increased steadily in Teton County from 1920-24 (136,000 a or 55,080 ha) through 1955-59 (258,000 a or 104,490 ha), except for a slight decline 1925-34 (Fig. 8). Since 1959, acreages cultivated for grain have stabilized at about 240,000 a (97,127 ha). Hay acreage also increased, 1920-74, but at a much lower level than that of grain. A low of 26,520 a (10,741 ha) hay was harvested in 1919 while a high of 75,300 a (30,497 ha) was cut in 1972. Livestock grazing peaked during 1935-39 at 67,120 livestock grazing units. The 1935-39 decrease in grazing pressure was attributed to drastically reduced numbers of sheep. The decrease could have been more severe, but was partially compensated for by increasing cattle numbers. The increase in grazing pressure since 1960 was virtually entirely due to increased cattle numbers. During 1970-74, a mean 65,600 livestock units were grazed annually.

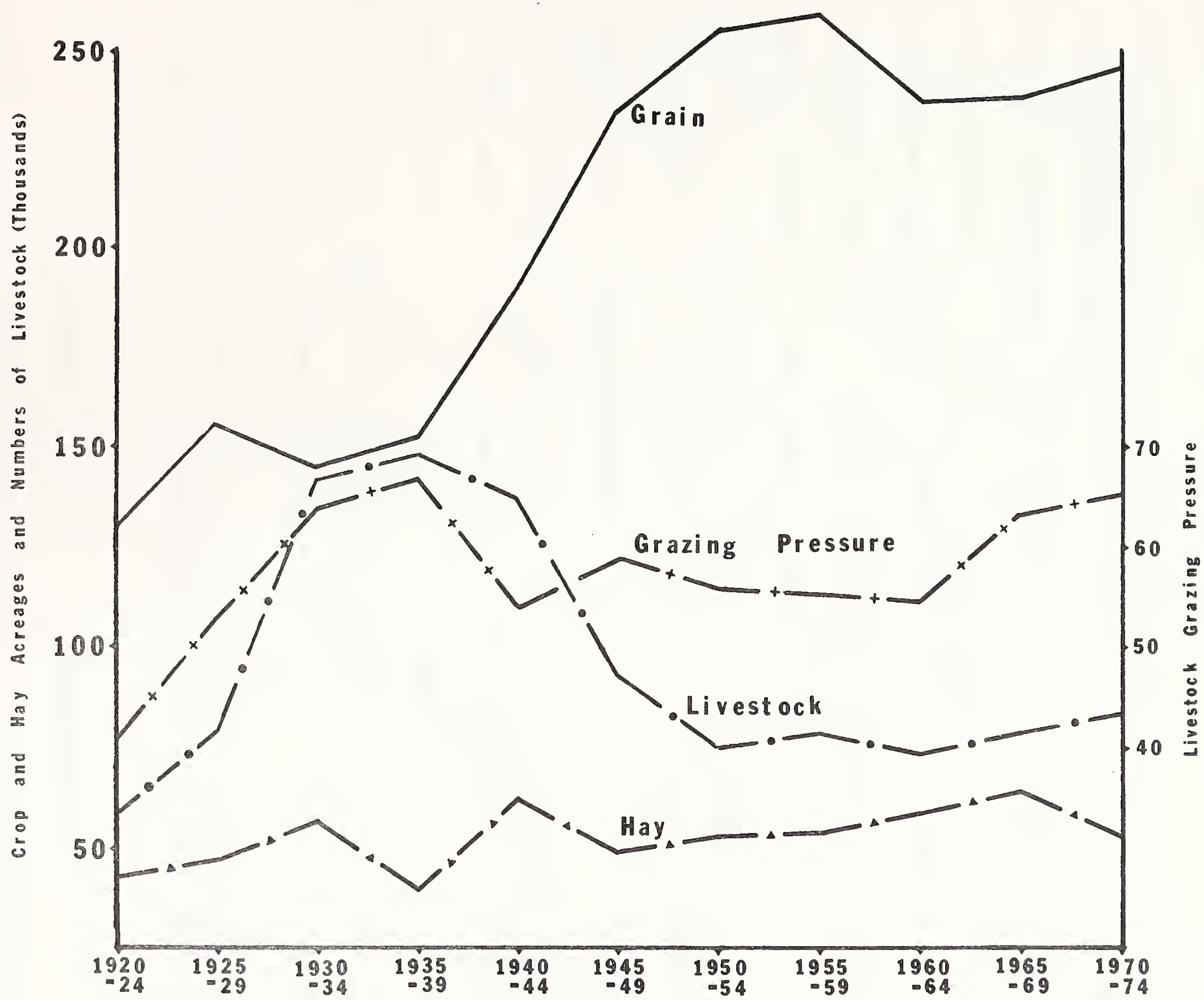


Figure 8. Grain, hay and livestock trends, by 5-year means, in Teton County, 1920-74.

Grain Crops

Spring wheat was the principal grain in Teton County until 1940 (Fig. 9). The highest 5-year mean acreage was 138,000 a (55,890 ha) in 1925-29, the lowest acreage was 29,200 a (11,826 ha) in 1965-69 and there was a mean 46,600 a (18,873 ha) spring wheat, or 19 percent of all grain acreage, during the current study. Winter wheat, the second major grain crop, increased from 3,900 a (1,580 ha) in 1925-29 to a high of 128,800 a (52,164 ha) in 1965-69. Winter wheat comprised 36 percent of county grain crops during 1969-74. Barley was the third important grain crop and attained a 5-year peak of 104,900 a (42,485 ha) during the present study. Acreages of oats increased to a 5-year peak of 13,800 a (5,589 ha) in 1940-44 and declined to the 55-year low of 4,300 a (1,742 ha) during 1965-69. Oats comprised 2 percent of the county's grain harvest, 1970-74. Flax cultivation increased from 3,100 a (1,256 ha) in 1920 to 20,800 a (8,424 ha) in 1943; less than 700 a (284 ha) flax was harvested 1969-71 and no flax was recorded in 1972-74. Corn and rye were minor cash crops; during the current study, up to 600 a (243 ha) corn and 200 a (91 ha) rye were harvested.

Proportions of annual harvests of major grains occurring on irrigated land, 1945-73; were: spring wheat, mean of 10 percent; winter wheat, mean of 6 percent; barley, mean of 14 percent; oats decreased from 56 to 9 percent annually; and, flax decreased from 82 to 29 percent annually.

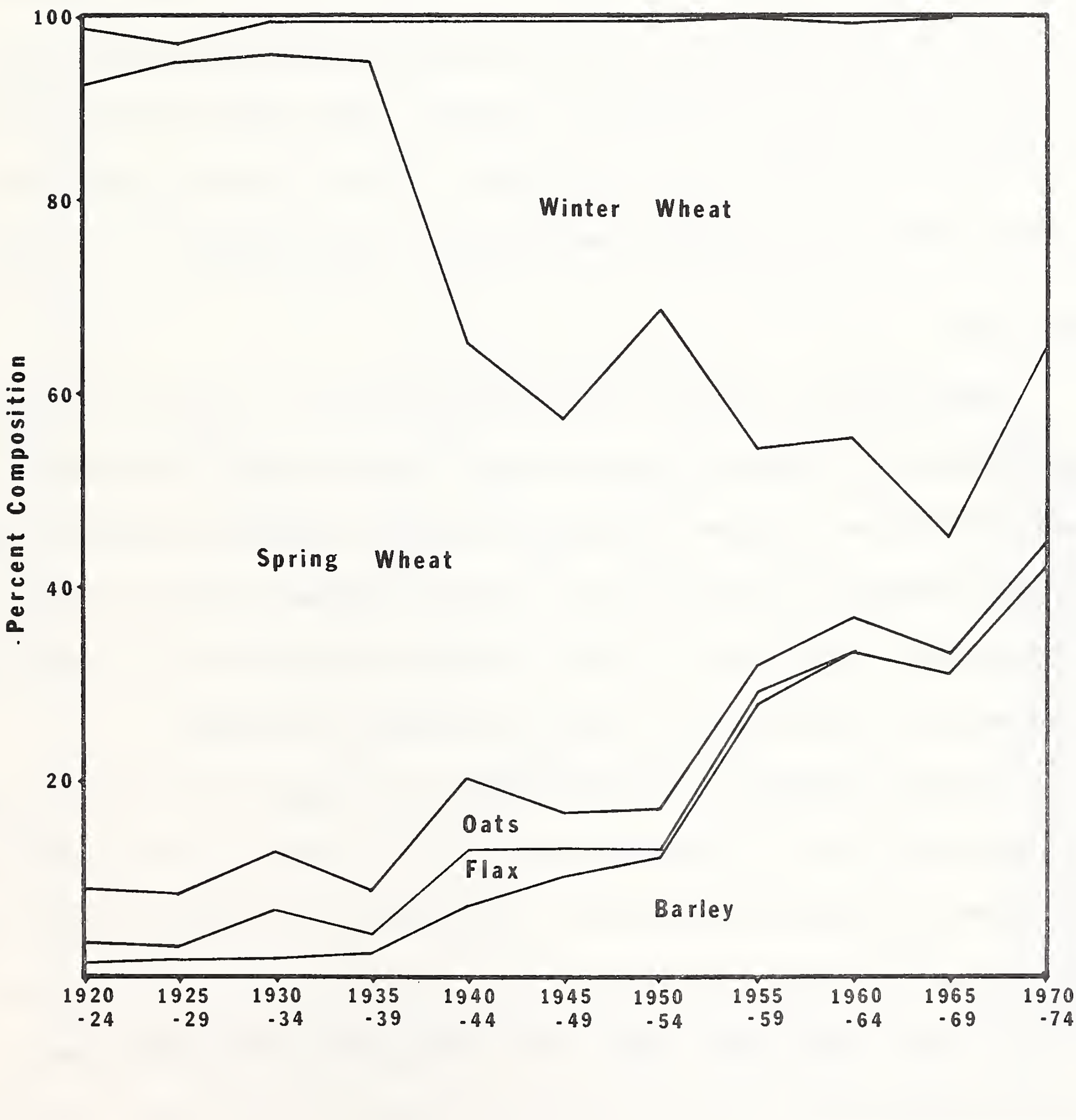


Figure 9. Mean proportions of the five principal grain species in Teton County, 1920-74.

Other seed crops harvested in Teton County (1946-63 records only) included mustards, sweet clover *(Melilotus* sp.) and crested wheatgrass *(Agropyron cristatum)*. Maximum annual harvests for these respective crops occurred on 4,800 a (1,944 ha) in 1946, 3,400 a (1,337 ha) in 1950 and 1,100 a (446 ha) in 1950. Peas were harvested from 400 to 5,200 a (162-2,106 ha) annually, 1944-48. Sugar beets and potatoes were cultivated on maximum acreages of 870 a (352 ha) and 360 a (146 ha), respectively, during 1945-51 and 1944-69, respectively.

Hay Crops

Hay acreages reflected the combined effects of moisture conditions and demands for winter livestock forage. Wild grasses, primarily on moist soils near streams and rivers, provided the major portion of vegetation harvested as hay (Fig. 10). While wild hay acreage increased from 20,000 a (8,100 ha) in 1919 to 35,800 a (14,499 ha) in 1959, the proportion of wild grass in total hay harvests decreased.

Alfalfa *(Medicago sativa)* represented the major cultivated hay crop since about 1929. It increased from a low of 2,400 a (972 ha) in 1919 to 46,700 a (18,914 ha) in 1973. The proportion of alfalfa in hay harvests also increased from the 1919-low (9%) to a high of 69 percent in 1973. During the present study (1974 acreages unavailable) alfalfa acreage ranged from 23,000 to 46,700 a (9,315 to 18,914 ha). Most harvested alfalfa (91%) was grown on irrigated land, 1944-73.

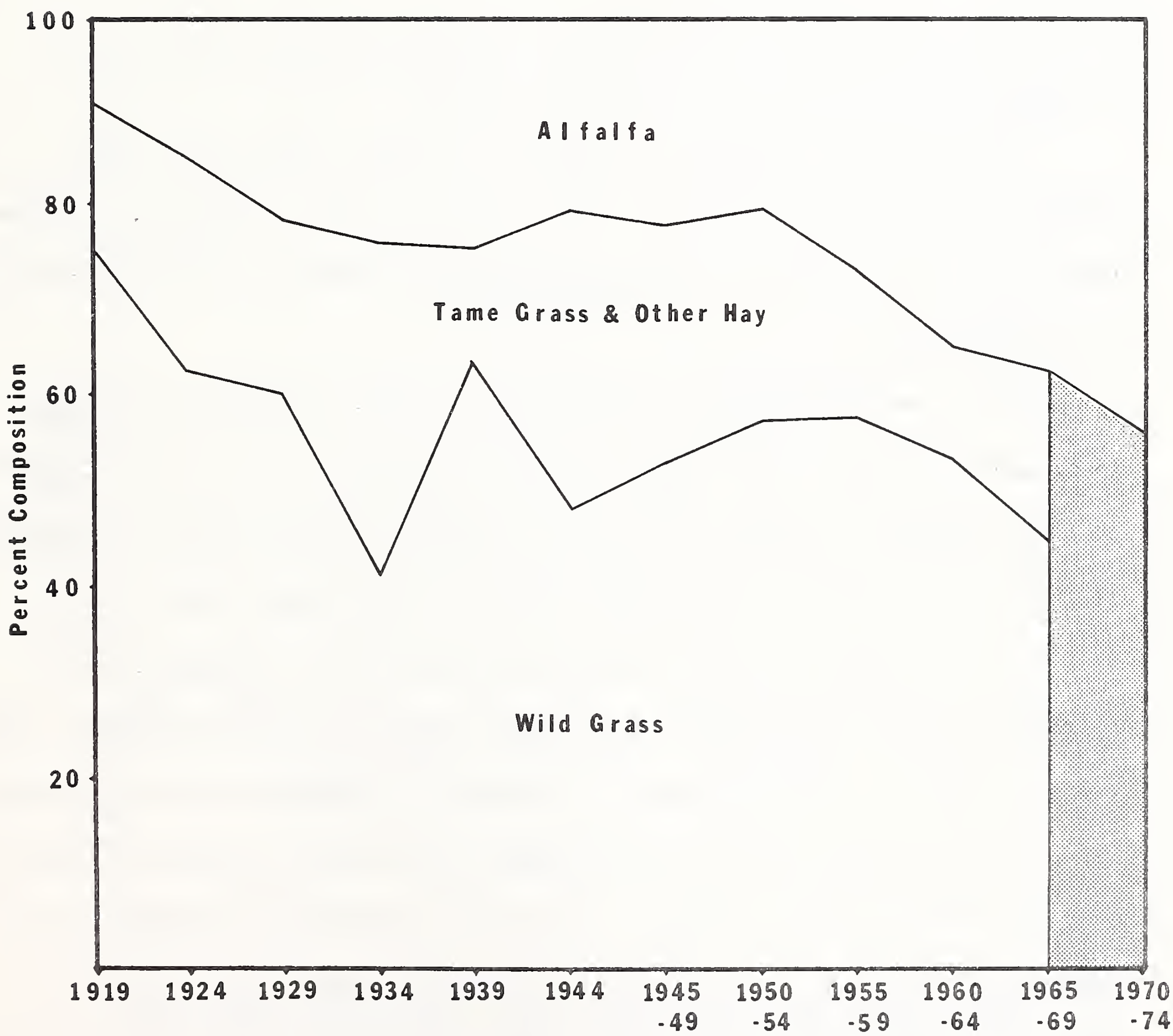


Figure 10. Proportions of individual types of hay in Teton County, 1919-74. Shaded area = data unavailable.

Tame hay included primarily smooth brome *(Bromus inermis)*, timothy *(Phleum pratense)*, bluegrasses *(Poa* spp.), Russian wildrye *(Elymus junceus)* and sweetclover. The maximum proportion of tame hay in total hay harvests occurred in 1945 (40%) while a low 8 percent was recorded in 1961.

Livestock

The principal classes of livestock in Teton County since 1920 included beef and dairy cattle, sheep, pigs, horses and mules. Chickens were also represented but were believed to be confined to the vicinity of farmsteads.

Sheep were the dominant livestock, in terms of numbers, between 1920 and 1950 (Fig. 11). Sheep numbers increased to a peak of 108,000 in 1942 and then declined to a low of 14,000 in 1970; between 14,000 and 16,500 sheep grazed in the county during the partridge study.

Cattle numbers in Teton County increased from 18,200 in 1919 to 61,800 in 1973. The highest 5-year mean number of cattle (59,500) occurred in 1970-74. Cattle became the principal livestock in the county in 1950. Beef breeds, primarily herefords, comprised 78 percent or more of the county's cattle numbers. Dairy cows comprised a maximum of 21 percent of all cattle in 1919 but decreased steadily to 2 percent in 1974. Less than 6,000 dairy cows were recorded in any year since 1920. During the current study dairy cows decreased from 1,700 to 1,100 animals in the county.

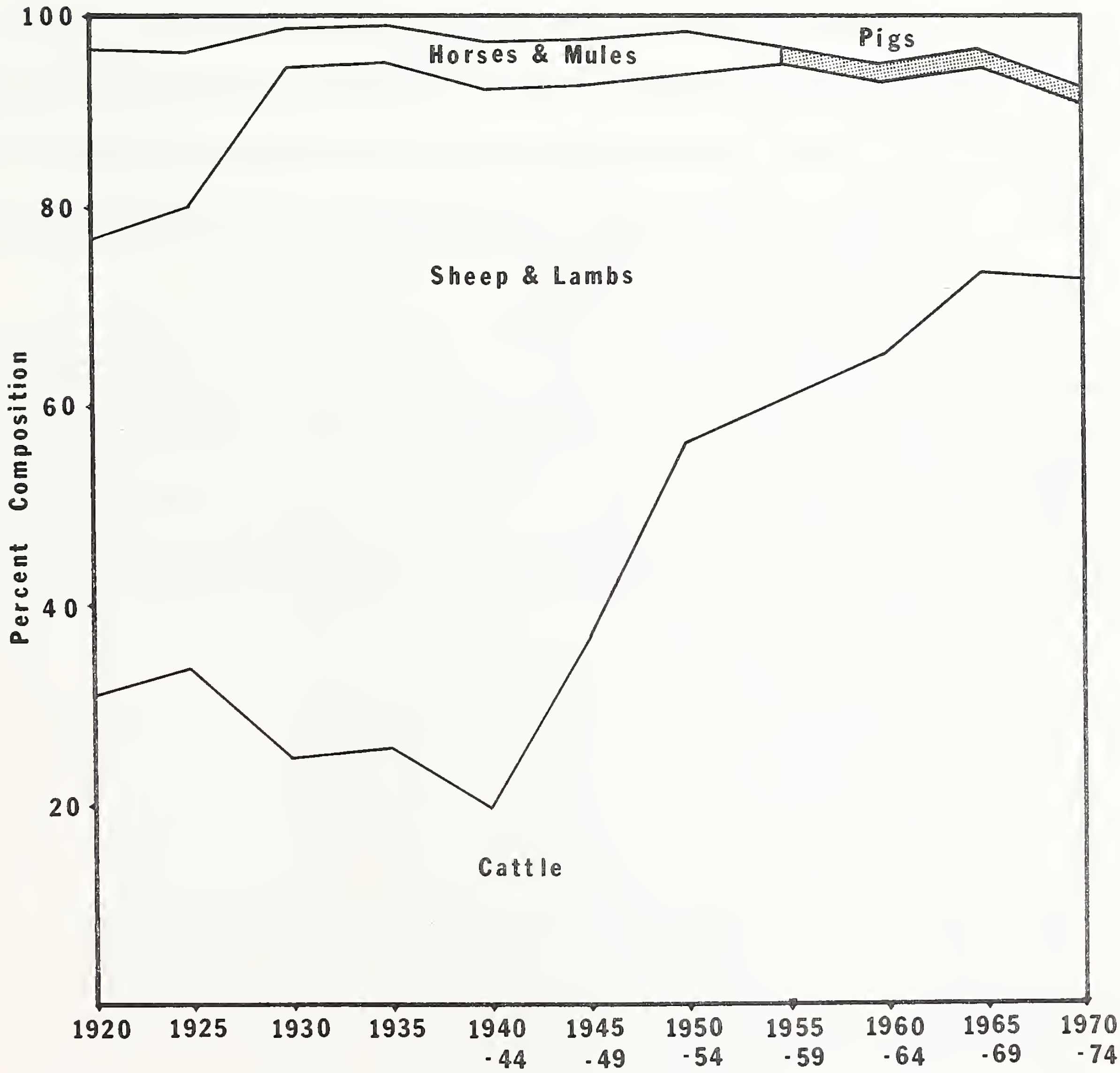


Figure 11. Proportions of individual livestock classes in Teton County, 1920-74. Shaded area = data unavailable.

Horses were the third principal rangeland grazer; mules were not numerous at any time and were included with horses for this report. Their numbers peaked about 1925 (12,710) and, after a 54 percent decrease by 1930, began a steady decline. When record-keeping of horse numbers ceased in 1960, only 1,600 remained in Teton County. It is doubtful more than 1,000 horses were present in the county annually, 1969-74. The primary horse raisers appeared to be ranchers and big game hunting guides and outfitters in the western, mountain-foothill portion of the County. A few small recreational and thoroughbred herds were scattered through the remainder of the county.

Pigs increased in numbers from a low 1,700 about 1935 to 8,900 in 1972. Five-year peaks in pig-raising were recorded during two periods of international conflict, 1940-44 and 1960-64; a third peak, during the final phase of the Viet Nam War, occurred during the present study.

DESCRIPTION OF THE STUDY AREA

The Agawam Study Area was located 14 miles north of Choteau, in northeastern Teton County, Montana. It encompassed 54 square miles representative of the cereal grain-producing and other diverse agricultural land uses of northcentral Montana. The review of geology and soils of the areas is summarized from Giesecker et al. (1933). Detailed descriptions of soil types are given in Appendix II.

Topography, Soils and Drainage

A large part of northern Montana east of the Rocky Mountains, including the Agawam Study Area, was overrun by the Keewatin ice sheet, probably during the late Wisconsin glaciation. The ice sheet dammed many east-slope mountain streams forming large glacial lakes. Lake deposits, consisting chiefly of gravel, silt and silty clay, lie between the 3,700 and 4,000 ft (1,349 and 1,458 m, respectively) elevations and have a maximum thickness of 100 ft (36.5 m). Morainic areas occurred along the Teton River, about 15 mi (24 km) south of the study area. Giesecker et al. (1933:3) thought:

> "Glaciation did not greatly influence the drainage of the area. Although the larger streams were diverted and their valleys partly filled with drift, nearly all returned to their former valleys after the recession of the ice sheet."

Muddy Creek, which formed part of the south boundary of the study area,

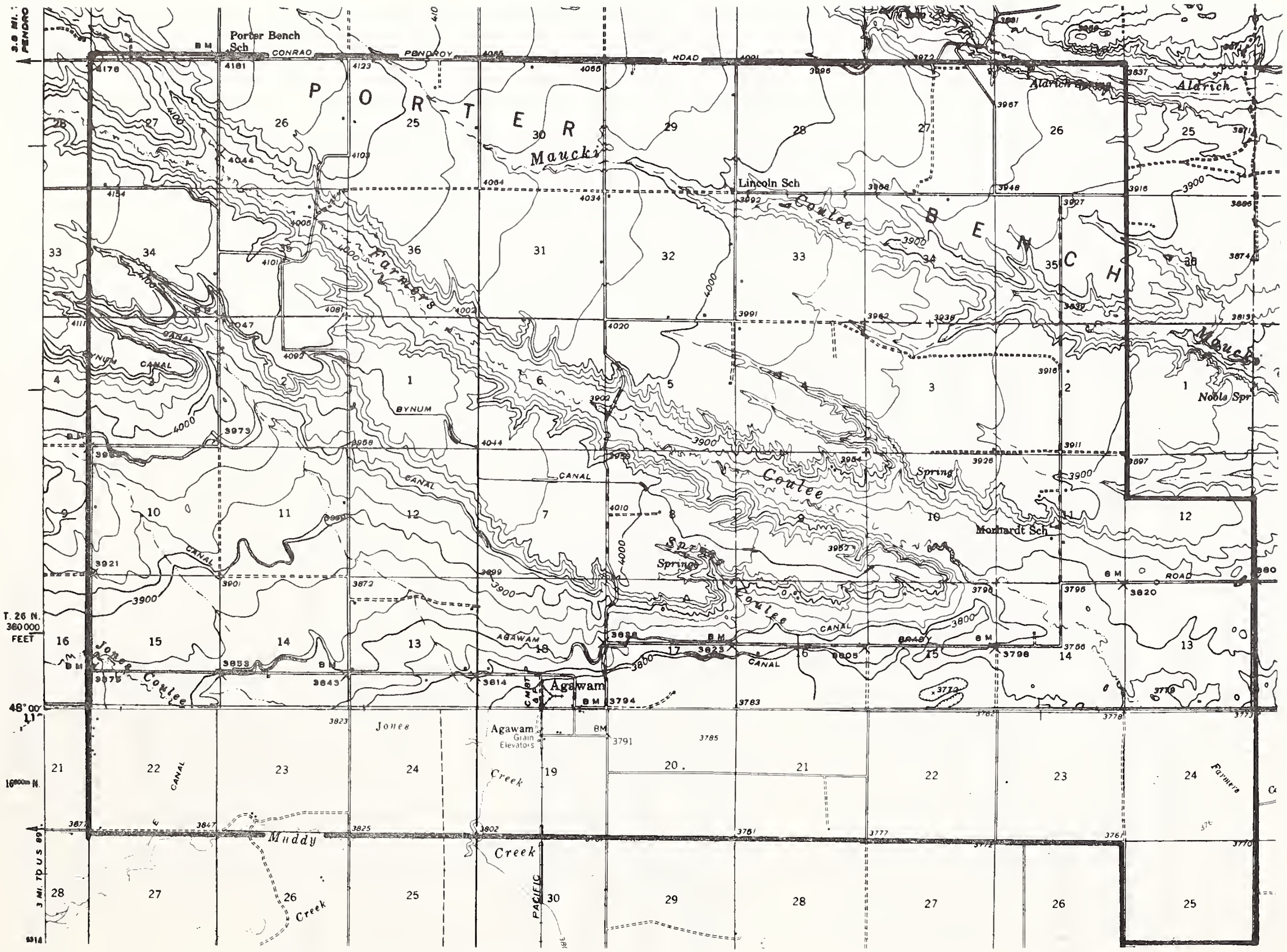


Figure 12. Physiography of the Agawam Study Area.

fitted this description, but tributaries of Muddy Creek may have formed after glacial recession.

The land sloped from the highest elevation on the study area, 4,178 ft (1,274 m), in the northwest corner to 3,740 ft (1,140 m), the lowest point, in the lowland basins of the southeast corner (Fig. 12). This elevation coincided with Giesecker et al.'s (1933) range for glacial lake deposits.

Soils on the higher elevations, Porter Bench, were Fairfield loams ranging in depth from 9 to 14 in (22.9 to 35.6 cm). This layer was underlain to a subsurface depth of 3 to 4 ft (1.1 to 1.5 m) by gray or gray-brown silty clay with a high lime content. Materials at greater depths were stratified brown sands, silts and gravels. Land slopes on Porter were 0 to 2 percent. Both surface and subsurface drainage were considered fair. Water table surfaces were 2.5 to 6 ft (0.9 to 2.2 m) below the ground surface.

Mauki and Farmers Coulees trisected Porter Bench and flowed to the southeast. While they were intermittent creeks, numerous springs on their tributaries yielded water year around. Alluvial soils, sediments carried from upper slopes or weathered drift materials, were present along these creeks.

Slopes along the southern edge of Porter Bench were generally less than 15 but some gradients to 35 percent were present. Soils were Morton loams which were very dark gray-brown with high lime content in their subsoils and overlaid sandstones and shales. Some gravel and a few quartzite fragments occurred at the surface and throughout the soil. Surface and subsurface drainages were considered good; soils were open and porous, yet had a good water-holding capacity.

A gently declining, secondary bench occurred in the southwest and southcentral portions of the study area. This bench contained Asheulot gravelly loams, the name given a series of brown terrace soils underlain by gravel. The most prevalent surface soil was a gray-brown or light brown loam which graded at 3 to 6 in (7.6 to 15.2 cm) into lighter brown, crumbly calcareous gravelly loam. About 15 in (38.1 cm) below the surface was a 5 to 6 in (12.7 to 15.2 cm) thick bed of gravel firmly cemented into a concretelike mass, impenetrable by plant roots. Slopes on this bench were less than 4 percent.

The final slope, not exceeding 8 percent, in the southwest corner of the study area was drained by Jones Creek which also flowed intermittently. Richey silty clay loam and Twin Lakes gravelly loam were the major soil types.

The lowland adjacent to Muddy Creek, the major stream in the area and which flows year around, was comprised of Straw silt loam and various mixtures of alluvial soils. The water table was at or near the surface and seeps or marshy areas frequented the lowland.

A low bench in the southeast corner of the study area contained Beaverton gravelly loams. These soils differed from the Cheyenne gravelly loams mainly in color and possessed a wide range of soil texture and subsoil characters. They were underlain by stratified, deep sands, silts and gravels.

Climate

The climate of the region encompassing the study area may be described as having generally hot summers, cold winters and a dry atmosphere (Giesecker et al. 1933). Rainfall was moderately low and winter snows were frequently melted by chinooks (Trewartha 1954:376).

No regularly reporting official weather stations were located on the study area which apparently lay in a local weather belt. Two stations, Choteau Airport (13 mi (20.9 km) to the south) and Conrad Airport (13 mi to the northeast) provided a range of weather data which probably bracketed conditions on the study area.

The mean annual temperature for Choteau was 43.5^{o}F (6.4^{o}C), 1969-74 (Table 2). Annual ranges in temperature extremes varied from 115^{o}F (63.9^{o}C) in 1970 to 139^{o}F (77.2^{o}C) in 1969. Monthly temperature ranges were greatest in January during each of the 6 years. Winters were characterized by minimum temperatures exceeding -15^{o}F (-26^{o}C) with extremes below -30^{o}F (-35^{o}C). Summers generally included one or more periods of >90^{o}F (32.2^{o}C) which usually occurred in July.

Weather conditions recorded at Conrad tended to be colder than Choteau in the winter, as warm as Choteau in the summer and extreme temperatures approximated those at Choteau (Table 3).

Table 2. Summary comparisons of minimum, maximum, mean and departure from normal temperatures and precipitation at Choteau, Montana, 1969-74[1].

	Temperatures (°F/°C)						Precipitation (in /cm)				
	Lowest Min.		Highest Max.								
Year	Temp	Month	Temp	Month	Annual Mean	Departure from Normal	No. Days Received	Daily Min.	Daily Max.	Annual Total	Departure from Normal
1969	-37/-38.3	Jan.	102/38.9	Aug.	42.5/5.8	-1.0/-0.6	78	Trace	1.44/3.66	10.85/27.56	-0.60/-1.52
1970	-20/-28.9	Jan.	95/35.0	July Aug.	43.8/6.5	0.3/+0.2	99+	Trace	1.57/3.99	13.81/35.08	2.36/-5.99
1971	-36/-37.7	Jan.	97/36.1	July	43.7/6.5	0.2/+0.1	121	Trace	0.62/1.57	7.04/17.88	-4.41/-11.20
1972	-34/-36.6	Jan.	91/32.7	July	42.9/6.0	-0.6/-0.3	123	Trace	1.67/4.24	10.21/25.93	-1.24/-3.15
1973	-16/-26.6	Jan.	101/38.3	July	46.1/7.8	2.6/+1.4	81	Trace	0.51/1.30	5.19/13.18	-6.26/-15.90
1974	-21/-29.4	Jan.	96/35.5	June	46.4/8.0	2.7/+1.5	90	Trace	0.72/1.83	8.04/20.42	-4.05/-10.29

[1]Data from Choteau Airport weather stations, elevation = 3,945 ft., 47°49' N. Lat. and 112°10' W. Long.
Data compiled from monthly reports of Climatological Data: Montana. U. S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service.

Table 3. Summary comparisons of minimum, maximum, mean and departure from normal temperatures and precipitation at Conrad, Montana, 1969-74[1].

	Temperatures (°F/°C)						Precipitation (in./cm)				
	Lowest Min.		Highest Max.								
Year	Temp	Month	Temp	Month	Annual Mean	Departure from Normal	No. Days Received	Daily Min.	Daily Max.	Annual Total	Departure from Normal
1969	-35/-37.2	Jan.	103/39.4	Aug.	42.5/5.8	-0.6/-0.3	65	Trace	1.29/3.28	7.66/19.46	-4.12/-10.46
1970	-20/-28.9	Jan. Dec.	98/36.6	Aug.	43.1/6.2	0/0	82	Trace	1.88/4.78	11.77/29.90	-0.41/- 1.04
1971	-39/-39.4	Jan.	95/35.0	Aug.	41.1/5.1	-2.0/-1.1	102	Trace	0.87/2.21	10.79/27.41	-1.39/-3.53
1972	-42/-41.1	Jan.	91/32.7	Aug.	39.8/4.3	-3.3/-1.8	105	Trace	1.22/3.10	14.61/37.11	2.43/ 6.17
1973	-18/-27.8	Jan.	101/38.3	July	43.3/6.3	0.2/+0.1	65	Trace	0.91/2.31	5.75/14.61	-6.43/-16.33
1974	-31/-35.0	Jan.	92/33.3	[2]	44.2/6.8	0.9/+0.5	86	Trace	0.74/1.88	8.50/21.59	-3.74/-9.50

[1]Data from Conrad Airport weather station, elevation = 3,537 ft., 48°10' N. Lat., 111°58' W. Long.

Data compiled from monthly reports of Climatological Data: Montana. U. S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service.

[2]Maximum temperatures recorded.

The frost-free season at Choteau averaged about 115 days between mid-May and mid-September during 1969-74 (Table 4). At Conrad the frost-free period averaged 98 days beginning in late May.

Precipitation was received at Choteau an average of 99 days annually, 1969-74 (Table 2). The normal annual precipitation, 11.45 in (29.08 cm), was exceeded only in 1970; precipitation was about normal in 1969 and the remaining 4 years varied from 11 to 55 percent below normal. Normal monthly precipitation ranged from 0.23 in (0.58 cm) in December to 3.07 in (7.80 cm) in June. Forty-four percent of the normal annual precipitation was received in May and June while 55 percent was received in May, June and July.

During 1969-74 precipitation was received at Conrad an average of 86 days annually (Table 2). Normal annual precipitation was 12.18 in (30.94 cm); the normal was exceeded only in 1972 with below normal amounts (12 to 53 percent) registered during the other 5 years. Thirty-nine percent of the normal annual precipitation was received in May and June and 52 percent was received in May, June and July.

Climatic winters extended from early December through late March; snow covered the ground almost continuously during this period except for brief interims following the chinooks. Monthly snowfall at Choteau, 1969-74, averaged 9.0 in (22.9 cm) in December, 12.1 in (30.7 cm) in January, 3.8 in (9.7 cm) in February and 6.4 in (16.3 cm) in March (Table 5). May through September represented the normally snow-free

Table 4. Frost-free seasons recorded at Choteau and Conrad, Montana, 1969-74[1].

Year	Choteau			Conrad		
	Dates of		Frost-Free Period (Days)	Dates of		Frost-Free Period (Days)
	Last Spring Frost	First Fall Frost		Last Spring Frost	First Fall Frost	
1969	14 June	15 September	93	13 June	15 September	94
1970	19 May	11 September	115	14 May	11 September	120
1971	21 May	17 September	119	22 May	14 September	115
1972	9 May	20 September	134	19 June	10 September	83
1973	12 May	14 September	125	11 June	2 September	83
1974	1 June	11 September	102	1 June	2 September	93

[1]Data compiled from monthly reports of Climatological Data: Montana, U. S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service.

Table 5. Snowfall and snow on ground at Choteau, Montana[1] for the winters 1968-74.

Year: Month	No. Days Snow Fell	Total Monthly Snowfall	Total No. Days with Snow on Ground	Total Days with ≥ 1-inch Snow on Ground	Snow Depth		
					Min	Max	Mean[2]
1968: December	7	23.5	28	28	1	11	4.5
1969: January	14	19.0	31	31	2	11	5.7
February	3	2.0	28	28	6	11	8.2
March	6	9.0	19	19	1	10	5.8
1969: December	4	2.0	NM[3]	NM	-Unavailable -		
1970: January	8	2.5	NM	NM	-Unavailable -		
February	6	11.0	8+	8+	1	7	3.4
March	NM	NM	16	16	1	14	5.3
1970: December	9	1.7	25	15	1	2	0.7
1971: January	16	14.9	29	19	1	7	2.8
February	8	3.0	10	9	1	2	1.2
March	8	4.0	10	5	1	2	1.2
1971: December	8	10.6	19	18	1	6	2.0
1972: January	13	25.0	30	30	1	7	3.6
February	8	3.0	22	21	1	8	4.7
March	5	10.0	7+	7+	-Unavailable -		
1972: December	11	10.6	25	18	1	8	6.6
1973: January	6	0.5	6	1	-	1	0.5
February	2	0.5	2	1	-	1	0.5
March	1	1.0	1	0	-	-	-

Table 5. Continued.

Year: Month	No. Days Snow Fell	Total Monthly Snowfall	Total No. Days with Snow on Ground	Total Days with $\geq$ 1-inch Snow on Ground	Snow Depth Min	Max	Mean[2]
1973: December	7	4.8	7	5	2	3	2.8
1974: January	8	10.5	12+	12+	2	8	3.7
February	3	3.0	5+	5+	-Unavailable -		
March	6	8.0	8+	4+	-Unavailable -		

[1]Data compiled from monthly reports of Climatological Data: Montana. U. S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service.
[2]Only days having more than 1-inch of snow on the ground used in computing means.
[3]Data not measured at weather station.

period, however, only July and August were consistently snow-free during 1969-74. Approximate mean snow depths at Choteau for days with at least 1 in (2.5 cm) of snow cover, 1969-74, were 3.3 in (8.4 cm) in December and January, 3.6 in (9.1 cm) in February and 3.2 in (8.1 cm) in March (Table 4). Extreme snow depths at Choteau ranged up to 14 in (35.6 cm). No snowfall or snow depth records were available from Conrad.

Severe winters occurred on the Agawam Study Area during 1968-69 and 1971-72. The latter was particularly severe due to a lengthy period of below zero ($^{\circ}$F) temperatures, up to 20 in (50.8 cm) of snow on level ground, frequent winds which caused considerable snow-drifting and extremely low chill-factors, and the lack of chinooks.

Land Uses

On the study area there were 35 active farm and ranch operations, 7 inactive farmsteads, and 1 farm that was occupied during the grain-growing season. Several farm and ranch operations were conducted by people not resident on the study area. The old townsite of Agawam had no human occupants but included two grain elevators (operated throughout the year), an unused school, house and community hall.

The major land use, 1969-74, involved cultivation for barley (*Hordeum distichum* and *H. vulgare*), spring and winter wheat (*Triticum aestivum*), oats (*Avena sativa*) and their attendant summer fallowing; dryland and irrigated crops were represented. Several farms included small gardens.

Alfalfa was the chief hay crop and was limited in extent largely by the availability of irrigation water. Domestic grasses, various combinations of alfalfa, grasses, yellow sweet clover *(Melilotus officinalis)* and sanfoin *(Onobrychis viciifolia)* comprised the other hay crops.

Domestic livestock grazing upland and lowland ranges was primarily by beef cattle although one dairy cow herd and one pig farm were present. Horses were pastured on several ranches. A few farmers raised small flocks of chickens, ducks and/or turkeys; no commercial poultry or egg-producing operations were present.

Bynum Canal, with its feeder and runoff ditches, transported water from Bynum Reservoir, 6 mi (5.5 km) west, to upland and lowland crops on the study area.

Approximately 57 mi (52.1 km) of improved, gravel roads and 5 mi (4.6 km) of trails provided access to all habitat types on the study area. One and one-quarter miles (on the study area) of railroad line served the Agawam elevators from Choteau.

Other land uses included oil extracting operations with associated oil pumps, oil-water separators, storage tanks and surface, open-air, settling sumps. One underground missile site and a gravel pit were active on the study area.

POPULATION STUDIES

Population characteristics of Hungarian partridge on the Agawam Study Area were limited to four categories: physical characteristics; food habits; population composition; and, population dynamics.

Physical Characteristics

Detailed physical descriptions of Hungarian partridge have been reported in earlier European and North American studies of this species (Ogilvie-Grant 1911/1912; Witherby et al. 1944; McCabe and Hawkins 1946; and Westerskov 1949). In this study two criteria for distinguishing between the sexes were investigated and tested for accuracy, and live-weights of birds were reported by month.

Criteria for Distinguishing Sex

Adults and Subadults

Sex-classes were assigned to 136 partridge examined internally and externally. Seventy-four adult and subadult males showed complete agreement between presence of testes and sex designations by scapular and facial plumage colors and patterns (Table 6). Only 1 female (an adult) showed disagreement between the presence of an ovary and scapular color and pattern. Eighteen percent of adult and 14 percent of subadult females were incorrectly sexed by facial plumage.

Thirty-three additional male adults (gonads not examined) showed complete agreement between scapular and facial plumages for sex

Table 6. Comparison among Hungarian partridge sex characteristics by sex-age class.

Sex	Age	Months Sampled	No. Sexed by Gonads	No. Sexed Correctly by Scapulars		No. Sexed Correctly by Facial Plumage	
				No.	Percent[1]	No.	Percent[1]
Male	Adult	Jan.-Apr. June-Dec.	51	51	100.0	51	100.0
	Subadult	Jan.-June, Oct.-Dev.	23	23	100.0	23	100.0
Female	Adult	Jan.-Nov.	27	26	96.3[1]	22	81.5[2]
	Subadult	Jan.-June, Oct.-Dec.	35	35	100.0	30	85.7[3]

[1]One female (3.7%) sexed as male by scapulars.
[2]Four females (14.8%) sexed as males and one (3.7%) sexed as male-female intermediate by facial plumage.
[3]Four females (11.4%) sexed as males and one (2.9%) sexed as male-female intermediate by facial plumage.

assignments. Ninety-five percent of 84 additional subadult males similarly examined, revealed close agreement between scapular and facial sex designations; 4 percent suggested intermediate facial plumage and 1 percent indicated female plumage. Fourteen adult females, not examined internally, showed complete agreement between scapular and facial plumage. Fifty-five subadult females examined only externally indicated 98 percent agreement between scapular and facial plumages.

Due to the veritable complete agreement in sex identification between gonads and scapular color and patterns, scapular plumage was considered an accurate sex designator for all partridge examined. Combined samples of examined partridge (gonad-scapular-facial plus scapular-facial), excluding intermediates, indicated the following accuracies: 84 adult males, 100 percent; 104 subadult males, 99 percent; 40 adult females, 90 percent; and, 85 subadult females, 99 percent. A population of 1,000 partridge field-sexed by facial plumage would include 613 males and 387 females compared to 601 males and 399 females in the actual population. Respective sex ratios in these populations were 158 males and 151 males per 100 females. Therefore, the facial plumage technique for field sexing resulted in a 4.4 percent overestimate of the male proportion between observed and actual sex ratios.

Juveniles

Week classes were assigned to juvenile partridge by measuring lengths of the two most recent growing adult primaries (Pepper 1967).

Sex was determined for 22 male and 21 female juveniles by examination of gonads. Sexes were also assigned, prior to gonad examination, to these same birds using scapular and facial plumage criteria. Male scapulars were identified on 6-week-old birds but were not completely accurate sex designators until the tenth week. Female scapulars were detected at 5-weeks of age and were completely accurate by the eighth week. McCabe and Hawkins (1946:45) reported that post-juvenal plumage starts developing in the seventh week. Since males in the present limited sample were not reliably sexed by scapulars until 10 weeks of age, it is recommended that no juveniles be sexed by this method before their tenth week.

Male facial plumage began appearing at 10 weeks and was considered a reliable sex-determining criterion at 13 weeks or older. Female facial plumage was not detected on females until their 13th week and was not considered a reliable sex-distinguishing character until 15 or more weeks of age. Willard (1973:39) noted molting of head plumage began the 12th week but rust-colored feathers did not appear until 14 weeks. These findings suggested that juvenile partridge should not be sexed by this method until their 15th week.

Weights

Adults and subadults

Live weights were obtained from 408 adult and subadult partridge from Teton and three adjacent counties. Mean weights were determined by month for each sex-age class; statistical comparisons were ignored due to small sample sizes during 10 months of the year. Since partridge weights of each sex suggested seasonal variations and since a majority of the present sample represented winter weights, annual average weights were not computed. Males were heaviest in winter, declined in weight through September and then returned to heavier weights in winter (Table 7). Maximum and minimum weights obtained for adult males was 468 gm in January and 315 gm in September. Females appeared the heaviest during April-June, the egg-laying period, and lightest in late summer (Table 8). The heaviest female (501 gm) was a subadult in June and the lightest (311 gm) was a subadult in November. Females outweighed males during 6 of 11 months (no female sample in August) and adults of both sexes appeared heavier than their subadult counterparts during most of the year.

North American partridge studies indicated mean annual weights for adult males and females, respectively, of 381.8 gm and 374.6 gm in Michigan (Yeatter:1934:38), and 386 gm and 367 gm in Washington (from Yocom 1942:12). These respective adult groups averaged 425 gm and 398 gm in Great Britain (Portal and Collinge 1932). Roseberry and Klimstra (1971) found male and female bobwhites in southern Illinois gained weight in late fall and maintained high weight levels during most of the winter. Their males were also slightly heavier than females.

Table 7. Monthly weights (in grams) of 218 adult and subadult[1] male Hungarian partridge from Teton County[2], Montana.

Season: Month	Adults			Subadults		
	No.	Mean	Range	No.	Mean	Range
Winter:						
December	4	400	324-393	4	391	371-417
January	30	413	343-468	45	407	354-466
February	34	402	363-458	40	408	361-459
Spring:						
March	6	401	376-420	13	378	353-415
April	3	371	344-401	4	389	376-410
May	0	-	-	2	393	369-416
Summer:						
June	2	394	353-435	2	377	363-390
July	3	377	344-398	0	-	-
August	8	365	346-400	0	-	-
Fall:						
September	5	361	315-383	0	-	-
October	4	390	367-416	0	-	-
November	5	375	324-393	4	346	332-380

[1]Classed as adults after 1 July; excludes juveniles during July-October due to weight variations among week-classes.
[2]Majority of birds from Teton County; several birds from Pondera, Lewis & Clark and Cascade Counties are included.

Table 8. Monthly weights (in grams) of 190 adult and subadult[1] female Hungarian partridge from Teton County[2], Montana.

Season: Month	Adults			Subadults		
	No.	Mean	Range	No.	Mean	Range
Winter:						
December	0	-	-	2	377	352-402
January	16	398	353-469	42	391	334-447
February	16	397	360-456	50	395	348-473
Spring:						
March	4	393	354-447	10	384	347-403
April	0	-	-	4	434	386-503
May	2	453	446-459	3	448	413-472
Summer:						
June	2	416	402-430	1	501	-
July	1	378	-	0	-	-
Fall:						
September	8	369	336-399	0	-	-
October	2	380	351-408	0	-	-
November	6	404	383-452	11	362	311-407

[1]Classed as adults after 1 July; excludes juveniles during July-October due to weight variations among week-classes.
[2]Majority of birds from Agawam Study Area; several birds from Pondera, Lewis & Clark and Cascade Counties are included.

A weight loss by males and a weight increase by females was recorded in April. Male partridge in this study did not noticeably decrease in weight in April, but female weights did increase March-June.

Juveniles

Weights of 53 juvenile partridge were plotted by week-class Fig. 13). The early rapid growth period, 4 to 8 weeks, probably was an extension of the previous 4 week period. Chicks appeared 1/2-grown (190 gm) by their 6th week and about 3/4-grown (289 gm) by the 8th week. During their 5th through 10th week, chicks of a given week-class were 15-45 gm heavier in August than chicks of the same week-class in September.

Pen-reared partridge chicks in Michigan and Wisconsin showed decelerated growth rates at about 300 gm (70 days, Yeatter 1934:38) and 350 gm (100 days, McCabe and Hawkins 1946:52), respectively. Heinroth and Heinroth (1928, from McCabe and Hawkins 1946), in Germany, also found a slower growth rate after 300 gm and 65 days of age. The weight curve for wild northcentral Montana partridge chicks agreed more closely with those found in Michigan and Germany than those for Wisconsin.

Food Habits

Crops containing food items were obtained from 67 male, 60 female and 4 unknown-sex partridge, 1969-74. All seasons were represented in the sampling. The largest sample was from harvested birds in the fall and the smallest was in summer. Seasonal food habits were determined

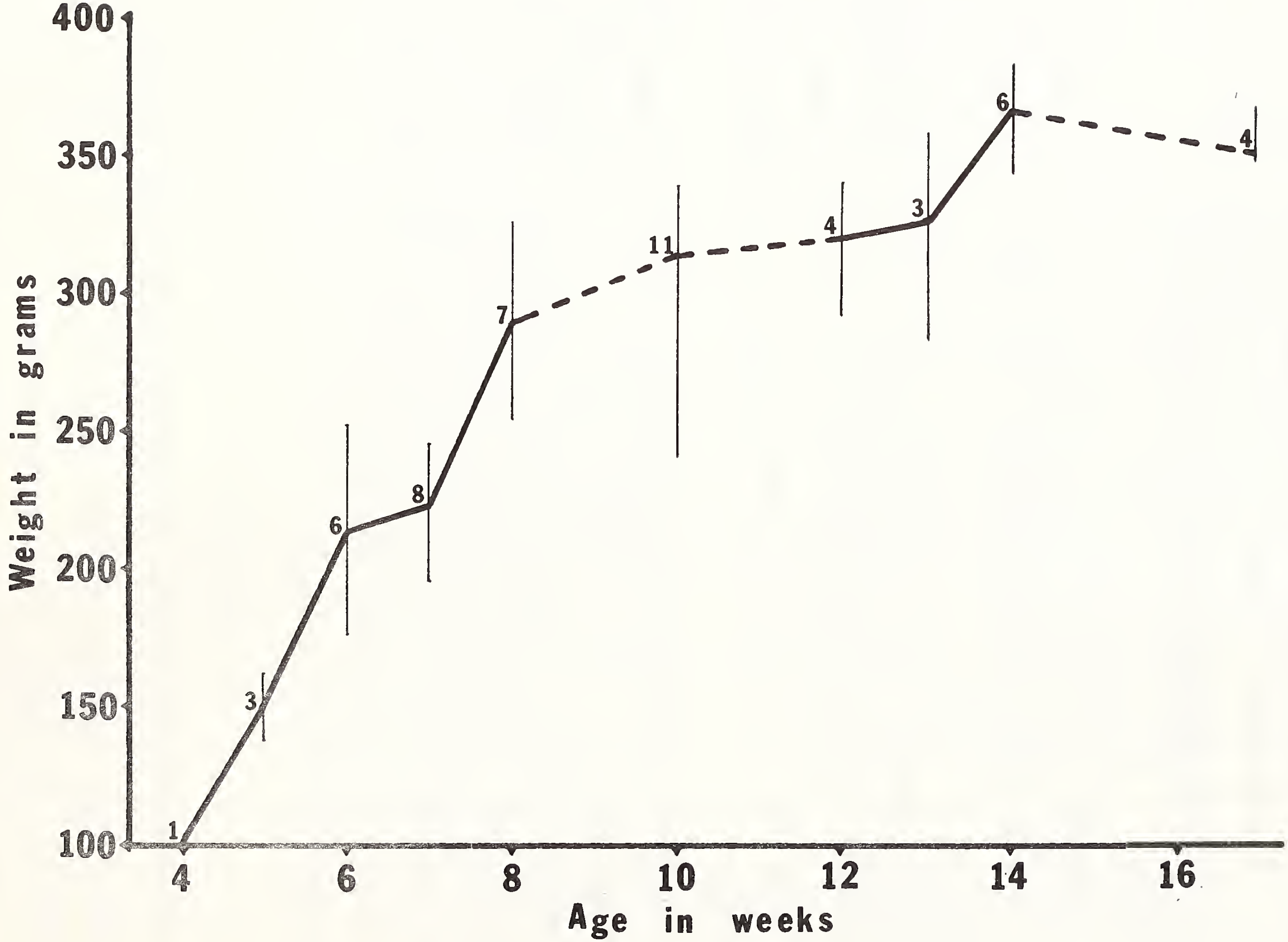


Figure 13. Weights of 53 wild, juvenile partridge by week class. Vertical lines are range in weights; numbers are sample sizes.

for adults throughout the year and for subadults during October-May. Food habits were determined separately for 40 juveniles, 4-15 weeks-old, for August and September.

Adults and Subadults

Food items most frequently consumed by partridge in spring were the grains of barley and wheat (Table 9). Cumulatively these items represented 75 percent of the volume of partridge spring diets. Eighty-five percent of the crops contained cereal grains. March was the only month in which grass materials comprised the entire monthly diet. Forb materials, principally dandelion *(Taraxicum officinale)* flowers and leaves and false-flax *(Camelina* sp.) seeds, showed their greatest volume in May. Insects, primarily ants *(Formicidae)* and beetles *(Coleoptera)*, constituted only 1 percent by volume of spring foods. The crop of a subadult female contained four land snails *(Pulmonata)* on 15 May 1973.

Although cereal grains continued to be the major partridge food in summer, it was the only season in which grain consumption was less than 90 percent of the seasonal diet (Table 10). Nonetheless, 78 percent of the crops contained grain. The month of lowest grain-consumption was June. Forbs, including eight species, comprised the greatest proportional seasonal volume in summer and the highest monthly average occurred in June. Eighty-five percent of the crops contained materials of one or more forb species. Dandelions and garden beans *(Phaseolus*

Table 9. Percent frequency and volume of food items eaten by 20 adult and subadult Hungarian partridge during the spring, 1969-74.

Food Item	March (9)[1] Percent Freq./Vol.	April (7) Percent Freq./Vol.	May (4) Percent Freq./Vol.	Spring Totals (20) Percent Freq./Vol.
Grasses				
Avena fatua	44/ 3	14/ 1		25/ 2
A. sativa	22/ 7			10/ 4
Bromus tectorum	11/ T			5/ T
Hordeum sp.	11/24			5/15
H. distichon		29/ 5	75/12	25/ 4
H. vulgare		14/ 1	25/ 6	10/ 1
Triticum aestivum	89/62	14/48	50/36	55/54
Unidentified	78/ 4	100/38	75/19	85/13
Subtotal	-/100	-/93	-/73	-/93
Forbs				
Camelina sp.			50/ 9	10/ 2
Polygonum sp.			25/ 2	5/ T
P. aviculare			25/ 1	5/ T
Taraxicum officinale		14/ 7	75/11	20/ 4
Unidentifed		14/ T	- -	5/ T
Subtotal	- -	-/ 7	-/23	-/ 6
Unidentified Plant Spp.	- -	- -	25/ T	5/ T
Insects				
Coleoptera			25/ 1	5/ T
Hymenoptera (Formicidae)			50/ 2	10/ 1
Other Animal Matter				
Mollusca (Pulmonata)			25/ 1	5/ T
Subtotal	- -	- -	-/ 4	-/ 1
Rock	11/ T	- -	- -	5/ T

[1]Number of crops.

Table 10. Percent frequency and volume of food items eaten by 9 adult Hungarian partridge during the summer, 1970 and 1974.

Food Item	June (4)[1] Percent Freq./Vol.	July (1) Percent Freq./Vol.	August (4) Percent Freq./Vol.	Summer Totals (9) Percent Freq./Vol.
Grasses				
Agropyron inerme	25/ 1			11/ 1
A. repens			25/ T	11/ T
Avena fatua	25/ T		25/ T	22/ T
Hordeum sp.	25/ 9			11/ 5
H. distichon	25/ 3			11/ 2
Triticum aestivum	50/28	100/66	100/84	67/52
Unidentified	50/ 3	100/17	50/ 7	44/ 5
Subtotal	-/44	-/83	-/91	-/65
Forbs				
Brassica kaber	25/ 4			11/ 3
Cirsium undulatum	25/ 3			11/ 1
Lappula echinata			25/ 4	11/ 2
Lepidium virginicum	25/ 2			11/ 1
Phseolus vulgaris	25/19			11/11
Polygonum sp.		100/17		11/ T
P. aviculare			25/ T	11/ T
P. convolvulus	25/ 5		25/ T	22/ 3
Taraxicum officinale	50/20			22/11
Vaccaria segetalis	25/ 1			11/ T
Vicia americana	25/ T			11/ T
Subtotal	-/54	-/17	-/ 4	-/32
Insects				
Coleoptera	25/ 1			11/ T
Orthoptera (Locustidae)			25/ 4	11/ 2
Other Animal Matter				
Arachnida	25/ T			11/ T
Subtotal	-/ 1	- -	-/ 4	-/ 2
Rock	25/ 1	- -	25/ 1	22/ 1

[1]Number of crops.

vulgaris) formed the major forb volume. Secondary forbs included knotweeds *(Polygonum* sp.) and mustard *(Brassica kaber)*. One percent of the summer diet and 22 percent of the crops included insects.

Grass materials, principally cereal grains, were major components of fall crop volumes (Table 11). Every crop contained one or more species of grain. Grass leaves were the lowest seasonal average volume in fall and were less in September than in any other month. Thirty-seven percent of the crops contained forb materials, primarily seeds. Dandelions (flower heads and leaves), knotweeds, and white clover *(Trifolium repens)* were the main forbs eaten. The crop of a female adult, collected 27 September 1973, contained some big sagebrush *(Artemisia tridentata)* leaves. Insects comprised five percent of the crops in fall.

Food items most frequently consumed by partridge in winter were grains of barley and wheat (Table 12), together comprising 65 percent of the winter diet. Fifty-eight percent of the crops examined contained one or more grain species. Wild oats *(Avena fatua)* were eaten more in winter, particularly in January, than in other seasons. Fragments of grass leaves, which presumably included winter wheat, were found in 63 percent of the crops and averaged 24 percent of the diet. Although only 5 percent of foods eaten were forbs, 37 percent of the crops contained forb materials (mostly seeds). A subadult male, obtained

Table 11. Percent frequency and volume of food items eaten by 43 adult and subadult Hungarian partridge during the fall, 1969-73.

Food Item	Sept. (12)[1] Percent Freq./Vol.	Oct. (18) Percent Freq./Vol.	Nov. (13) Percent Freq./Vol.	Fall Totals (43) Percent Freq./Vol.
Grasses				
Avena fatua		33/ 6	31/ 4	23/ 3
A. sativa		11/ 1		5/ 1
Hordeum sp.			23/ 1	7/ T
H. distichon		22/17	38/19	21/10
H. vulgare	25/ 5	28/ 5	23/16	26/ 8
Triticum aestivum	92/91	67/61	38/46	65/70
Unidentified	50/ 1	67/ 6	62/ 5	60/ 4
Subtotal	-/97	-/96	-/91	-/96
Forbs				
Amaranthus retroflexus		6/ T		2/ T
Brassica sp.		6/ T		2/ T
Chenopodium sp.			8/ 2	2/ T
Lappula sp.		6/ T		2/ T
Polygonum sp.		11/ 1	15/ 3	9/ 1
P. aviculare	8/ T	11/ T		7/ T
P. convolvulus	17/ T			5/ T
Sonchus sp.			8/ T	2/ T
Taraxicum officinale	17/ 1	6/ 2		7/ 1
Trifolium sp.	8/ T			2/ T
T. repens		6/ T	23/ 3	9/ 1
Vaccaria segetalis			8/ T	2/ T
Unidentifed		6/ T		2/ T
Subtotal	-/ 1	-/ 3	-/ 8	-/ 3
Shrubs				
Artemisia tridentata	8/ T	- -	- -	2/ T

Table 11. Continued

Food Item	Sept. (12) Percent Freq./Vol.	Oct. (18) Percent Freq./Vol.	Nov. (13) Percent Freq./Vol.	Fall Totals (43) Percent Freq./Vol.
Unidentified Plant Spp.	- -	6/ T	- -	2/ T
Insects				
Orthoptera (Locustidae)	17/ 1			5/ T
(Gryllidae)	8/ T			2/ T
Subtotal	-/ 1	- -	- -	-/ T
Rock	9/ T	- -	15/ -	7/ T

[1]Number of crops.

Table 12. Percent frequency and volume of food items eaten by 19 adult and subadult Hungarian partridge during the winter, 1969-74.

Food Item	Dec. (3)[1] Percent Freq./Vol.	Jan. (10) Percent Freq./Vol.	Feb. (6) Percent Freq./Vol.	Winter Totals (19) Percent Freq./Vol.
Grasses				
Avena fatua	33/ 2	20/ 7		16/ 5
A. sativa			17/ 1	5/ T
Hordeum sp.		10/ T		5/ T
H. distichon	33/16	20/30		16/22
H. vulgare	33/ 4	40/21	33/30	37/22
Triticum aestivum		40/16	50/46	37/21
Unidentified	100/48	60/24	50/18	63/24
Subtotal	-/70	-/98	-/95	-/94
Forbs				
Brassica kaber		10/ T		5/ T
Chenopodium sp.	33/ T			5/ T
Leguminosae	33/30			5/ 2
Medicago sativa		10/ 1		5/ 1
Polygonum sp.	33/ T			5/ T
P. aviculare		10/ T		5/ T
P. convolvulus		10/ T		5/ T
Psoralea sp.		10/ T		5/ T
Trifolium repens			17/ 3	5/ 1
Unidentified		10/ T		5/ 1
Subtotal	-/30	-/ 1	-/ 1	-/ 5
Unidentified Plant Spp.	33/ T	10/ T	- -	16/ T
Insects				
Orthoptera (Locustidae)	- -	- -	17/ 2	5/ 1
Rock	33/ T	20/ T	-/-	16/ T

[1]Number of crops.

28 February 1974, had eaten a grasshopper which was the only insect material recorded during the winter.

Juveniles

The greatest proportion of food volumes in crops of young partridge were grass materials (Table 13). Wheat and barley caryopses averaged 73 percent, cumulatively, during August and September. Eight-eight percent of the crops contained one or more grain species. Fourteen forb species were represented in juvenile food habits; they averaged 10 percent of food volumes and occurred in 55 percent of the crops examined. Wild carrot *(Daucus carota)* seeds, dandelion flowers and leaves, and white clover leaves and seeds were the most important forb materials eaten. Insects were second in volume (12%) but third in frequency (33%) of the three groups represented. Grasshoppers, ants and ant eggs were major insect foods for juveniles.

Food Characteristics

Grasses, including cereal grains, clearly dominated foods of Hungarian partridge in the present study. Caryopses of the Tribes Triticeae and Aveneae, particularly those of cultivated grains, appeared to be staple food items throughout the year. Eighty-nine percent of 91 adult and subadult, and 88 percent of 40 juvenile partridge crops examined included one or more grain species. Wheat formed the largest proportion of grain in partridge diets. Partridge chicks apparently

Table 13. Percent frequency and volume of food items eaten by 40 juvenile[1] Hungarian partridge during late summer, 1970-74.

Food Item	August (5)[2] Percent Freq./Vol.	September (35) Percent Freq./Vol.	Totals (40) Percent Freq./Vol.
Grasses			
Agropyron desertorum		6/ 1	5/ 1
Avena fatua	40/ T	11/ 1	15/ 1
A. sativa		6/ T	5/ T
Bromus japonicus	20/ T		3/ T
Deschampsia elongata		3/ T	3/ T
Hordeum sp.		3/ T	3/ T
H. distichon	40/52	9/ T	13/ 8
H. jubatum		6/ 1	5/ 1
H. vulgare		20/10	18/ 8
Triticum aestivum	80/21	71/62	73/56
Unidentified	100/ T	46/ 4	53/ 3
Subtotal	-/73	-/79	-/78
Forbs			
Amaranthus retroflexus		3/ T	3/ T
Carduus nutans		3/ 1	3/ 1
Cirsium arvense		6/ T	5/ T
C. undulatum		3/ T	3/ T
Daucus carota	40/20		5/ 3
Helianthus annuus		3/ T	3/ T
Lappula echinata		3/ T	3/ T
Medicago sativa		17/ 1	15/ 1
Phaseolus vulgaris		6/ T	5/ T
Polygonum sp.		3/ T	3/ T
P. aviculare	60/ 1	3/ 1	10/ 1
P. convolvulus	40/ T	9/ T	13/ T
Taraxicum officinale		3/ 3	3/ 2
Trifolium repens		14/ 2	13/ 2
Vaccaria segetalis		3/ T	3/ T
Unidentified		3/ T	13/ T
Subtotal	-/21	-/ 8	-/10
Insects			
Coleoptera[3]		9/ 1	8/ 1
Diptera		3/ T	3/ T

Table 13. Continued.

Food Item	August (5) Percent Freq./Vol.	September (35) Percent Freq./Vol.	Totals (40) Percent Freq./Vol.
Insects (cont.)			
Hymenoptera (Formicidae)[4]		20/ 5	18/ 4
Orthoptera (Locustidae)[4]	60/ 6	25/ 7	30/ 7
Subtotal	-/ 6	-/13	-/12
Rock	- -	6/ T	5/ T

[1] Includes 4 to 15 week-old birds.
[2] Number of crops.
[3] Includes *Erotylidae* and *Silphidae*.
[4] Principal family listed.

learned to feed on grain at an early age, probably as soon as it became available. Barley occurred in the crop of a 4-week-old chick on 14 September while wheat was found in the crop of a 5-week-old chick on 10 August.

Maximum grain-consumption by partridge occurred during winter and early spring in Alberta, Canada (Westerskov 1966) and North Dakota (Kobriger 1970); late summer-early fall was the annual low grain-use period in these regions. By contrast, maximum grain-consumption by partridge in Great Britain (Middleton and Chitty 1937) and eastern Washington (Yocom 1942) occurred in late summer-early fall and lowest grain use was noted in spring. Fall plowing of grain stubble was thought responsible for grain-use patterns in these latter regions.

Grass leaves, and some florets, many of which appeared in crops containing grain, were present in every monthly sample. A majority of the leaves had been clipped into 5-20 mm segments, although one 65-mm piece was found. Sixty-six percent of adult and subadult crops contained grass leaves; 53 percent of juveniles' crops also included grass leaves. The high frequency of leaf consumption, although sometimes low in volume, and its highest volume proportions occurring in winter diets suggested leaves were a dietary necessity.

Green plant materials were apparently eaten by partridge in significant quantities each season except fall. The degree of consumption appears directly related to availability. Other studies have confirmed the lowest seasonal use of green plant materials to be in fall with peaks of utilization either in spring (Hicks 1936; Middleton and Chitty 1937; Spärck 1947; and Kobriger 1970) or summer (Hicks 1936; Porter 1955; and Westerskov 1966). Partridge also readily fed on green plants in winter (Yeatter 1934; Yocom 1942; Pulliainen 1965, 1968) with extensive consumption noted during mild winters in Great Britain (Middleton and Chitty 1937). In Finland where severe winters occur frequently, Soumus (1958) reported the primary food (79%) of partridge was green forage taken under the snow. He thought partridge resorted to seeds only when snow was difficult to penetrate. During the severest winter of the present study (1971-72), green grass leaves comprised 25-40 percent of crop volumes.

Seventeen species of forbs were identifiable food items in the annual diet of adult and subadult partridge with four additional species appearing in late summer diets of juveniles. Forbs occurred in all monthly diets except March. Thirty-seven (41%) of adult and subadult partridge crops contained forbs and 55 percent of juveniles' crops included forbs. Seeds were the major forb structure eaten. Exceptions to this were alfalfa, dandelion and white clover. Dandelion was the most important forb species eaten and apparently was selected for in late spring and early fall. Although forb volumes were a low second of the two plant categories consumed, their frequency indicated they were necessary items in a balanced partridge diet. The high frequency of forb seeds in late summer juvenile diets suggests either the small seeds are more easily eaten than grain or they contain requisite amounts of certain nutrients needed more by young than older partridge.

Seeds of forbs consistently occupied secondary or less importance in Hungarian partridge food habit studies. This low ranking may be due to their limited seasonal availability and small seed size, compared to cereal grains. However, they have been found to exceed one-third of partridge diets in Great Britain (Middleton and Chitty 1937), Alberta, Canada (Westerskov 1966) and Finland (Pulliainen 1965, 1968). Greatest seasonal use in the first two countries occurred in summer and early fall while lowest use was in spring; these seasonal use-extremes were reversed in Finland, perhaps due to differences in cultivation practices. Knotweeds, hemp nettle *(Galeopsis tetrahit)* and goosefoot *(Chenopodium album)* commonly appeared in partridge diets of these regions.

The occurrence of material from woody plants in partridge diets was conspicuous due to its veritable absence. In the current study, a trace of big sagebrush was recorded in 1 of 131 crops examined. Although the study area included considerable amounts of rose, snowberry, caragana *(Caragana arborescens)* and hawthorn *(Crataegus* sp), no fruits or seeds of these woody species were found in partridge crops. Woody species which occur in Montana and have appeared in partridge food habits in the United States included juniper *(Juniperus communis)*, spruce *(Picea* sp.), snowberry, and Russian olive *(Elaeagnus angustifolia)* (Kelso 1932; Yocom 1942; and Westerskov 1966).

During this study, insects were a minor food item of adult and subadult partridge, constituting 2 percent or less of average seasonal food volumes. The greatest amount of insects consumed occurred in May and August. The highest frequency was recorded for 5- to 10-week-old chicks in August. In September, 4- to 15-week-old juveniles ate the greatest average volume of insects of any age group in any season.

Animal material, primarily insects, appeared to be the major, and probably critical, food item in diets of very young partridge. Ford et al. (1938) examined contents of 69 crops from chicks accidentally killed (primarily due to hay mowing) in Great Britain. Animal composition for chicks up to 7-days-old was 95.3 percent; for 8-14 day-olds, 90.7 percent; 15-21 day-olds; 52.0 percent; and 21+ day-olds, 3.3 percent. The decline in animal composition occurred even though insects continued in abundance. Janda (1959), in central Bohemia, noted a comparable high animal component (95 to 80%) in partridge chick diets during their first 3 weeks of life; by the fourth week, plant food comprised 70 percent of the diet. He reported further that chicks 1 week-old ate wheat and barley grain. Porter (1955), in Utah, found ants were one of the most important food items in the diets of one adult, six juveniles and 8 chicks he collected 17 June-13 August.

Feeding and Other Activities

Daily activities of partridge were monitored from field observations and volumes of crop contents in relation to times of sunrise and sunset. Activities were categorized as dusting (D), feeding (F), picking grit (G), and roosting (R) (Fig. 14). Courtship and conflicts were also recorded but occurred only seasonally and were thus omitted.

Activities were determined for 141 partridge groups in spring; more than 85 percent of the groups were pairs with the remainder being winter coveys and single birds. Two feeding and grit-picking periods were noted; 68 percent of the observations from dawn to 2 hours post-sunrise and 81 percent from 1 hour pre-sunset until dark were involved in these activities (Fig. 14a). Forty-six percent of the interim day-light period observations involved roosting and dusting. In March,

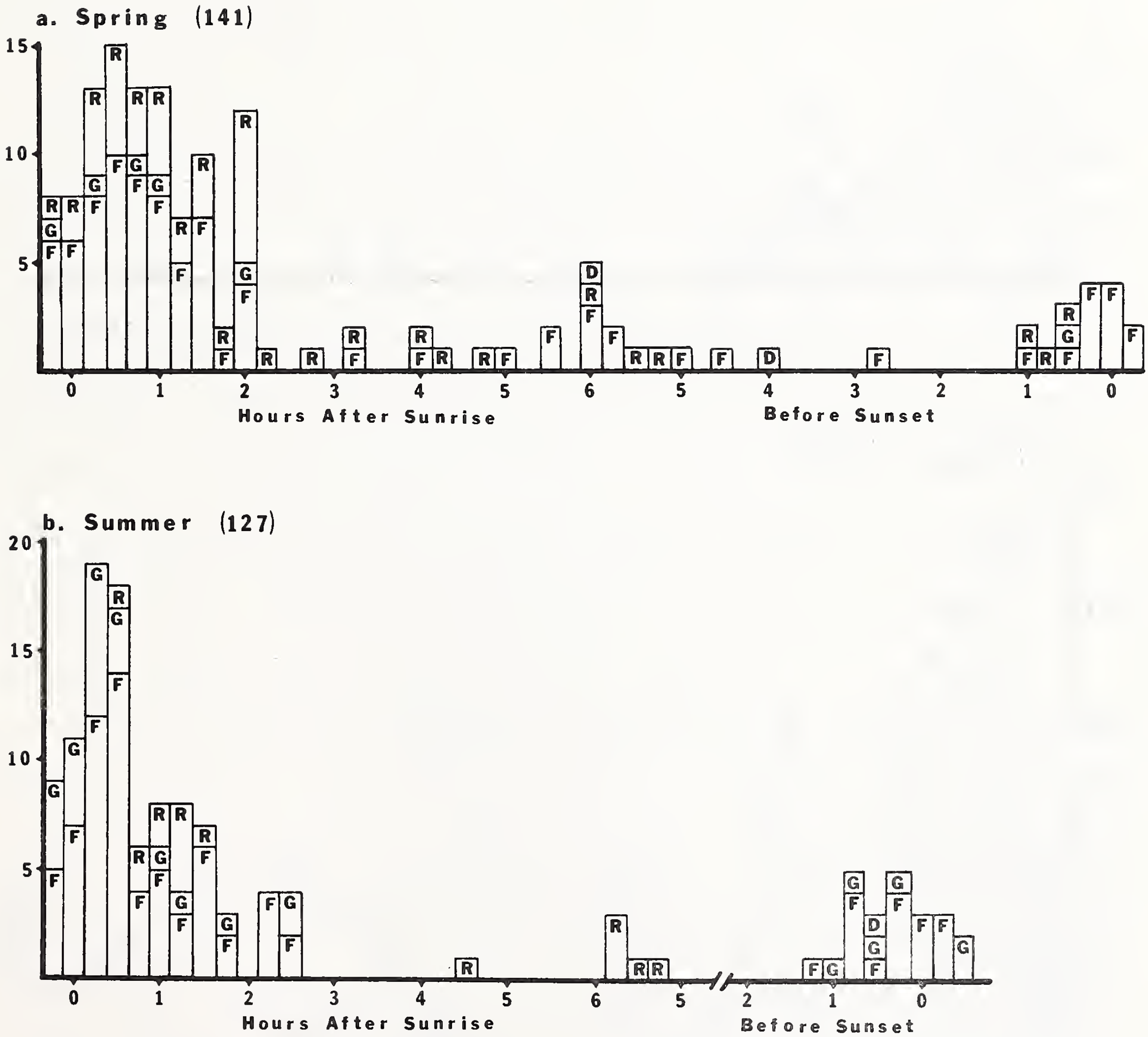


Figure 14. Daily activities engaged by partridge in relation to sunrise and sunset by season. D=Dusting, F=Feeding, G=Gritting, R=Roosting.

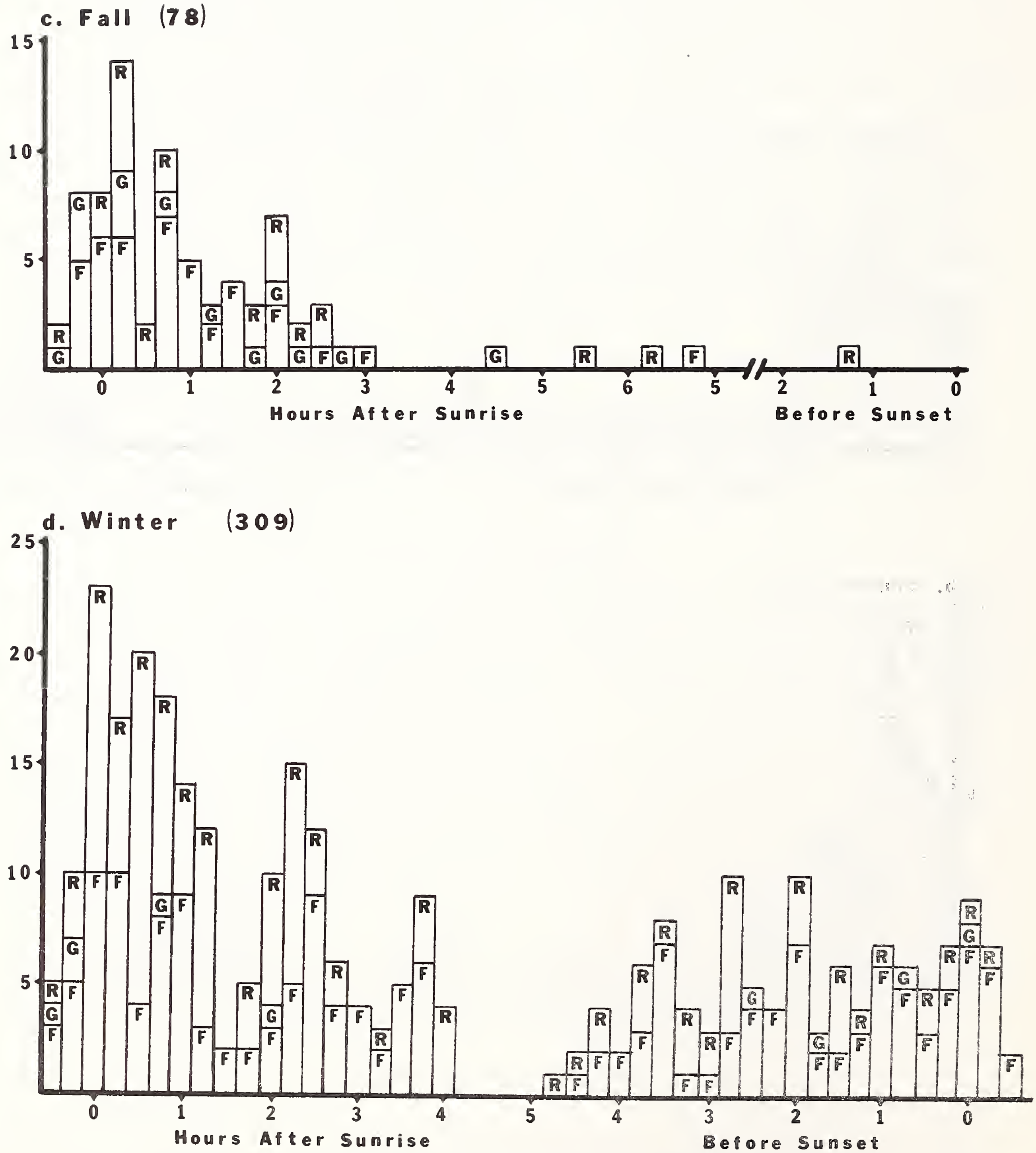


Figure 14. Continued.

the major feeding period was in the afternoon, probably a pattern carried over from winter, and the shift to morning feeding occurred in April. Activity patterns based on volumes of contents of 24 partridge crops in spring (Fig. 15a) supported those of field observations.

In summer, daily activity patterns were established from 127 groups; pairs comprised most of the June observations, adult groups were 60 percent of those in July with the remainder being broods, and broods formed 80 percent of August observations. Ninety percent of all observed groups were feeding or picking grit between dawn and 3 hours post-sunrise (Fig. 14b). Ninety-six percent of observations between about 1 hour pre-sunset and dark also involved these activities. Limited observations suggested roosting was the only major activity engaged in during the interim period. This activity pattern was generally supported by volumes of 21 partridge crops obtained in summer (Fig. 15b).

Observations from 78 partridge groups (45 were broods) in fall were heavily biased to early morning (Fig. 14c). Proportionately less (73%) activities included feeding and grit-picking, and they extended later into the morning. Feeding in fall, as determined from volumes of crop contents, began about sunrise and continued through 4 hrs post-sunrise; a second daily feeding occurred during the last 3 hrs before sunset (Fig. 15c). Evening appeared to be the most important foraging period in September; 38 percent of crops in evening contained 5.0 cc or more of food compared to 33 percent in the afternoon and 18 percent in morning.

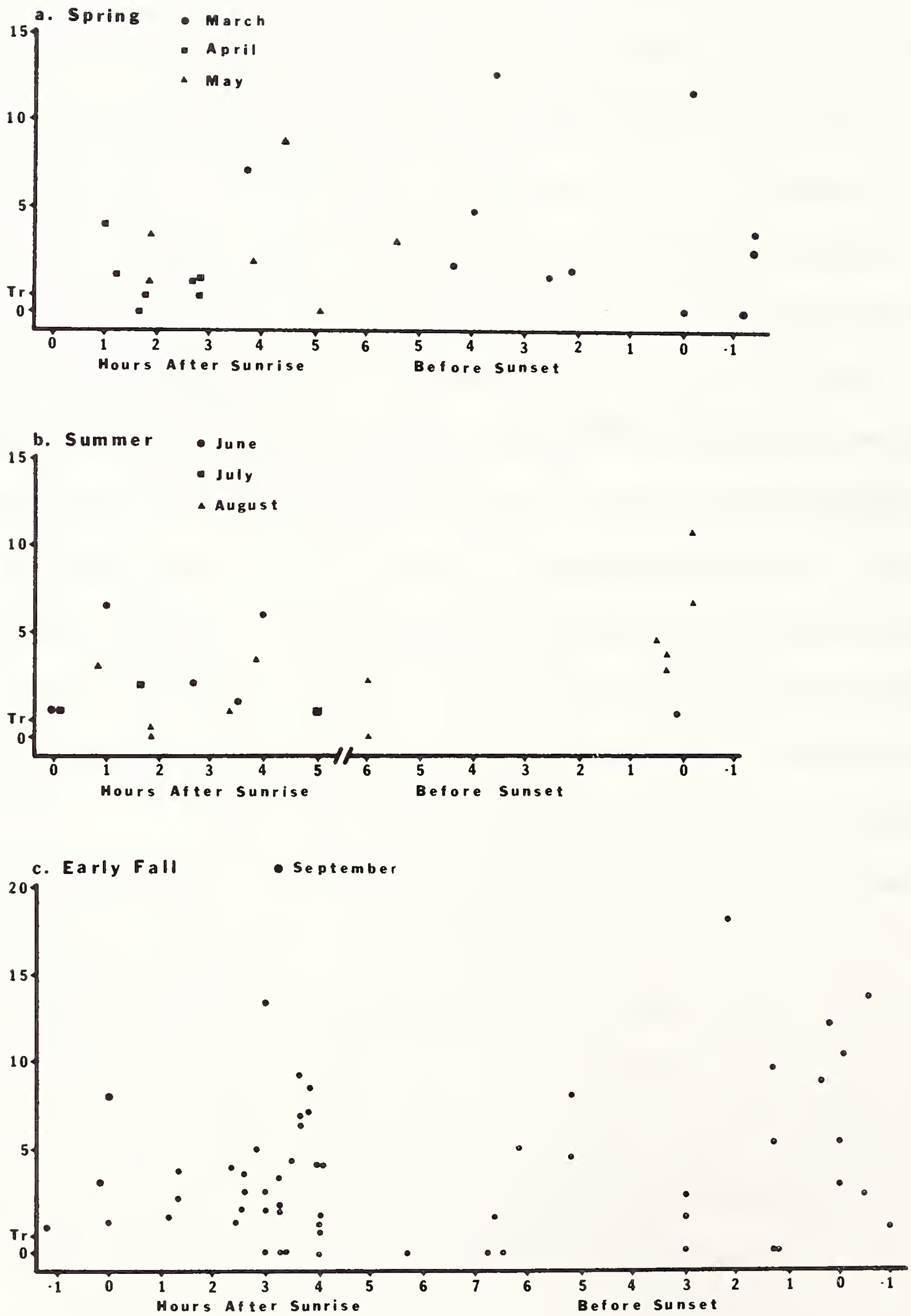
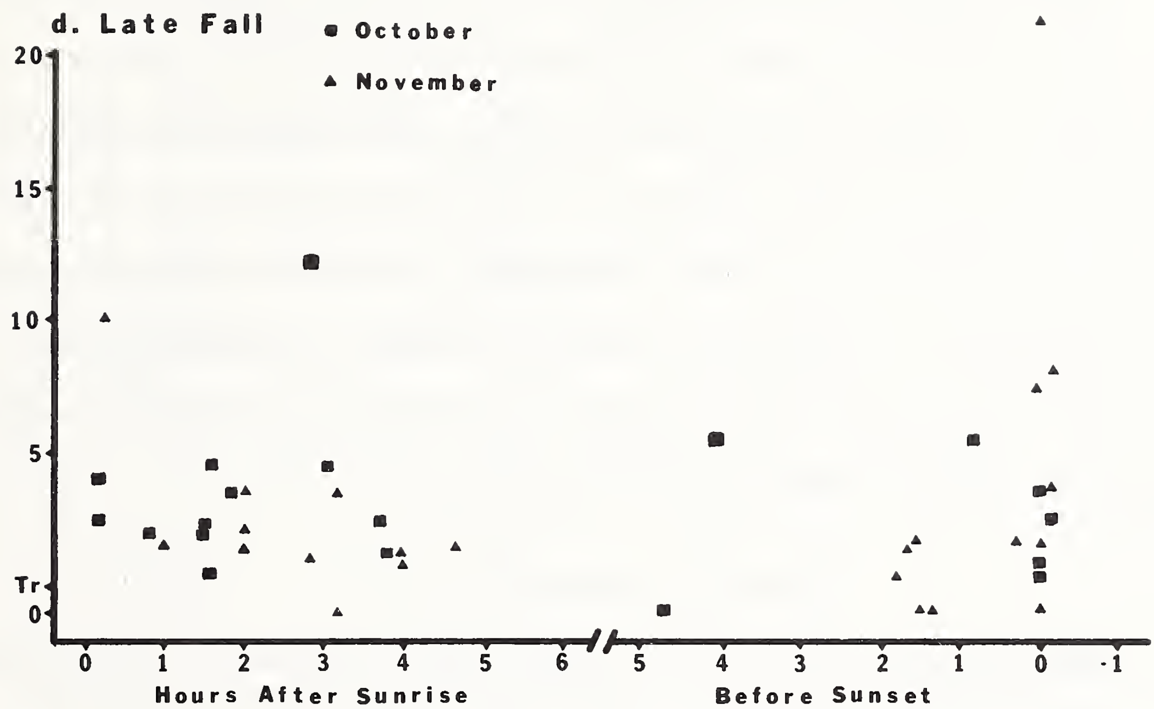


Figure 15. Volumes of contents (in cc, vertical axis) of partridge crops in relation to sunrise and sunset by season.



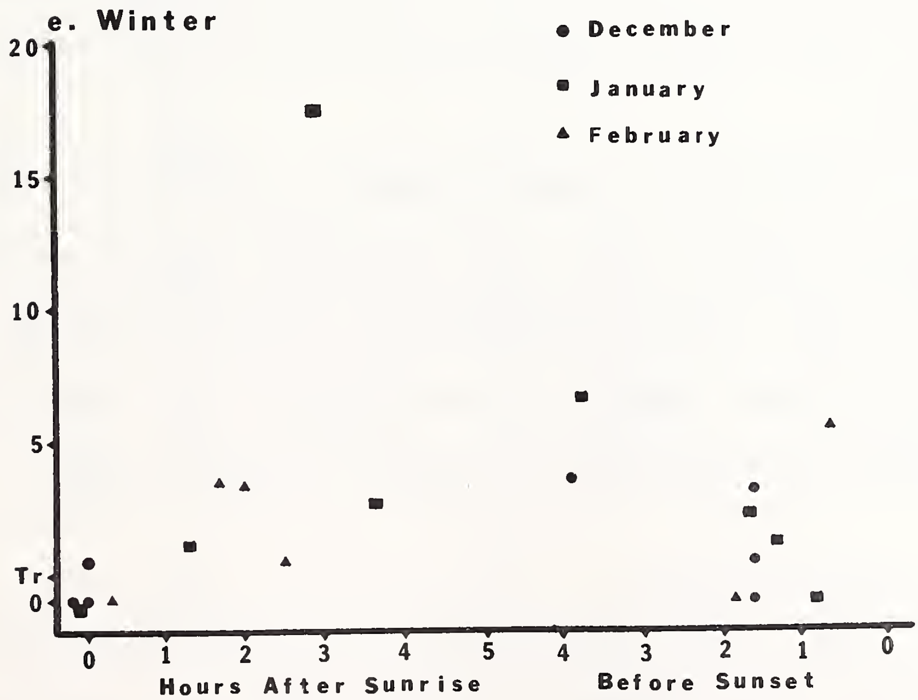


Figure 15. Continued

Observations of 309 partridge groups in winter suggested feeding and grit-picking was engaged in during all but one or two midday hours (Fig. 14d). Sixty-nine percent of afternoon and evening observations included these activities compared to 51 percent in the morning. Feeding and gritting occurred more frequently in late afternoon and evening than in morning in January; in February, proportions engaging these activities were about equal. Volumes of contents from 21 crops suggested agreement with the above pattern (Fig. 15d).

Population Composition

Field surveys yielded 2,873 observations totaling 17,736 partridge between 21 January 1969 and 30 April 1974. These observations included multiple observations of the same groups but excluded those of radio-instrumented birds.

The Hungarian partridge is a highly gregarious species; 87 percent of the observations and 98 percent of the birds observed were recorded in groups of two or more. These percentages were considered minimal since many single males and unknown-sex birds noted in late spring and summer were suspected as males paired to females attending nests.

Spring Population Characteristics

Composition of the study area's partridge population was determined from 809 observations of 2,206 birds (Table 14). Forty-four percent of

Table 14. Numbers of observations and partridge during spring by social groups, by month, by year, 1969-74.

Month: Year	Winter Coveys	Pairs	Susp. Pairs	Mixed Adults	Bachelor-Male Flocks	Unknown Sex-Age Groups	Single Birds M	Single Birds F	Single Birds Unk.	Totals
March:										
1969	116/756[1/]	34/ 68	21/ 42		3/6		16/16	8/8	8/ 8	206/ 904
1970		8/ 16	14/ 28				7/ 7		3/ 3	32/ 54
1971		29/ 58	9/ 18			2/ 9	12/12		1/ 1	53/ 98
1972	26/223	20/ 40	16/ 32		1/2	2/ 6			1/ 1	66/ 304
1974		51/102	22/ 44	1/3		2/ 7	5/ 5	1/1		82/ 162
5-Year Totals	142/979	142/284	82/164	1/3	4/8	6/22	40/40	9/9	13/13	439/1,522
April:										
1970		24/ 48	35/ 70				8/ 8		3/ 3	70/ 129
1971		24/ 48	11/ 22		1/5	2/ 8	4/ 4		3/ 3	45/ 90
1972		15/ 30					4/ 4			19/ 34
1974		41/ 82	19/ 38				9/ 9		2/ 2	71/ 131
4-Year Totals		104/208	65/130		1/5	2/ 8	25/25		8/ 8	205/ 384
May:										
1969		6/ 12	7/ 14	2/6	2/4		7/ 7		3/ 3	27/ 46
1970		20/ 40	32/ 64		1/2		7/ 7	1/1	7/ 7	68/ 121
1971		25/ 50	17/ 34				2/ 2		3/ 3	47/ 89
1972		21/ 42					1/ 1		1/ 1	23/ 44
4-Year Totals		72/144	56/112	2/6	3/6		17/17	1/1	14/14	165/ 300

[1/] Number of observations/number of partridge.

the average spring population was winter coveys; all such coveys were observed in March 1969 and 1972.

The main population segment (47%) consisted of pairs or suspected pairs. True pairs, consisting of a male and a female, were observed during every month except October, November and December. Pairs were observed within larger groups in January and as a separate groups, February through August. Suspected pairs (two birds flushing together) were also observed during February-August. These could have included homosexual "pairs" since several observations of an adult-subadult male "pair" were observed in late winter-early spring, 1969.

Single males, females and unknown-sex birds were observed from late winter dispersal through early fall. Although they collectively comprised only six percent of spring populations, single birds were observed more commonly in spring than during other seasons. In February-April, males were judged as either those seeking mates or those attached to pairs. During April-August single males were judged to be waiting for nearby females attending various nesting activities, or attached to nesting pairs. Unknown-sex single birds could have fit any of these interpretations; in September they could have been survivors of hunter-harvested coveys searching for a larger group with which to become associated.

Pairs and Pairing

Hungarian partridge tend to pair earlier in winter and spring in southern portions of their geographical range than in the north (Table 15). It appears that photoperiod lengths are a major influence in annual development of sexual behavior. A notable exception to this pattern was in Denmark where the maritime climate may result in milder winters than in continental weather regions, thereby permitting earlier pairing by partridge. Moderation or recurrence of winter weather seemed to accelerate or delay pairing. Pairing was well underway during 11-20 February 1969-71 and 21-29 February 1972 on the present study area.

Pair and pair associations were determined from 408 observations in late winter-spring (Table 16). A great majority of these associations were pairs only. The second most important association consisted of pair-accessory male groups. Only two observations of pair-accessory female groups were recorded.

Pairing success and relationships were determined from observations of 90 bibbed partridge (Table 17). These relationships are not additive among sex-age groups due to the inability to assign covey-associations for some mates, multiple pairings within a given spring and pairing by birds (trapped as subadults) in second or third springs. Adult and subadult females experienced total pairing success while that of adult and subadult males was 81 and 83 percent, respectively.

Table 15. Dates of first observed pairings of Hungarian partridge from 60^{o} to 40^{o} North Latitude.

Approx. North Latitude	First Pairing Dates	Province or Country/State/Locale	Reference
60^{o}	25-29 March 1965 1- 5 April 1966	Finland/Helsinki/Turku	Pulliainen 1966a
55^{o} - 57^{o}	January-February	Denmark	Rørbaek 1935:339[1]
53^{o}	mid-March	Canada/Alberta/Edmonton	Westerskov 1965:28
51^{o}	1-10 February	England/Hampshire/Winchester	Jenkins 1961:161
48^{o}	18 February 1972 17 February 1971 12 February 1970, 1974 7 February 1969	U.S.A./Montana/Teton County	Present Study
47^{o}	4-7 February 1940-42	U.S.A./Washington/Whitman County	Knott et al. 1943:284
43^{o}	late February 1938	U.S.A./Iowa/Winnebago County	Green and Hendrickson 1938:20
42^{o}	mid-February	U.S.A./Wisconsin/Jefferson County	McCabe and Hawkins 1946:17
42^{o}	15 February 1930 4 February 1931 20 January 1932 18 January 1933	U.S.A./Michigan/Lenawee County	Yeatter 1934:25
39^{o} - 42^{o}	late January 1950	U.S.A./Utah/Box Elder, Juab and Tooele Counties	Porter 1955:102
40^{o}	late December	U.S.A./Ohio	Hart 1945[1]

[1]From Westerskov 1949:244-245.

Table 16. Partridge pairs and pair-associations during late winter-spring, 1969-74.

Month	Years	Pair-only	Number Pairs With: Accessory Male	Accessory Female	Unknown-Sex Bird	Totals
February	1969-74	70 (92.1)[1]	5 (6.6)	0 -	1 (1.3)	76 (100.0)
March	1969-74[2]	139 (93.3)	9 (6.0)	1 (0.7)	0 -	149 (100.0)
April	1970-74[2]	102 (92.7)	7 (6.4)	1 (0.9)	0 -	110 (100.0)
May	1969-72	70 (95.9)	3 (4.1)	0 -	0 -	73 (100.0)
Totals	-	381 (93.4)	24 (5.9)	2 (0.5)	1 (0.2)	408 (100.0)

[1]Percent.
[2]Does not include 1973.

Each of the intra- and intercovey plus one of the unknown-covey-origin mates of adult females were adults. The remaining unknown-covey mate was an unknown-age male. Seven of these pairings could represent maintenance of previous year pair-bonds. Two adult females did continue pair-bonds with intracovey males during their second spring post-capture.

Twenty-five subadult females participated in 29 pairings, 2 of which occurred when the females were adults. An additional female was

Table 17. Summary of pairing and breeding success and mate relationships among sex-age groups as determined by observation of 90 bibbed partridge.

			Pairing			Pair Mate			Breeding		
Sex	Age	No. Birds	No.[1]	Succ.	Unsucc.	Intra-Covey	Inter-Covey	Unk.	Succ.	Unsucc.	Unk.
Female	Adult	8	10	10	0	7	1	2	1	0	9
	Subadult	25	29	29	0	8	18	3	9	3	17
Male	Adult	22	26	21	5	8	5	8	4	2	15
	Subadult	35	40	33	7	5	10	18	7	5	21

[1]Includes more than one pairing attempt during the same or successive springs.

not observed until her first adult-spring and was included in adult female evaluations. Three of eight intracovey mates were adults with the remainder being subadults. Five of 18 intercovey mates were also adults, 10 were subadults and 3 were unknown-age males. Ages of the 3 unknown-covey-origin mates were equally represented by the three age categories.

Subadult females known to have paired at least twice included multiple pairings during one spring as well as single matings during successive springs. One female was paired with an intercovey subadult male her first spring but was observed that summer with an intracovey subadult male and their young. The second female also paired with an intercovey subadult her first spring but was with a second intercovey subadult and their young in summer. A third female paired with an intercovey adult her first spring and an intracovey subadult the second; breeding successes during each year remained unknown. The last female paired with an intracovey subadult the first spring and an intercovey subadult the second; she produced broods both years.

Twenty-two adult males engaged in 26 pairings. Six of the intracovey mates were adults while 2 were subadults. All of the intercovey mates were subadults. One of the unknown-covey-origin mates was an adult and the remainder were unknown age females. One unsuccessfully pairing male "paired" with a subadult male for his first spring post-capture but was seen with an unknown-sex (but not this subadult male) during the succeeding summer. Three other unsuccessfully paired males became accessory males to individual pairs while the fourth male was only observed alone.

Two adult males remained paired with their respective intracovey adult females during two successive springs. One of these males paired his third spring with a female whose age and covey-origin were unknown. A third male paired two successive springs, with a different intercovey subadult involved each year. The second mate of this male was apparently lost as he was observed as the accessory male to a pair and their young that summer.

Subadult males tended to be mated with subadult females. Four intra- , 8 inter- and 3 unknown-covey mates were subadults. Although 2 males mated with adult females, one each from intra- and intercoveys, these pairings did not occur until the males' first adult-spring. One intercovey and 15 unknown-covey-origin females were of unknown age. One unsuccessfully paired male was a member of a "homosexual pair", 3 males were accessory to individual pairs, 2 joined bachelor-male flocks and one was observed alone.

Four subadult males also engaged in multiple pairings or had mixed pairing successes in successive years. One paired with an unknown-age and unknown-covey-origin female his first spring, they were unsuccessful in producing a brood and joined a pair-brood that summer. He paired with an intercovey adult female his second spring; they were unsuccessful breeders and joined seven other adults that summer. A second male paired with an intercovey subadult his first spring, they did not produce a brood and were seen with three females that August. Another male paired with an intracovey adult his first spring and apparently lost his mate as he was seen with a pair-brood that summer. The last male spent his first spring as accessory to a pair and paired with an unknown-age, unknown-covey-origin female the second.

Data from this study suggested several behavioral mechanisms contributed to the pairing process in partridge populations. Every female surviving the winter is successfully paired in the spring. Adult and subadult males were paired in about equal proportions. Unsuccessfully paired adult males tend to become accessories to pairs while subadult males under similar circumstances became either accessories to established pairs or members of bachelor-male flocks.

The tendency of female and male adults to pair among themselves, and especially with intracovey members supported a hypothesis of lifetime pairing among Hungarian partridge. Ninety percent of adult females were mated with adult males and these males tended to be from their mutual winter covey. Adult males paired mostly with intracovey females, 75 percent of these mates were adults and all intercovey mates were subadults. Adult-adult pairing could also have indicated more refined or elaborate courtship displays were performed by adult than subadult males and that adult males were therefore "preferred" mates by adult females.

Intercovey pairings between subadult females and males of known covey-origins represented the majority of their respective pairings; 69 percent of 26 female and 67 percent of 15 male pairings involved intercovey members. Ten of the 15 known-age males involved in subadult female pairings were subadults. Eight of 9 known-age females involved in intercovey pairings with subadult males were also subadults. Although subadult females tended to be paired slightly more with male subadults than adults, there were proportionately more subadults (71%) than adults in late winter populations. These data suggested subadult females also "preferred" adult to subadult males as mates. The data also indicated subadult females and males tended to pair with intercovey rather than intracovey members, i.e. probable non-siblings.

Winter covey breakup and pairing in this study's low density populations occurred on winter ranges. Since these areas contained most of the available protective cover at that season, they were the focal point of all partridge activity. Without prior knowledge of occupancy and concentration of coveys on winter ranges, the large "gathering" of partridge on such areas could be misinterpreted as spring communal and mating sites.

In Great Britain, reference was made to communal mating areas by two authorities. Spark (1930) reported the tendency for coveys to collect at a meeting place at mating time. Witherby et al. (1944)

referred to a gathering of 200 to 300 partridge at mating time; paired birds were seen leaving the congregation. In Wisconsin, McCabe and Hawkins (1946:16) found "areas where several coveys often gathered to cavort in early mornings or late afternoons of February and March. These areas were covered with droppings as thickly as are prairie chicken booming grounds. It is probable that at these communal meeting places an exchange of birds occurs ...". Observations of Yeatter (1934), Jenkins (1961) and this author indicated no such behavior.

An apparent disparity exists between reports of intra- vs. inter-covey members pairing. In southern Michigan, Yeatter (1934:25) stated: "Pairing of birds within the covey is doubtless the rule, but this does not necessarily involve inbreeding because of the exchange of members that may occur between adjacent coveys during winter." McCabe and Hawkins (1946:15) thought courtship occurred in winter coveys in southern Wisconsin. Blank and Ash (1956:381) in Great Britain, stated an opposite view: "In most cases pairing occurs between birds of different coveys; although occasionally pairs form between birds of the same covey, we have no record of intra-family mating." Jenkins (1961:163), also in Great Britain, observed the behavior of 1,046 marked partridge and reported: "The only instances of pairing between birds in the same covey were when a pair of the previous season re-formed, or when the active bird in mate selection was the hen."

He further noted (P. 164): "If both members of a pair survived to the next spring, they usually mated again after little courtship."

Results of Jenkins' (1961) work and this study showed both inter-covey and intracovey pairing occurred in partridge populations. When two members of the same covey did pair, it was extremely doubtful that it occurred between immediate family members (any combination of father, mother, brother or sister). This apparently was true in high density populations (< 5A/pair) studied by Jenkins (1961:158) as well as in the low density populations (> 5A/pair) studied in northcentral Montana.

Jenkins (1961) thought females were the mate-selecting member of a pair and described female-female battles for the attention of a male. Observations in the current study also revealed battles between females over a male but no such battles were engaged about non-displaying males. Males actively displayed on winter ranges before most pairing occurred. The pairing sequence for partridge, other than for those maintaining previous pair-bonds, seemed to be: courtship display by sexually active males; female selection of a male; and, acceptance of the female by the male which cemented the pair-bond. Female partridge apparently searched for a mate until this sequence was completed. Surplus males in spring populations precluded this sequence from occurring for all males. These males were forced to substitute loose bonding with a pair or with other unpaired males for the pair-bond with a female.

Pairs combined into semi-compact flocks in spring with the return of winter weather conditions. Close inspection of flock composition revealed pairs were separated from one another by usually less than 2 yd (3.8 m). In 1970, pairs were noted through 15 February; a snowstorm, 27-28 February, covered the ground with 3 to 6 in (7.6 to 15.2 cm) snow and daytime temperatures ranged from 10° to 20°F (-12.1° to -6.6°C). A flock of ten partridge (four pairs, one male and one unknown-sex bird) was observed roosting in a shrub grove 27 February. On 28 February, a flock of 4 pairs and 1 male was also roosting in a shrub grove at another location. Twenty-eight other partridge groups observed during these 2 days consisted of pairs-only or pairs-plus accessory birds. Winter flocks were seen through 3 March in 1972 and by 17 March only pairs, pairs-plus-accessory birds and male flocks were noted. On 28 March, a heavy fog and an estimated 25°F (-3.9°C) temperature prevailed and a group of 4 pairs together was observed roosting in a shrub grove. On 29 March with warmer temperatures and no fog, only pairs were observed.

Blank and Ash (1956:384), in Great Britain, stated partridge did not regroup into coveys once they paired. Knott et al. (1943:284) in Washington, McCabe and Hawkins (1946:17) in Wisconsin, Porter (1955:102) in Utah and Jenkins (1961:165) in Great Britain observed regrouping of pairs during adverse weather in spring. The latest such pair-flocking behavior was noted by Porter (1955:102), on 15 May 1950 following a severe snowstorm.

Calling Counts

Hungarian partridge may be heard calling throughout the year. Calling during winter-covey dissolution and pairing tends to be associated with courtship displays. Post-courtship calling was interpreted to be related to territorial defense. The feasibility of counting calling partridge for use as a spring pair-density index was therefore investigated.

Fifty-four percent of 52 partridge groups observed 11-20 February 1970 consisted of 2-bird groups. By 11-20 March, 2-bird groups comprised 7 of 8 groups observed indicating pairing and dispersal to spring ranges was essentially complete.

Call counts ranged from 3 to 13 along a 10-mile route during 18 March-30 April (Table 18). The peak count occurred during the second survey and represented a maximum average density of 1.3 calling-partridge per survey-mile. No calls were recorded during three of the five surveys after 30 April. During five of six surveys, 50 percent or more of the calls were heard prior to sunrise and before temperatures were $\geq 32^{o}$F (0^{o}C).

Assuming an average of 15 eggs per nest laid at a rate of 1 egg per day, allowing 24 days for incubation starting immediately upon clutch completion, and counting back from the first observed hatching on 11 June (by field aging broods), the first nest should have started 5 May. The peak week of nesting should have occurred 14-20 May.

Table 18. Partridge calling counts and prevailing weather conditions along Route B during the Spring, 1970.

	Date										
	March 18	March 23	April 3	April 9	April 18	April 30[1]	May 6	May 14	May 22	May 26	June 6
TIME:											
Start	0559	0545	0526	0522	0455	0530	0523	0510	0503	0503	0455
Sunrise[1]	0638	0639	0605	0555	0536	0613	0603	0558	0550	0544	0537
WEATHER:											
Temperature °F	21-22	31-39	12	33	16-24	35-36	41-55	28-34	38	51-52	53-57
Wind (mph)	4-7	1-3	1-7	1-7	0-7	4-12	1-7	4-7	0	1-3	1-7
Percent Clouds	35-70	70	5	100	0	100	40-70	5	0-5	70-80	40-70
Ground	Dry	Dry	1-2" Snow	Dry	Dry	2-5" Snow	Dry	Light Frost	Heavy Dew	Dry	Light Dew
STOP NUMBER:											
1	1	2		2	1	1			1		1
2		1				1					1
3		1	1		1						1
4		5		1		1					
5				1		1					
7											1
8				*							
9		1		2		*					1
10	*		*		*	1					
11	2	*					*			*	
12		1	2	2	1				*		*
13					1			*			1
14											
15											
16		1	1								
17		1									
18											
19											
20											
TOTAL CALLS	3	13	4	8	4	5	0	0	1	0	6
CALLS TO Number	1	10	1	4	2	4	0	0	1	0	5
SUNRISE: Percent	33	77	25	50	50	80	--	--	100	--	84

[1]Mountain Standard Time up to April 25; Mountain Daylight Time effective April 26.
*Stop number at sunrise.

No calls were recorded during two of the three surveys conducted 6-22 May; only 1 call was heard during the third survey. This suggested that pairs do not "advertise" their location during nesting. The increase to 6 calls recorded 6 June may have reflected renewed territorialism following earlier nesting failures.

The lack of any progressively increasing or decreasing calling patterns during this period suggested several alternatives: such a pattern may not exist and either the peak or average count in April may be an adequate index; surveys should be conducted more frequently than at 1-week intervals; or calling counts are unreliable spring pair-density indices in an area containing low partridge densities.

Breeding

Successful or unsuccessful breeding, as indicated by observations of birds with their young, was evaluated for the same bibbed partridge used in the pairing discussion. Breeding success was determined for only 1 of 10 adult females (Table 17); she was paired with an adult male of unknown covey origin. Twelve of 29 successful pairings by subadult females resulted in successful breeding. Nine successfully breeding subadult females included 2 intracovey adults and 5 intercovey and 2 intracovey subadults. Two of the unsuccessfully breeding subadult females involved intercovey subadult males and the third was an unidentifiable male.

One of four successful breedings by adult males involved an unknown-covey adult and three were intercovey subadults. Two unsuccessful breeding adult males included pairings with an intracovey adult and an unknown-age female.

Five of seven breeding successes for subadult males represented pairings with subadult females and the remainder were unknown-age females. Successful breeding with the subadults included two intracovey and three intercovey members. Two of the unsuccessful breedings included adult females; one was an intracovey and one was an intercovey mate. A third unsuccessful breeding included an intercovey subadult while the other two pairings were with unknown-age females of unknown covey origin.

Only 33 percent of the identifiable pairs yielded breeding success information. Sixty-eight percent of these pairs successfully produced a brood. Although limited, these data indicated that successful breeding probably occurred among all male-female age combinations. Adult male pairings with subadult females tended to have greater breeding success than subadult male-female pairs. All of the recorded subadult male pairings successful in producing young with known-age females were with subadults. The data showed subadult males and females are sexually active their first spring. They also illustrated that subadult pairs produced young, even when the pair members may have been siblings.

Nesting

Nest-starting dates were determined by pre-dating hatching dates of 173 broods field-aged during summer surveys. In addition to the previously stated rate of egg-laying and length of incubation period, predating also assumed no eggs or chicks were lost between initiation of egg-laying and the date of brood observation. This assumption posed the greatest vulnerability since loss of eggs from dead embryos or infertile eggs, or the loss of chicks between brood hatching and observation would skew the actual nesting curve to somewhat earlier nesting dates than those stated.

The earliest and latest nest-initiation in 5 years was 15 April 1972 and 26 July 1969, respectively. The mean peak week of nest-starting occurred 13-19 May with 28 percent of the nests started during this period (Table 19). In individual years, 24-29 percent of the nests were started during peak weeks. Seventy-five percent of the nests were started on or before 3 June and 90 percent were started by 16 June.

In southern Michigan, Yeatter (1934:30) stated first partridge eggs were laid during the last 10 days in April; the majority were laid during the first 2 weeks in May. Gates (1973:4) reported the earliest nest was started 2 May and the latest was 17 July in southeastern Wisconsin; the average nest-starting date was 26 May. Gates noted a second peak in early July which he suspected was due to renesting. In eastern Washington, partridge nesting began in late April and peaked during the last week of April and first week of May (Knott et al. 1943:284).

Bissonnette and Csech (1941) and Buss et al. (1951) demonstrated

Table 19. Partridge nesting dates on the Agawam Study Area, 1969-1973.

Year	No. Nests	Dates: Earliest Nest Started	Dates: Latest Nest Started	Peak Week of Nest Starting: Dates	Peak Week of Nest Starting: Nests No.	Peak Week of Nest Starting: Nests %	Proportion of Nests Started (by:) 25%	50%	75%
1969	18	May 3	July 26	May 21-26	7	38.8	May 22	May 25	June 4
1970	41	May 11	June 27	May 24-30	10	24.4	May 22	June 2	June 11
1971	31	April 26	July 11	May 8-14	8	25.8	May 8	May 18	May 31
1972	25	April 15	June 27	May 7-13	8	32.0	May 1	May 13	May 26
1973	58	April 25	July 24	May 11-17	15	25.8	May 4	May 15	May 27
Five-Year:									
Totals	173	April 15	July 26	-	-	-	-	-	-
Means	-	-	-	May 13-19		27.8	May 11	May 21	June 3

experimentally that initiation of egg-laying in pheasants was stimulated by photoperiodism. Weather conditions, age composition of the population and population densities may also affect time of nesting (Baskett 1947:20). In Wisconsin, Besadny (1967) proposed that cumulative mean temperatures above 32°F (0°C) in the spring were important stimuli in prompting nesting and incubation by pheasants.

Cumulative degrees of daily median temperatures above 32°F measured at the U. S. Weather Station at Choteau were plotted annually for 1 March-31 May 1970-73 (Fig. 16). When daily medians were below 32°F, differences were subtracted from cumulation totals to that date (e.g. 1970 and 1972).

No firm relationship between the time of nesting and spring temperatures was detected. The earliest first-nest (15 April 1972) was started after an accumulation of 302 degrees F and occurred during the second-warmest spring recorded. The latest first-nest (11 May 1970) was started with an accumulated 330 degrees F during the coolest spring. A positive relationship between peak weeks of hatching and temperatures was also lacking.

No first-nests were started below a level of 248 accumulated degrees F and no peak of nesting began before an accumulation of 476 degrees. These data suggest thresholds of cumulative ambient warmth must be attained before nesting begins in the spring. Whether the 248-

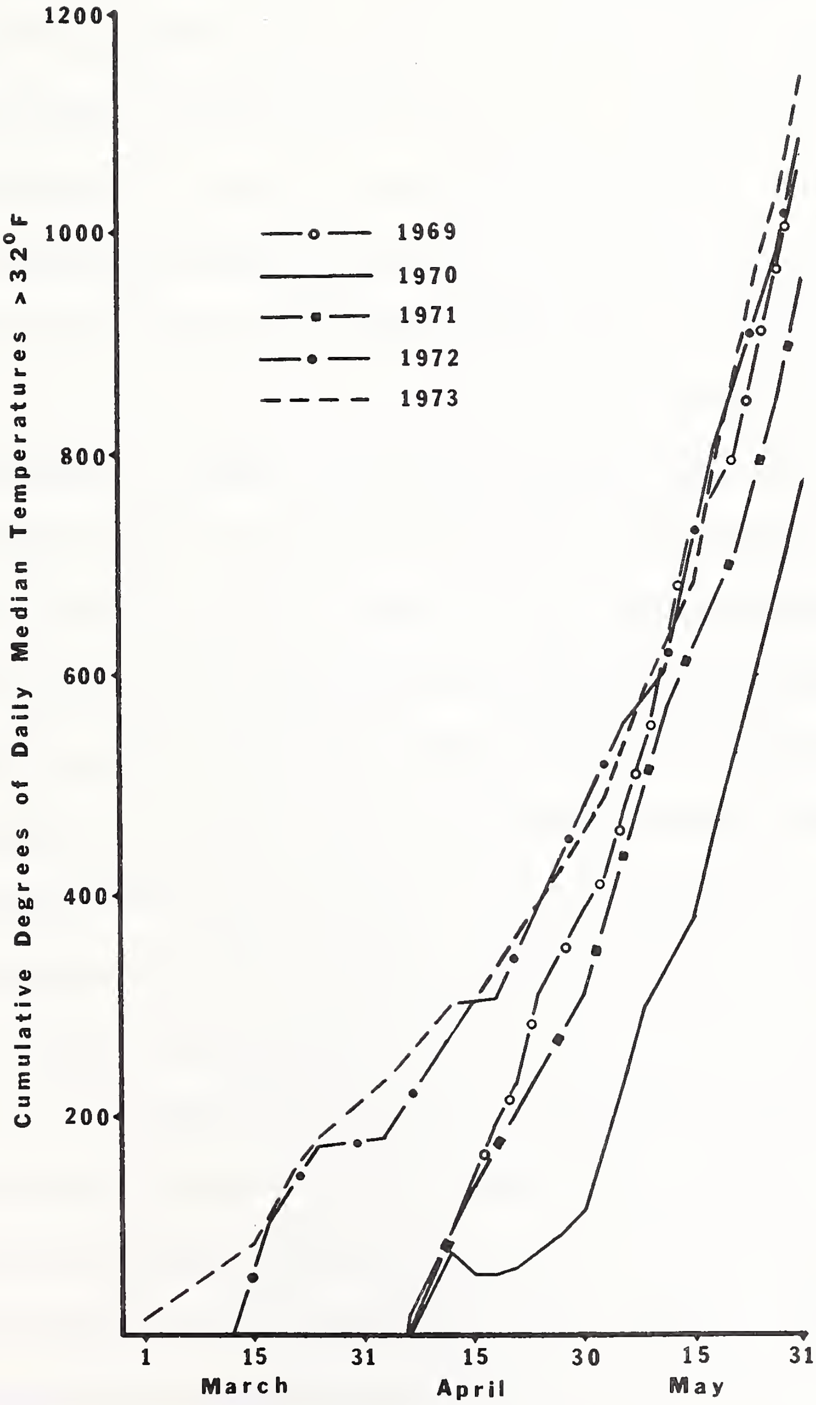


Figure 16. Cumulative degrees of daily median temperatures above 32°F, 1 March-31 May, 1969-73.

degree threshold was reached over a short period during a relatively late spring (1971) or over a longer period during an early spring (1973) appeared irrelevant. That partridge could have begun nesting in 1973 as early as 4 April but apparently did not do so until 25 April indicated other environmental and/or population factors also influenced nest initiation. A maximum accumulation of 416 degrees before onset of nesting occurred in 1969.

Ten partridge nests were located during 3 summers of the current study. Clutch sizes for seven completed clutches ranged from 7 to 17 eggs; the mean size was 14.3 eggs. In Great Britain, Middleton (1935, 1936, 1937) found annual averages of 15.1-15.5 eggs per clutch in 14,851 partridge nests. Paludan (1954) reported average clutches of 15.9 eggs in Finland. Average clutches of 15.7 eggs for 44 complete nests were reported in Michigan (Yeatter 1934:32), 14.7 in Minnesota (Schrader 1944), 16.7 for 392 complete clutches and 14.9 in 31 complete clutches in Wisconsin (McCabe and Hawkins 1946:22; Gates 1973:6) and 16.7 in 69 full clutches in Washington (Knott et al. 1934:284).

The low mean clutch size in Montana could be due to the limited nest sample and the inclusion of a 7-egg clutch in the averaging; the latter nest included only egg fragments from successful hatching. The average clutch size for the other six nests was 15.5 eggs which was comparable to means of other studies. Maximum numbers of eggs found in partridge nests in the wild (U.S.A.) were 32 (Jewett et al. 1953) in Washington and 36 (Green and Hendrickson 1938) in Iowa.

Summer Population Characteristics

Pair associations in early summer-early fall showed a steady decline from 100 percent pairs-only in June to 2 percent pairs-only in September (Table 20). This decline was offset by a July-September increase in pairs being associated with broods. Although pairs were noted with accessory males in August, and with accessory females in August and September, similar associations doubtless also occurred in early summer but were not identified. Many 3-bird groups were recorded with 1, 2 or 3 members listed as unknown-sex during these seasons.

Brood-hatching and unsuccessfully breeding adult aggregations contributed to the diverse social organization of the partridge population in July and August (Table 21).

Young accompanied by one or more adults were recorded as broods. A few groups of young without adults were also classed as broods. Suspected broods included groups containing at least one chick and resulted from incomplete identification of late-summer covey members. Records of broods were maintained as long as young could be distinguished from adults, usually in late September-early October. Broods and suspected broods formed 81 percent of observed summer populations. Ninety percent of the broods and suspected broods in summer were recorded during August.

Table 20. Partridge pairs and pair-associations during summer-early fall, 1969-73.

Month	Years	Pair-Only	Number of Pairs With: Access. Male	Access. Female	Access. Unk.-Sex Bird	Other Pair	Brood	Sus-pected Brood	Brood + Access. Male	Brood + Access. Female	Brood + Other Adults	Total Pairs
June	1970-72	38 (100.0)										38 (100.0)
July	1969-71	22 (64.7)			2 (5.9)	1 (2.9)	8 (23.5)	1 (2.9)				34 (99.9)
August	1969-73	16 (10.4)	8 (5.2)	4 (2.6)		2 (1.3)	65 (42.2)	1 (0.6)	20 (13.0)	5 (3.2)	33 (21.4)	154 (99.9)
September	1969-73	1 (1.6)		1 (1.6)			35 (55.5)		9 (14.3)	7 (11.1)	10 (15.9)	63 (100.0)

Table 21. Number of observations and partridge during summer by social group, by month, by year, 1969-73.

Month: Year	Pairs	Susp. Pairs	Mixed Adults	Bachelor-Male Flocks	Unknown Sex-Age Groups	Single Birds M	Single Birds F	Single Birds Unk.	Broods	Susp. Broods	Totals
June:											
1970	20/ 40[1/]	25/ 50				8/ 8	1/1	11/11	1/ 2		66/ 112
1971	16/ 32	5/ 10		1/ 2		3/ 3		2/ 2			27/ 49
2-Year Totals	36/ 72	30/ 60		1/ 2		11/11	1/1	13/13	1/ 2		93/ 151
July:											
1969	5/ 10		6/ 16			8/ 8		4/ 4	10/ 131		33/ 169
1970	11/ 22	9/ 18	1/ 3	2/ 4		8/ 8	1/1	15/15	5/ 54		52/ 125
1971	6/ 12	4/ 8	2/ 6	2/ 5		3/ 3		8/ 8	2/ 31		27/ 73
1972											
1973		8/ 16						3/ 3	8/ 107		19/ 126
5-Year Totals	22/ 44	21/ 42	9/ 25	4/ 9		19/19	1/1	30/30	25/ 323		131/ 493
August:											
1969	3/ 6		3/ 20	3/17	7/ 23	2/ 2	1/2[2/]	4/ 4	38/ 421	14/191	76/ 686[2/]
1970	3/ 6	6/ 12	6/ 25	1/ 2	1/ 8	6/ 6			45/ 463	6/ 83	74/ 605
1971	1/ 2	5/ 10	12/ 50	1/ 2	3/ 19	3/ 3		2/ 2	46/ 554	10/133	83/ 775
1972	2/ 4	1/ 2	7/ 24	8/39	6/ 68		1/1	3/ 3	29/ 410		57/ 551
1973	7/ 14	5/ 10	18/ 79	1/ 2	5/ 35	1/ 1	2/2	3/ 3	69/ 892	11/136	122/1,174
5-Year Totals	16/ 32	17/ 34	46/198	14/62	22/153	12/12	4/5	12/12	227/2,740	41/543	411/3,791

1/ Number of observations/number of partridge.

2/ One observation of two females.

Field aging of broods during July-September yielded hatching dates for 179 broods. The earliest hatching brood was 17 May 1972 while the latest was 20 August 1969. The mean peak week of hatching was 19-25 June with 29 percent of the broods hatching during this period (Table 22). For individual years, 25-35 percent of the broods hatched during peak weeks. Seventy-five percent of the broods hatched on or before 5 July; approximately 90 percent hatched by 17 July. Twenty percent of 1,661 young hatched during the 19-25 peak hatching week. Proportionately more young than broods were hatched during the weeks prior to than after the peak week.

Four of the 10 nests successfully hatched; four nests were abandoned due to disturbance by human activities, one was destroyed by an unknown predator and the fate of one nest remained unknown. Two of the abandoned nests were deserted because of farming activities and two due to inspection of nest sites by the author. Middleton (1935, 1936, 1937), in Great Britain, reported 77-78 percent hatching success. Records of nesting were kept by estate gamekeepers; apparently gamekeepering duties included removal of nest predators. Thirty-two percent nest hatching success was given by Yeatter (1934:50) for 143 nests in Michigan and by McCabe and Hawkins (1946:29) for 435 nests in Wisconsin Porter (1955:103) stated 3 of 8 nests in Utah successfully hatched. In Washington, hatching success for 113 nests averaged 37.2 percent (Knott et al. 1943:285).

Table 22. Partridge brood hatching dates on the Agawam Study Area, 1969-73.

		Dates		Peak Week of Hatch			Proportion of Broods Hatched (by:)		
					Broods				
Year	No. Broods Aged	Earliest Brood Hatched	Latest Brood Hatched	Dates	No.	%	25%	50%	75%
1969	18	June 3	August 20	June 20-26	6	33.3	June 22	June 26	July 9
1970	43	June 11	August 5	June 20-26	11	25.6	June 24	July 3	July 15
1971	32	June 1	August 6	June 9-15	11	34.3	June 11	June 17	July 1
1972	26	May 17	July 21	June 15-21	9	34.6	June 9	June 16	June 23
1973	60	May 26	August 18	June 17-23	15	25.0	June 8	June 15	June 23
Five-Year:									
Totals	179	May 17	August 20	-	-	-	-	-	-
Mean	-	-	-	June 19-25	52	29.1	June 13	June 22	July 5

Only 1 of 49 eggs in 4 successfully hatched clutches in this study failed to hatch. In Great Britain, Middleton (1935, 1936, 1937) reported annual hatching success ranged from 91 to 97 percent for 4 years. Based on examination of a sample of the unhatched eggs, he estimated only 0.1 percent of all eggs found were infertile. Lack (1947:22), in Great Britain, stated 90.4 percent of 57,202 partridge eggs hatched. While hatching success varied somewhat (88.0-92.1%) with clutch size, maximum success was experienced by clutches with 21-29 eggs. In Michigan, Yeatter (1934:32-33) found 76 percent of the eggs hatched in 23 nests. McCabe and Hawkins (1946:27), in Wisconsin, reported 74-93 percent (average, 84.5%) of 1,838 eggs in 104 hatched nests produced chicks; 13.7 percent of the eggs were judged infertile.

Apparently unsuccessfully breeding pairs in July-September were the most frequent members of mixed adult groups. Such groups comprised five percent of the average summer population and were most commonly observed in August.

Bachelor-male groups were most frequently observed during the summer; they comprised three percent of an average summer population. These flocks were recorded for all months except October, December and January. The largest group recorded contained nine males while the average was 3.4. No bachelor-female flocks were recorded during the study.

Summer trapping for partridge was relatively unsuccessful. Two of ten attempts to capture broods by dragging a mist net over vegetation netted birds; one attempt yielded two adults (a pair without young) and the other a 5-week-old juvenile from a previously flushed and scattered brood. One of four standard mist net sets yielded one adult male partridge captured from a group of four adults.

Thirty-eight of 82 partridge broods sighted were considered available for netting with the truck-mounted cannon net. Thirty-one of these groups flushed or moved into heavy vegetation upon approach of the vehicle. Firing at the remaining 7 groups netted five juvenile birds (three from one brood and one from each of two others). Cannon netting attempts resulted in 20.5 hrs expended and 113 miles driven per captured bird.

Fall Population Characteristics

A total of 335 groups and 3,454 partridge were recorded during fall (Table 23). The complexity of partridge population composition continued from summer into fall. Broods and suspected broods constituted the largest (53%) segment of the average fall population. Unknown sex-age coveys, a result of groups flushing before classification of individual birds was possible, formed the second-largest (44%) social group. They were the entire component of November populations.

Winter Population Characteristics

Observations of 1,094 groups and 7,624 partridge were recorded during the winter (Table 24). Winter coveys, believed to be extensions

Table 23. Number of observations and partridge during fall by social group, month, and year, 1969-73.

Month: Year	Mixed Adults	Bachelor-Male Flocks	Unknown Sex-Age Groups	Single Birds M	Single Birds F	Single Birds Unk.	Broods	Susp. Broods	Totals
September:									
1969	1/ 3[1/]	2/ 6	1/ 6				5/ 47	14/155	23/ 217
1970	3/17		16/126			2/ 2	38/416	7/107	66/ 668
1971	2/10		9/ 96			1/ 1	7/ 70	8/120	27/ 297
1972	3/18		6/ 65	1/ 1		1/ 1	15/216	2/ 36	28/ 337
1973	6/28		13/ 91			1/ 1	37/393	5/ 72	62/ 585
5-Year Totals	15/76	2/ 6	45/384	1/ 1		5/ 5	102/1,142	36/490	206/2,104
October:									
1970			27/243				6/ 70	3/ 44	36/ 357
1971			17/162				7/ 83		24/ 245
1972			7/ 78						7/ 78
3-Year Totals			51/483				13/153	3/ 44	67/ 680
November:									
1969			1/ 9						1/ 9
1970		1/ 6	38/436						39/ 442
1971			11/120						11/ 120
1973			11/ 99						11/ 99
4-Year Totals		1/ 6	61/664						62/ 670

[1/] Number of observations/number of partridge.

Table 24. Number of observations and partridge during winter by social group, month, and year, 1969-74.

Month: Year	Winter Coveys	Pairs	Susp. Pairs	Bachelor-Male Flocks	Single Birds M	Single Birds F	Single Birds Unk.	Totals
December:								
1969	3/ 25[1]							3/ 25
1970	17/ 127							17/ 127
1971	64/ 581							64/ 581
1973	45/ 352							45/ 352
4-Year Totals	129/1,085							129/1,085
January:								
1969	113/ 853							113/ 853
1970	103/ 798							103/ 798
1971	78/ 525							88/ 525
1972	56/ 444							56/ 444
1974	95/ 861							95/ 861
5-Year Totals	445/3,481							445/3,481
February:								
1969	164/1,277	3/ 6	8/ 16	2/ 5			2/2	179/1,306
1970	34/ 167	27/ 54	32/ 64		4/ 4	1/1	7/7	105/ 297
1971	23/ 166	4/ 8	4/ 8	1/ 4	4/ 4			36/ 190
1972	92/ 681	4/ 8	4/ 8	2/ 8				102/ 705
1974	54/ 477	21/ 42	14/ 28	2/ 6	7/ 7			98/ 560
5-Year Totals	367/2,768	59/118	62/124	7/23	15/15	1/1	9/9	520/3,058

[1]Number of observations/number of partridge.

of social groups formed during summer and fall, comprised 86 and 96 percent of the observations and birds, respectively. Composition of December and January populations consisted entirely of winter coveys. Pairs, suspected pairs, bachelor-male flocks and single birds appeared in February as winter coveys disbanded.

Group size data were obtained during 5 winters. Mean group size declined 9 percent between December and January and 25 percent between January and February (Table 25). By mid-February, however, winter groups had begun disbanding, pairing had commenced and partridge were dispersing from wintering areas. One- and 2-bird groups approximated only 3 percent of those observed in December and January. It appeared that 3-bird groups represented a threshold for normal covey functions during winter. Five- to 8-bird groups appeared to be the most common covey size in December while 5 to 10 were most frequent in January. Groups containing 14 or more members comprised less than 11 percent of December coveys and only 6 percent of January coveys. The largest winter covey counted contained 23 birds. Only one observation of groups combining was recorded and there were occasional instances of single groups dividing into two smaller groups.

Trapping

Trapping efforts during 5 winters resulted in the capture of 978 partridge, 548 of which were initial captures. In this study one trap-effort was defined as one trap set during one of three daily periods.

Table 25. Size frequencies of partridge groups, by 10-day period, during winter, 1969-74.

Period		Years[1]		Group Size 1	2	3	4	5	6	7	8	9	10	11	12	13	Others	Totals Groups	Totals Birds	Mean Group Size
December	1-10	1969-71[2]	No.				1		1		1			2				5	40	8.0
			%				20.0		20.0		20.0			40.0				100.0		
	11-20	1971	No.						2	1	1	2	1	1			1/ 15	9	81	9.0
			%						22.2	11.1	11.1	22.2	11.1	11.1			11.1	99.9		
	21-31	1970-73[3]	No.	2	2	4	4	20	10	17	16	5	11	4	5	2	13/238	115	964	8.4
			%	1.7	1.7	3.5	3.5	17.4	8.7	14.8	13.9	4.3	9.6	3.5	4.3	1.7	11.3	99.9		
	Subtotals		No.	2	2	4	5	20	13	18	18	7	12	7	5	2	14/253	129	1,085	8.4
			%	1.6	1.6	3.1	3.9	15.5	10.1	13.9	13.9	5.4	9.3	5.4	3.9	1.6	10.8	100.0		
January	1-10	1970-74	No.	2	3	4	8	8	23	14	17	10	9	9	8	4	6/104	125	995	8.0
			%	1.6	2.4	3.2	6.4	6.4	18.4	11.2	13.6	8.0	7.2	7.2	6.4	3.2	4.8	100.0		
	11-20	1970-74	No.			1	4	9	19	13	2	4	6	12	1	3	5/ 76	79	640	8.1
			%			1.3	5.1	11.4	24.1	16.5	2.5	5.1	7.6	15.2	1.3	3.4	6.3	99.8		
	21-31	1969-74	No.	4	4	17	16	24	31	32	21	30	25	9	10	2	16/256	241	1,846	7.7
			%	1.7	1.7	7.1	6.6	10.0	12.9	13.3	8.7	12.4	10.4	3.7	4.1	0.8	6.6	100.0		
	Subtotals		No.	6	7	22	28	41	73	59	40	44	40	30	19	9	27/436	445	3,481	7.8
			%	1.3	1.6	4.9	6.3	9.2	16.4	13.3	9.0	9.9	9.0	6.7	4.3	2.0	6.1	100.0		
February	1-10	1969-74	No.	1	3	6	17	21	28	23	15	13	20	10	15	8	9/144	189	1,502	7.9
			%	0.5	1.6	3.2	9.0	11.1	14.8	12.2	7.9	6.9	10.6	5.3	7.9	4.2	4.8	100.0		
	11-20		No.	20	67	15	14	17	16	15	13	19	18	4	3	8	2/30	231	1,210	5.2
			%	8.6	29.0	6.5	6.1	7.4	6.9	6.5	5.6	8.2	7.8	1.7	1.3	3.5	0.9	100.0		
	21-28/29		No.	8	57	9	5	3	5	3	2	2	1	1	1	2	1/18	100	346	3.5
			%	8.0	57.0	9.0	5.0	3.0	5.0	3.0	2.0	2.0	1.0	1.0	1.0	2.0	1.0	100.0		
	Subtotals		No.	29	127	30	36	41	49	41	30	34	39	15	19	18	12/192	520	3,058	5.9
			%	5.6	24.4	5.8	6.9	7.9	9.4	7.9	5.8	6.5	7.5	2.9	3.6	3.5	2.3	100.0		

[1]No data for the winter, 1972-73.
[2]No 1970 data.
[3]No 1972 data.

Conditions for trapping were available an average of only 18 days each winter and an average 334 trap-efforts were made each year (Table 26). A mean 0.6 partridge was captured per trap-effort. The most productive birds-per-trap-effort occurred in 1968-69.

Females were not more or less vulnerable to winter trapping than males. A positive, significant correlation ($r = 0.82$, $N = 5$, P .05) was shown between the percent females in winter-trapped samples and the percent females observed (from total winter observations). Exclusion of 1968-69 percentages resulted in an even higher correlation ($r = 0.95$, $N = 4$, P .05).

Four hundred seventy partridge were fitted with vinyl bibs. Proportions of each sex-age class bibbed compared favorably with proportions of the trapped birds: adult males, 17 vs. 17 percent; subadult males, 41 vs. 41 percent; adult females, 9 vs. 9 percent; and, subadult females, 34 vs. 33 percent.

Mean frequency of observation was 1.4 per bibbed bird. Observation rates for sex-age classes were: adult males, 1.7; subadult males, 1.5; adult females, 0.9; and, subadult females, 1.3. Higher observation rates for males was attributed to excess males in the population, to spring calling and displaying by males and to egg-laying and incubation by females.

The percent of bibbed partridge not observed after initial trapping was 42, 41, 58 and 52 percent of adult males, subadult males, adult

Table 26. Summary of trapping efforts and success during 5 winters, 1968-74.

Year	Month	Total No. Trapping Days	No. Trap-Efforts Morning	Mid-Day	Evening	Total	No. Partridge Captured New	Recaptures	Totals	Birds Per Trap-Effort
1969:	January	9.00	15	12	13	40	8	0	8	0.20
	February	8.33	20	20	20	60	48	16	64	1.07
	March	5.67	36	30	36	102	85	47	132	1.29
	Totals	23.00	71	62	69	202	141	63	204	1.01
1970:	January	6.67	38	47	54	139	26	8	34	0.24
	February	3.33	32	16	32	80	9	3	12	0.15
	Totals	10.00	70	63	86	219	35	11	46	0.21
1971:	January	7.67	62	42	54	158	36	24	60	0.38
	February	5.67	40	48	48	136	33	19	52	0.38
	Totals	13.34	102	90	102	294	69	43	112	0.38
1971:	December	3.33	28	28	38	94	48	11	59	0.63
1972:	January	9.00	75	67	85	227	70	89	159	0.70
	February	12.33	75	89	96	260	107	178	285	1.10
	March	3.00	15	15	15	45	15	14	29	0.64
	Totals	27.66	193	199	234	626	239	292	531	0.85
1974:	January	6.67	45	48	52	145	46	8	54	0.37
	February	9.00	59	63	62	184	17	13	30	0.16
	Totals	15.67	104	111	114	329	63	21	84	0.26
5-Year:	Totals	89.67	540	525	605	1,670	548	430	978	-
	Means	17.93	108	105	121	334	-	-	-	0.59

females and subadult females, respectively. No further contact was made with 23 percent of bibbed birds compared to 75 percent for leg-banded-only birds (Table 27). Females showed higher no-contact rates than males in both bibbed and leg-banded-only categories.

There were no detrimental short-term effects of bib-wearing on 18 partridge weighed at 3- to 25-day intervals between initial bib-fitting and recapture. Changes in weights ranged between -25 and +29 gm and showed a mean gain of 3.7 gm.

Group Constancy

Winter-groups seemed to possess a degree of constancy, possibly attributable to social bonding aamong members within the group. To test this constancy, Cole's (1949) formula for determining coefficients of association was applied to winter partridge groups containing bibbed birds. The formula used was: $\frac{2\,ab}{a+b}$, where a = the total number of times *bird a* was trapped and/or observed, b = the total number of times *bird b* was trapped and/or observed and ab = the number of times *birds a and b* were trapped and/or observed together. Associations at the time of initial capture were included in the calculations. A coefficient value of 1.0 indicated a perfect or maximum association, while a value of 0 indicated no association. Coefficients were determined only for groups containing three or more marked partridge.

Forty-eight groups, totaling 396 partridge, yielded 1,655 intra-covey coefficients of association during 5 winters (Table 28).

Table 27. Numbers and percent of partridge with no further contact after marking, 1969-74.

	Bibbed				Unbibbed			
	Males		Females		Males		Females	
Winter	Adults	Subadults	Adults	Subadults	Adults	Subadults	Adults	Subadults
1968-69:			1/					
Number	0	9		10	5	16	2	10
Percent	0.0	16.1	-	33.3	71.4	66.7	100.0	90.9
1969-70:								
Number	3	4	0	4	2	1	1/	1/
Percent	50.0	28.6	0.0	44.4	100.0	100.0	-	-
1970-71:					1/		1/	
Number	2	4	1	7		1		1
Percent	16.7	16.0	12.5	33.3	-	50.0	-	100.0
1971-72								
Number	9	16	11	20	2	3	1	1
Percent	21.4	20.3	39.3	25.6	66.7	75.0	50.0	33.3
1973-74								
Number	1	9	1	5	1	1	1	2
Percent	11.1	50.0	16.7	21.7	50.0	100.0	50.0	100.0
5-Winter Totals								
Number	15	41	13	40	11	23	4	14
Percent	19.0	21.4	28.9	24.8	78.6	71.9	66.7	82.4

[1]No birds marked in this category.

Table 28. Intracovey coefficients of associations of winter partridge coveys, 1969-74.

Group Size	No. Groups	Coefficients of Association: 0		0.01-.25		0.26-.50		0.51-.75		0.76-1.0		Total	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
3	4	0	-	0	-	5	41.7	2	16.6	5	41.7	12	100.0
4	4	3	12.5	2	8.3	5	20.8	9	37.5	5	20.8	24	99.9
5	4	3	7.5	3	7.5	17	42.5	11	27.5	6	15.0	40	100.0
6	9	11	8.1	3	2.2	38	28.1	46	34.1	37	27.4	135	99.9
7	5	9	8.6	3	2.8	33	31.4	26	24.8	34	32.4	105	100.0
8	4	36	32.1	3	2.7	38	33.9	17	15.2	18	16.1	112	100.0
9	2	11	15.3	0	-	23	31.9	12	16.7	26	36.1	72	100.0
10	2	8	8.9	0	-	5	5.6	36	40.0	41	45.6	90	100.1
11	5	68	24.7	1	0.4	118	42.9	51	18.5	37	13.5	275	100.0
12	3	82	41.4	17	8.6	76	38.4	18	9.1	5	2.5	198	100.0
13	1	30	38.5	8	10.3	22	28.2	18	23.1	0	-	78	100.1
14	3	53	19.4	47	17.2	101	37.0	50	18.3	22	8.1	273	100.0
15	1	47	44.8	4	3.8	34	32.4	12	11.4	8	7.6	105	100.0
17	1	35	25.7	20	14.7	59	43.4	19	14.0	3	2.2	136	100.0
Totals	48	396	23.9	111	6.7	574	34.7	327	19.8	247	14.9	1,655	100.0

Approximately 24 percent of the coefficients were 0 while 65 percent were $\geq$ 0.50. Eng and Schladweiler (1972) found 94-97 percent of 12-15 marked sage grouse, a polygamous species, observed on wintering areas with coefficients of $\leq$ 0.50. These low coefficients plus the large variation of flock sizes with which marked birds were associated suggested only weak associations among sage grouse in winter flocks. The high coefficients and relative constancy of group size of wintering partridge in the current study suggested a high association among flock members.

The hypothesis that intracovey member bonds had biological significance was supported by determining coefficients of association between members of each group and members of other groups utilizing the same winter range (i.e. intercovey coefficients). Only coveys used to determine intracovey coefficients were included in these comparisons; eight groups were deleted since there were too few or no intercovey associations for comparison. Intracovey coefficients were subtracted from potential coefficient numbers to establish the total intercovey coefficients available.

Forty groups, totaling 308 partridge, yielded 3,148 intercovey coefficients of association (Table 29). A 0-coefficient was determined for 93 percent of these associations and $\leq$ 0.25-coefficients comprised 98 percent of the associations. These data indicated that any two partridge, occurring simultaneously on the same winter range, which

Table 29. Intercovey coefficients of association of winter partridge coveys, 1969-74.

Winter	Location	No. Groups	No. Birds	Coefficients of Association: 0 No.	0 %	0.01-.25 No.	0.01-.25 %	0.26-.50 No.	0.26-.50 %	0.51-.75 No.	0.51-.75 %	0.76-1.0 No.	0.76-1.0 %	Total[1] No.	Total[1] %
January-March, 1969	Breding	5	28	312	99.7	0	-	1	0.3	0	-	0	-	313	100.0
	D. Rice	6	44	732	92.2	38	4.8	22	2.8	1	0.1	1	0.1	794	100.0
	Sub-Total	11	72	1,044	94.3	38	3.4	23	2.1	1	0.1	1	0.1	1,107	
January-February 1971	Rauscher	2	10	24	100.0	0	-	0	-	0	-	0	-	24	100.0
	D. Rice	2	15	64	100.0	0	-	0	-	0	-	0	-	64	100.0
	Sub-Total	4	25	88	100.0	0	-	0	-	0	-	0	-	88	100.0
December 1971-March 1972	Keller	2	15	62	96.9	0	-	2	3.1	0	-	0	-	64	100.0
	Klette	4	45	669	90.7	55	7.4	14	1.9	0	-	0	-	738	100.0
	Rauscher	4	34	404	97.8	6	1.5	3	0.7	0	-	0	-	413	100.0
	D. Rice	3	33	362	98.0	1	0.3	5	1.4	1	0.3	0	-	369	100.0
	P. Rice	2	11	24	100.0	0	-	0	-	0	-	0	-	24	100.0
	D. Stott	2	19	86	100.0	0	-	0	-	0	-	0	-	86	100.0
	Thomas	3	17	96	100.0	0	-	0	-	0	-	0	-	96	100.0
	Tschantre	3	24	84	63.2	38	28.6	11	8.3	0	-	0	-	133	100.1
	Sub-Total	23	198	1,787	92.9	100	5.2	35	1.8	1	0.1	0	-	1,923	100.0
January-February 1974	L. Stott	2	13	20	66.7	6	20.0	4	13.3	0	-	0	-	30	100.0
	Sub-Total	2	13	20	66.7	6	20.0	4	13.3	0	-	0	-	30	100.0
4-Year totals & Averages		40	308	2,939	93.4	144	4.6	62	2.0	2	T	1	T	3,148	100.0

exhibited coefficients of $\geq$ 0.26 were members of the same group; only 2 percent probability of error was incurred. However, one could not safely assume that coefficients of $\leq$ 0.25 between any two partridge were members of separate coveys; 31 percent of such coefficients in intracovey comparisons were actually members of the same group.

Comparison among group sizes indicated $\leq$ 10 percent probability of encountering 0-association coefficients with intracovey groups of 7 or fewer partridge and probabilities up to 45 percent of a 0-coefficient with $\geq$ 8-bird groups. The probability of encountering high coefficients seemed to decrease as winter covey size increased with $\leq$ 8 percent probability of $\geq$ 0.76 coefficients occurring in groups of 12 or more birds. However, several conditions existed which may have precluded higher coefficients in larger groups: (1) individual bird activity in an observed group; (2) time limitations prevented identifying every marked member; (3) birds moved away from the observer due to alarm or adverse weather conditions; and (4) only part of a group may have been captured while the remainder had left the vicinity of the trap.

Sex-Age Structure

Sex and age composition of winter populations was determined from individual bird examination during trapping operations. Five-year mean proportions of individual sex-age classes were: adult males, 17 percent; subadult males, 41 percent; adult females, 9 percent; and, subadult females, 33 percent (Table 30). Males comprised 58 percent of the

Table 30. Numbers of partridge, by sex and age, initially captured and marked during the winters, 1969-74.

Trapping Period:	Males		Females		Total	No. Males Per 100 Females			No. Subad. Per 100	No. Subad. Per 100 Adult
	Adults	Subadults	Adults	Subadults	Birds	Adults	Subadults	Total	Adults	Females
January-March 1969:										
Number	17	80	2	41	141[1]	[2]	195	226	[2]	[2]
Percent	12.1	56.7	1.4	29.1	100.0					
January-February 1970:										
Number	8	15	3	9	35	267	167	192	218	800
Percent	22.9	42.8	8.6	25.7	100.0					
January-February 1971:										
Number	12	27	8	22	69	150	123	191	245	613
Percent	17.4	39.1	11.6	31.9	100.0					
December 1971-March 1972:										
Number	45	83	30	81	239	153	102	116	216	547
Percent	18.8	34.7	12.6	33.9	100.0					
January-February 1974:										
Number	11	19	8	25	63	138	76	91	232	550
Percent	17.5	30.1	12.7	39.7	100.0					
5-Year:										
Totals: No.	93	224	51	178	548[1]					
%	17.0	40.9	9.3	32.5	100.0					
Means						182	126	138	281	792[3]

[1] Includes 1 unknown-age female; this bird excluded from other calculations.
[2] Calculations excluded because of low number of adult females in sample.
[3] Mean for last 4 years only.

trapped birds for a mean 137 males per 100 females. Subadult males showed the greatest annual variation of the sex-age classes while adult males exhibited the least. The mean adult sex ratio (182 males per 100 females) was significantly higher (x^2 = 3.07, P .10) than that of subadults (126 males per females).

Sex ratios between adults and subadults were positively and significantly correlated (r = .904, N = 4, P .05) during the last 4 winters. Assuming this relationship also applied to 1968-1969 data, an adult sex ratio of 285 males per 100 females would be expected rather than the 850:100 ratio indicated in the trapped population. A 5-year declining trend was noted in adult and subadult sex ratios.

A highly significant, inverse correlation (r = -0.997, N = 5, P .01), was determined between proportions of females in trapped bird samples and in subadult sex ratios. The data indicated either progressively increasing mortality of males or progressively increasing survival of females during the 5-year period. Since females comprised a proportionately larger segment of subadults than adults, survival of subadult females must have increased during the period.

Eighty-three percent of 416 observed groups were completely classified. These coveys, totaling 2,183 birds, indicated an observed 5-year mean of 131 males per 100 females (Appendix III). Individual-winter mean sex ratios ranged from 99 (1973-74) to 173 (1969-70) males per 100 females. Incompletely classified coveys, 73 groups totaling

627 birds, indicated the 5-year mean sex ratio was 139 males per 100 females; the range was 114 (1973-74) to 192 (1970-71) males per 100 females (Appendix IV).

Sex ratios of incompletely classified coveys approached the mean winter ratio of those completely classified as the proportion of identified covey members increased. Only coveys with 76 percent or more of their members classified reflected this accuracy; those with less showed progressively higher proportions of males. The data showed a tendency by the author to recognize males more readily than females, despite accumulating experience in classifying birds.

Corrections for errors in field-sexing birds by facial plumage (4.4% too many males) yielded sex ratios of 125 and 133 males per 100 females in completely and incompletely classified coveys, respectively. That the ratio from completely classified coveys was notably different from that of trapped birds suggested either greater vulnerability of males to trapping than females or individual coveys, containing proportionately fewer males, were recorded in greater frequency than they occurred in the population.

McCabe and Hawkins (1946:59) reported a secondary sex ratio of 75 males:100 females from 331 chicks; apparently differential mortality of the sexes occurred between time of egg fertilization and time of hatching. If this ratio applied also to the Agawam partridge population, significant mortality of females occurred between the time of hatching and that of winter-trapping.

Movements

Partridge movements were determined from observation and recapture of bibbed birds and from locations of radio-instrumented females. Movements of bibbed partridge from initial winter trap sites were determined for the winter in which they were trapped and to spring, summer, fall and second-winter ranges. Bibbed bird data were considered by lifetime and by seasonal movements of individual sex-age classes and homing movements to winter ranges.

Mean distances moved were compared by the Studentized Range or *Q* test; it was considered to yield more conservative evaluations between compared means. Significance and non-significance between means was determined at P .05. When no significance was indicated, the variance or *F* test was applied to detect subtle significant differences. Winter ranges were determined by mapping locations of coveys containing bibbed birds. Mapping locations of radio-instrumented birds provided late winter-spring home range information. Movements data for each sex-age class for individual seasons and years are presented in Appendices VI-XIV.

Lifetime

Lifetime maximum movements were determined for each of 320 bibbed partridge which were relocated at least once; some birds were observed only during the initial winter of trapping. All movements by 56 males and 24 females initially trapped as adults were included in adult sex classes. Movements by 141 male and 99 female subadults through their second-winter were included in subadult sex classes. Subadults entering their second summer were adults chronologically, but were still in their first year of independence and were continued in their subadult classification in this discussion. Movements by subadults beyond their second winter were grouped with the adult-cohort at time of observation or recapture.

Approximately 59 percent of the partridge population remained within 220 yd of their initial winter trap site and 86 percent lived their life within 660 yd (Table 31). Adult and subadult males appeared to be the most mobile during their lifetimes (81 and 82%, respectively, moved ≤ 660 yd) while subadult females were the least mobile (94% moved ≤ 660 yd). While adult and subadult males ranked close in their mobility, subadult females were more resident than adult females (87% moved ≤ 660 yd).

Since only 14 percent of the observed lifetime movements exceeded 660 yd, movements by these 43 birds were further analyzed. Six of these birds were adult males, 28 were subadult males, 3 were adult females and 6 were subadult females.

Three of the adult males remained within a conceivable sphere of influence of their winter range; maximum movements of these males were 793 yd (725 m), 1,170 yd (1,070 m) and 1,207 yd (1,104 m). The other

Table 31. Lifetime maximum movements from initial winter trap-sites by individual partridge sex-age classes, 1969-72.

Trap. Period	Sex	Age[1]	No. Birds	Yd M	0-220 0-201	221-440 201-420	441-660 403-604	661-880 604-805	881-1320 806-1207	1321-1760 1208-1609	1761-2640 1610-2414	2641-3520 2415-3219	3521+ 3320+	Totals
Jan.-Mar. 1969	M	Ad.	9		3(33.3)[2]	2(22.2)	2(22.2)	1(11.1)	1(11.1)		0		0	9
		S-Ad.	48		32(66.7)	6(12.5)	5(10.4)	1(2.1)	2(4.2)		1(2.1)		1(2.1)	43
	F	S-Ad.	20		17(85.0)	3(15.0)								20
Jan.-Feb. 1970	M	Ad.	3		4(100.0)	0	0		0					4
		S-Ad.	9		6(66.7)	1(11.1)	1(11.1)		1(11.1)					9
	F	Ad.	2		2(100.0)									2
		S-Ad.	5		5(100.0)									5
Jan.-Feb. 1971	M	Ad.	10		7(58.3)	3(25.0)	1(8.3)		0		1(8.3)		0	12
		S-Ad.	20		10(50.0)	5(25.0)	0		1(5.0)		3(15.0)		1(5.0)	20
	F	Ad.	5		2(25.0)	1(12.5)	1(12.5)		1(12.5)		2(25.0)	1(12.5)		8
		S-Ad.	15		10(66.7)	3(20.0)	0		0		2(13.3)	0		15
Dec.-Mar. 1972	M	Ad.	34		26(57.8)	7(15.6)	2(4.4)	1(2.2)	4(8.3)	0	3(6.3)	0	2(4.4)	45
		S-Ad.	64		23(35.9)	22(34.4)	5(7.8)	5(7.8)	2(3.1)	2(3.1)	3(4.7)	1(1.6)	1(1.6)	64
	F	Ad.	17		16(80.0)	4(20.0)	0		0		0	0	0	20
		S-Ad.	59		37(62.7)	14(23.7)	4(6.8)		1(1.7)		1(1.7)	1(1.7)	1(1.7)	59
4-Year Totals & Averages	M	Ad.	56		40(57.1)	12(17.1)	5(7.1)	2(2.9)	5(7.1)	0	4(5.7)	0	2(2.9)	70
		S-Ad.	141		71(50.4)	34(24.1)	11(7.8)	6(4.3)	6(4.3)	2(1.4)	7(5.0)	1(0.7)	3(2.1)	141
	F	Ad.	24		20(66.7)	5(16.7)	1(3.3)		1(3.3)		2(6.7)	1(3.3)	0	30
		S-Ad.	99		69(69.7)	20(20.2)	4(4.0)		1(1.0)		3(3.0)	1(1.0)	1(1.0)	99
Population Totals and Averages			320		200(58.8)	71(20.9)	21(6.2)	8(2.4)	13(3.8)	2(0.6)	16(4.7)	3(0.9)	6(1.8)	340

[1]See text for explanation of movements by adults vs. subadults.
[2]Number of movements (Percent of movements for sex-age class).

three adult males left the vicinity of their original winter ranges and were observed near other, disjunct winter ranges. One of these latter birds was recaptured 30 December 1971 on the same winter range on which it had been initially captured the preceding winter. He was observed 29 February and 2 March 1972 at a second winter range, 2,135 yd (1,952 m) from the first, and then moved back to the vicinity of his original range by 3 March 1972. Four of the five adult males made their extended moves during spring or early summer.

Fourteen of the 28 subadult males remained within the sphere of influence of their original winter range, while 13 moved to new winter ranges and remained there. The most dramatic and maximum movements by a partridge in this study were recorded for a subadult male initially trapped 21 January 1970. He was recaptured 14 January 1971 at a second winter range 6,376 yd (5,830 m) from the first range; on 30 January he was recaptured on his original range and was observed 10 February back on the second winter range. While on the second winter range he was a yearling recaptured or observed with the same winter covey; it is not known whether the other covey members accompanied him on his brief return to his original range.

Eight of the 14 subadult males remaining within the influence of their original winter range moved away from these ranges during their first spring, 5 males moved during their first spring or summer and 1 moved his first summer. One of the 5 males moving in spring or summer was observed as a yearling on 28 September 1970, 939 yd (859 m) from his original trap site. During the following winter he was on his original range but on 28 September 1972 he was observed at the same location he was noted on 2 years earlier. The maximum movement recorded by one of these eight males was 1,586 yd (1,450 m) from his initial trap site.

Four of the 13 subadult males moving to new winter ranges moved during the winter of initial capture (all occurred during the winter of 1971-72), 2 moved during their first spring, 3 moved their first spring or summer and 4 moved sometime during the interim to their second winter. None of these males returned to their original winter range once they left it. The maximum distance moved by one of these birds was 4,572 yd (4,181 m).

Two adult females left their initial winter range between the winter of initial capture and the following winter; none apparently returned. The maximum movement by an adult female was 2,815 yd (2,574 m); she moved 2,075 yd (1,897 m) to a second winter range, and then moved an additional 740 yd (677 m) to a third winter range; the latter two movements occurred during the second winter.

The six subadult females moving >660 yd apparently made permanent movements since none were recorded as having returned to original winter ranges. Two females moved during each of the following periods: winter of initial capture; first spring; and first spring or summer.

The maximum distance moved by a subadult female was 3,527 yd (3,225 m).

Nine partridge experienced > 660 yd movements resulting from entire coveys moving during the severe winter, 1971-72. The first group of 7 birds (1 adult male, 1 adult female, 3 subadult males and 2 subadult females), probably a family, was part of a covey of 22 observed on 24 December 1971. Nineteen birds were observed at this site 30 December (one additional bird could have been missed at this time) and 13 birds remained there 7 February 1972. Three of the 7-bird covey were recaptured 7 February 1972 at a ranch 2,145 yd (1,961 m) from the original site; 1 new bird was in the trap with those marked and 9 birds flushed from the trap site. Since the 7-bird covey was subsequently observed with these other birds through 2 March, the two coveys may have merged; this was the only quasi-evidence of covey mergence during any winter of the study.

Two other adult partridge, a male and female, moved >660 yd with three male and two female subadults; this was presumably also a family covey. This group was initially captured together on one winter range 30 December 1971 and was observed on the second winter range 14 January 1972. There was no other covey resident at the second ranch during this winter.

Seasonal

These movements were refined into three comparisons: (1) movements of each sex-age class from initial-winter trap sites about the initial winter range; (2) inter-seasonal movements were compared within sex-age classes; and (3) adult vs. subadult movements wherein moves by previous subadults experienced a given season for a second or more times.

Initial Winter. Data for this period extended from the date of initial capture through 28-29 February, or through early March during prolonged winters. The greatest mean movement was recorded for subadult males, while adult males showed the lowest mean movement (Table 32). There was no significant difference between mean movements of adult and subadult males (Q= 2.60, df = 444), adult and subadult females (Q = 0.13 df = 285) adult males and females, (Q = 1.60, df = 185) nor subadult males and females (Q = 0.73, df = 544).

Spring. Movements from winter to spring ranges were recorded for adults with previous range-selection experience and by the inexperienced subadults. The relatively narrow range of mean movements indicated none of the sex-age classes moved very far to spring ranges (Table 32). Statistical comparison between mean movements of adult vs. subadult males (Q = 0.22, df = 120), adult vs. subadult females (Q = 0.31, df = 61), adult males vs. females (Q = 0.91, df = 40) and subadult males vs. females (Q = 0.60, df = 141), revealed no significant differences. The longest movement to spring range was noted for a subadult female, whereas an adult female moved the shortest distance.

Although all sex-age classes showed increases in mean distances moved, initial winter vs. first spring, only those for adult and

Table 32. Maximum and mean seasonal movements from initial-winter trap-sites by individual partridge sex-age class, 1969-74.

Season	Sex	Age	No. Birds	Movements Per Bird	Distance Per Movement[1] Maximum	Mean ±	Std. Dev.
Initial Winter (5 years)[2]	Male	Adult	58	2.3	905 (828)	102 (93) ±	168 (154)
		Subadult	125	2.5	3,709 (3,392)	158 (144) ±	341 (312)
	Female	Adult	24	2.3	2,095 (1,916)	147 (134) ±	398 (364)
		Subadult	101	2.3	2,110 (1,929)	143 (131) ±	319 (292)
First Spring (5 years)	Male	Adult	8	1.8	1,778 (1,626)	267 (244) ±	348 (318)
		Subadult	59	1.5	2,894 (2,646)	281 (257) ±	474 (433)
	Female	Adult	5	2.0	556 (508)	194 (177) ±	160 (147)
		Subadult	30	1.8	3,527 (3,225)	241 (220) ±	666 (609)
First Summer (4 years)	Male	Adult	4	1.0	1,207 (1,104)	612 (560) ±	506 (462)
		Subadult	14	1.0	1,250 (1,143)	582 (532) ±	333 (305)
	Female	Subadult	8	1.3	586 (536)	226 (207) ±	161 (147)
First Fall (4 years)	Male	Adult	3	1.7	505 (462)	197 (180) ±	182 (166)
		Subadult	5	1.6	2,435 (2,227)	1,000 (914) ±	932 (852)
	Female	Subadult	8	1.5	2,872 (2,626)	517 (473) ±	902 (825)
Second Winter (3 years)	Male	Adult	4	4.0	2,135 (1,952)	430 (393) ±	670 (613)
		Subadult	15	1.9	6,384 (5,838)	1,634 (1,494) ±	1,959 (1,791)
	Female	Adult	3	1.7	2,815 (2,574)	2,094 (1,915) ±	789 (722)
		Subadult	3	4.7	253 (231)	109 (99) ±	75 (68)

[1]In yards (meters)

[2]Number of years data collected.

subadult males were significant (Q = 5.57, df = 163, and Q = 3.89, df = 401, respectively).

Movements data to second, third or more spring ranges from initial-winter trap-sites were significant (Q = 3.06, df = 108) only between subadult (Table 32) and adult males (Table 33).

Summer. Mean movements from initial-winter areas by adult males were the greatest, while those by subadult females were the shortest (Table 32). Adult females were not represented by observations during this period. Mean movements by subadult males were significantly greater than for subadult females (Q = 4.41, df = 22). The largest movement from winter to summer range was recorded for a subadult male, while the shortest maximum movement was made by a subadult female.

Increases in distances moved, winter-spring vs. spring-summer, were noted for adult and subadult males; only the increases by subadult males (Q = 3.68, df = 79) were statistically significant. Apparently the small sample for adult males precluded significance at P .05 (Q = 2.53, df = 32). Data from subadult females suggested a decrease in distances from spring to summer, but this decline was not statistically significant (Q = 0.16, df = 58).

There was no significant difference (Q = 0.53, df = 22) between distances moved by adult (new-plus-previous) males from initial winter to second or more summer ranges and those of subadult males to first summer ranges (Table 33).

Table 33. Maximum and mean seasonal movements from initial winter trap-sites by adult[1] male and female partridge, 1969-74.

Season	Sex	No. Birds	Movements Per Bird	Distance per Movement[2] Maximum	Mean	±	Std. Dev.
Spring (5 years)	Male	23	1.9	3,671 (3,367)	516 (472)	±	916 (838)
	Female	7	1.7	556 (509)	179 (163)	±	150 (137)
Summer (4 years)	Male	8	1.3	3,651 (3,339)	700 (640)	±	1,102 (1,008)
Fall (4 years)	Male	8	1.1	939 (859)	243 (222)	±	277 (253)
Winter (4 years)	Male	23	2.4	6,384 (5,538)	1,187 (1,086)	±	1,687 (1,543)
	Female	14	1.7	2,815 (2,574)	487 (445)	±	391 (815)

[1]Defined as having experienced their second spring or winter, or third summer or fall.
[2]In yards (meters).

Fall. Ranges during this period appeared similar to summer ranges although movements from them could have been influenced by early winter weather. Mean movements from initial-winter areas were greatest for subadult males and were least for adult males (Table 32). No significant difference in distances moved was detected between adult and subadult males ($Q = 2.65$, $df = 11$, P .05); however, the variance ratio was significant at P .20 ($F = 3.51$). There was no significant difference between mean distances moved by subadult males and females ($Q = 1.64$, $df = 18$). Apparently the range in individual movements by the few birds observed in each class nullified significances at P .05. The longest distance moved by a partridge during this period was made by a subadult female. No adult female observations were available for comparison.

Increases in mean distances moved, spring-summer vs. summer-fall, were shown by subadult males and females but a decrease was suggested for adult males. Only the increase indicated for subadult males was statistically significant ($Q = 4.15$, $df = 20$).

Mean distances moved by adult males (new-plus-previous, Table 33) from initial-winter to adult summer ranges were significantly greater ($Q = 3.30$, $df = 15$) than movements to first-summer ranges by subadult males. No significance was detected ($Q = 1.71$, $df = 17$) between spring-summer and summer-fall movements by adult males.

Winter. Mean distances between initial-winter and second-winter ranges were determined from 25 bibbed partridge (Table 32). Movements were greatest for adult females and least for subadult females. Distances were significantly greater for subadult than adult males (Q = 3.35, df = 42), adult than subadult females (Q = 13.88, df = 17), adult females than males (Q = 6.59, df = 19), and subadult males than females (Q = 4.09, df = 40). Maximum distances moved were greatest for subadult males and lowest for subadult females.

Adult and subadult males showed increases in movements, summer-fall vs. fall-winter ranges, but neither were significantly different (Q = 1.07, df = 19, Q = 1.24, df = 34, respectively). The suggested decrease between these distances for subadult females was insignificant at P .05 (Q = 2.39, df = 24) but was significant in the P .20-.50 range (F = 2.86).

Movements of adults (new-plus-previous) indicated no significant differences between males and females at P .05 (Q = 2.71, df = 78) but were significant at P .20 (F = 3.68) (Table 33). Mean movement differences were insignificant between adult and subadult males (Q = 1.53, df = 82) and between adult and subadult females (Q = 2.23, df = 36; significant P .20-.50, F = 2.48). Distances moved by adult males, summer-fall vs. fall-winter, were insignificant at P .05 (F = 2.35).

Maximum and mean movements of each sex-age class, by season, by year are presented in Appendices V-XIII.

Fidelity to Winter Ranges

Information regarding homing to winter ranges where birds were initially trapped was obtained from 31 marked partridge. All four adult males trapped as adults returned to their initial winter ranges during the second winter, one of which also returned the third winter.

Seventy-four percent of 19 subadult males returned to original winter ranges in subsequent winters. Ten of these 14 males returned as yearlings whereas 4 others returned as 2-year-olds; the returning 2-year-olds were not observed or captured during their second winter. One of the yearlings returning to his original winter range also returned to it as a 3-year-old; no record of his winter range as a 2-year-old was obtained. Return of yearlings to initial winter ranges could reflect return of their mates to previous winter ranges.

Five subadult males occupied other winter ranges as adults. Four appeared on other winter ranges as yearlings and one as a 2-year-old. Movements of non-returning subadult males may have corresponded to those non-family groups which they joined in summer and fall.

Two of four adult females returned to initial winter ranges; one returned the second winter and the other, the third. A third female returned to a winter range viewed as a satellite to her initial range. This satellite range was about 880 yd from the main range and movements of partridge between the areas was not uncommon. The fourth female moved to a new winter range prior to the second winter after initial capture. She, and her covey members, then moved to yet another winter range during the second winter.

All four subadult females returned to original winter ranges; three returned as yearlings and one as a 2-year-old. One of the yearlings also returned to the original range as a 2-year-old.

From overall observations and recaptures of bibbed partridge it was readily apparent that subadult males were the most seasonally mobile sex-age segment of the population. Subadult females were the least mobile group and adult males were intermediate between the subadult sexes. Adult females were more mobile than adult males but moved less than subadult males; data for these females were available only for three of the five seasonal categories.

The relatively narrow range of movements among the four sex-age classes during the initial winter of capture suggested intracovey relationships coordinated movements among the classes. Observations of winter groups showed that when a covey fed, roosted or moved about their winter range, all members of the covey were involved. Thus one would expect no difference in movements between the sex-age groups. Variations in the magnitude of maximum and mean movements were probably caused by the order in which a covey's members were trapped and marked (first birds captured probably yielded more movements data) as well as the inability to identify every marked member upon covey observation.

Maximum movements by individual partridge during their winter of initial capture did not exceed 677 yd (619 m) during four of five winters. Mean movements by any sex-age group did not exceed 111 yd (102 m) during four of five winters. In both cases, these values were exceeded during the winter of 1971-72, considered to be the severest of the five winters. Only five percent of the 189 marked birds observed or recaptured that winter, participated in these extreme movements; seven of the nine birds involved in long movements belonged to one covey. Apparently adverse weather, possibly combined with winter habitat limitations, prompted the longer movements. Partridge remained within 880 yd, and most remained within 440 yd, of trap sites during mild and average winters.

The lack of statistical significance between group movements and the magnitude of the mean movements to first-spring ranges suggested a majority of the partridge population remained on or very near winter ranges. The most mobile groups were female and male subadults, birds inexperienced at selecting spring range. Subadult males, unable to secure mates on home winter ranges, may travel to disjunct winter ranges to pair. Maximum movements by subadult females were notably greater than by adult females. Subadult females may also move to other winter ranges to find a mate, although males outnumbered females on most winter ranges. Successfully paired subadult females may also move away from winter ranges to find unoccupied nesting cover.

Maximum and mean movements to spring ranges for all sex-age groups, were greatest in the spring of 1972. Matting down of herbaceous vegetation by heavy snowfall the preceding winter could have effected abnormally long movements.

Throughout the summer, both male age groups moved slightly greater distances than female subadults, indicating that females maintained somewhat closer affinity for winter ranges. Subadult males apparently moved over significantly greater ranges during summer than in spring. Males attached to bachelor-male flocks or which were unsuccessful breeders and joined other unsuccessful pairs may have resulted in wider ranging than pair males with young. Data were too sparse for comparing movements among summers.

The limited fall movements data were difficult to interpret. Observations in late fall could have reflected movements toward winter ranges. It is believed that subadult males did move greater distances than adult males between initial winter-capture sites and summer ranges; reasons supporting this belief are the same as those for longer spring movements by subadult males. Additional supportive evidence is the 26 percent subadult males which homed to other than original home winter ranges for their second or subsequent winters.

The greatest movements to second winter ranges were exhibited by adult females, only half of which returned to previous winter ranges.

Subadult females showed the least movements with a total return of this group to initial winter ranges during subsequent winters. Adult males also moved shorter distances to winter ranges and all returned to those previously used.

Subadult males showed the greatest mobility and were the only sex-age group showing continued seasonal range expansion between initial and second winter ranges. This information indicated partridge moving the longest distances to second-winter ranges showed no preference for previous or new winter ranges. Birds traveling the shortest distances to second-winter ranges tended to return to initial winter ranges.

Detailed information of most seasonal partridge movements is lacking in published literature although general and winter movements have been reported. In Wisconsin, McCabe and Hawkins (1946:13-14) observed egress of two coveys to locations off their study area during the winter, 1940-41. Both coveys moved in December and neither returned to the area. Ingress into the study area by unstated partridge numbers was observed during the winter, 1937-38. Since actual distances moved by individual coveys was not reported, these movements could have represented shifting from original to other winter ranges similar to those reported in the current study. Paludan (1963) reported movements of partridge released on Illumø Island, Denmark to the mainland, approximately 1 km over the intervening sea. Twenty-four partridge were liberated in March 1959. Eight days after the release a female was recovered several kilometers away, on the mainland, and a male was found on the mainland beach, 24 km (14.9 mi) from the release site. Pulliainen (1966a), in Finland, observed apparent wandering movements of partridge flocks during the severe winter, 1965-66, which he attributed to difficulty in finding food. Marked birds in the Montana study showed no "wandering movements" even during the most severe winter, 1971-72. Schulz (1974) found maximum winter movements ranged from 0.13 mi (0.21 km) to 0.63 mi (1.0 km) for six coveys in North Dakota.

Mixing of gene pools to maintain diversity of characteristics within partridge populations at low densities on this study area was believed due to individual recognition and bird movements. Pairing data indicated Hungarian partridge are able to recognize close relatives. Such recognition permits mate selection on winter ranges from "non-relative" (at least not close relatives of the previous breeding season) groups. Mate selection in this manner is the mechanism which reduces the probability of inbreeding within local populations. Isolated small populations are probably maintained by the dictates of species survival, even if this involves incestuous mating. As suggested by Petrides (1945), a species limited to this type of mating contributes not only to inbreeding but probably also to demise of the species.

Excess males in late winter populations result in movement of males, primarily subadults, to remote winter range for mate selection. Subadult females probably engage in extensive spring movements only when their initial winter ranges contain an excess of females or insufficient numbers of non-relative males. Their physiological drive to reproduce mandates pairing. Successful pairing and breeding by displaced subadults provides the vehicle for extensive gene pool mixing.

Emigration by entire winter groups to disjunct winter ranges also provides a mechanism for mixing of population gene pools over extensive areas. Effective gene mixing may occur either during the current or the following year. Emigrating adult females have the advantage of the previous year's nest-habitat selection experience and would probably be subordinate only to resident female adults in choosing a nest site. If the previous year's pair-bond is still intact, a female adult's first brood in the new area would retain similar genetic composition to any previous broods. Survivors of this particular brood would then engage in gene mixing their first successful breeding season. Immigrating subadults and unpaired adults would be expected to choose mates from coveys resident on the new area and successful breeding and gene-mixing in this case would occur during the first post-move summer.

While only small segments of populations experience moves to new areas, apparently it is sufficient to assure gene pool mixing of populations over wide areas. The major vehicle for gene mixing over extensive areas is probably annual emigration-immigration during the spring. Severe winter conditions, and winter habitat limitations, which effect covey displacement, occur less frequently.

Winter Ranges

Forty sites on and 6 sites bordering the study area appeared as potential winter ranges for partridge. Twenty-six sites comprised 22 *primary* winter ranges (Fig. 17), ranges occupied by partridge during 3 or 4 of the 4 winters. Seven additional sites formed individual *secondary* winter ranges; they yielded population data during 2 winters. Three sites each provided a *tertiary* winter range (1 winter-use only), 5 sites were not winter ranges and 2 sites were not annually censused.

Winter censuses of the study area revealed 95 coveys with 700 partridge in 1968-69, 43 with 338 in 1969-70, 59 with 412 in 1970-71 and 61 with 501 in 1971-72. The 1969-70 census was considered incomplete due to prevailing mild weather and field conditions. Nonetheless, the data showed a substantial reduction between the first 2 years, followed by increasing winter populations thereafter. Fourteen primary winter ranges, yielding data during all 4 winters, contained 70 coveys with 522 birds, 39 with 298, 37 with 246 and 41 with 351 for these respective winters. Data from these ranges were not minimal until the third winter, indicating the mild 1969-70 winter masked the overall population trend with lesser winter ranges receiving little use by partridge. They also suggested trends in winter populations should be monitored on primary rather than on other winter ranges.

Although primary winter ranges comprised 65 percent of numbers of actual winter ranges, they contained a mean 72 percent of all coveys

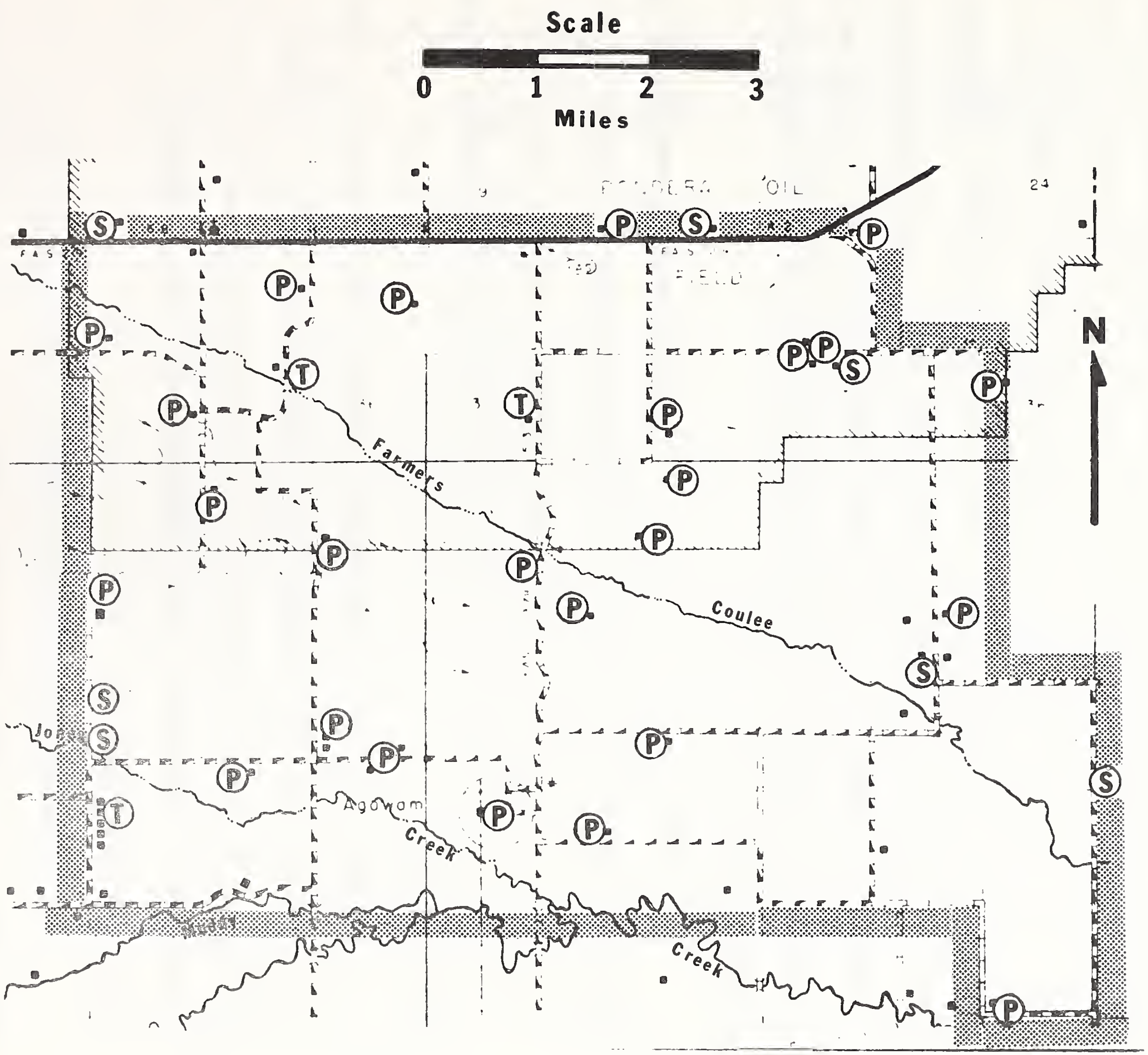


Figure 17. Location of primary, secondary and tertiary winter ranges on the Agawam Study Area.

and of partridge observed on the study area in winter. This further justified their designation as "primary" winter ranges. Only one secondary and none of the tertiary winter ranges contained partridge during the winter of 1969-70 and each of these lesser ranges contained partridge the severe winters of 1968-69 and 1971-72. These data, plus the decline in primary winter range use in a mild winter, suggested that in excess of 28 percent of the study area's partridge population remained dispersed away from winter ranges during mild winters and that secondary and tertiary ranges were used by most of this population segment only in severe winters.

Individual winter ranges for 22 coveys were determined by mapping observation and trap-site locations of bibbed partridge. The coveys were distributed among seven disjunct wintering areas; 1 to 7 coveys occupied each area. One to 11 coveys were represented in any given winter.

Lines connecting the outside points of marked-bird locations were drawn to designate minimum home ranges (Mohr 1947). A second series of lines were drawn between points of observation which excluded peripheral, "unvisited" areas; the outermost lines encompassed "known minimum home ranges."

The mean winter home range size for all coveys was 3.5 a (1.4 ha) (Table 34). The largest mean range, 5.6 a (2.3 ha), for a single winter occurred during the severe winter of 1971-72. The smallest

Table 34. Covey and covey winter range sizes at seven wintering areas, 1968-74.

Location	Winter	Covey No.	No. Birds	No. Locations	Winter Range Size - A (ha) Min.	Known-Min.
Breding, M.	1971-72	8	12	11	0.5 (0.2)	0.4 (0.2)
Klette, M.	1971-72	9	6	6	2,6 (1.1)	-
		10	13	21	11.3 (4.6)	5.2 (2.1)
		11	14	21	11.2 (4.5)	8.1 (3.3)
Rauscher, H.	1969-70	5	6	4	0.6 (0.2)	-
	1970-71	6	11	5	0.5 (0.2)	-
	1971-72	12	13	9	3.5 (1.4)	-
	1971-72	13	7	10	6.4 (2.6)	3.5 (1.4)
	1971-72	14	6	8	13.9 (5.6)	4.3 (1.8)
	1971-72	15	8	5	0.6 (0.2)	-
Rice, D.	1968-69	1	10		1.1 (0.4)	-
	1968-69	2	9		2.2 (0.9)	1.6 (0.6)
	1968-69	3	13		6.1 (2.5)	-
	1968-69	4	5		0.9 (0.4)	-
	1971-72	16	11		4.0 (1.6)	-
	1971-72	17	11		5.9 (2.4)	-
	1973-74	20	10		0.3 (0.1)	-
Rice, P.	1973-74	7	10		1.3 (0.5)	-
Stott, L.	1973-74	21	13		2.8 (1.1)	1.8 (0.7)
Tschantre, J.	1971-72	18	17		0.8 (0.3)	-
	1971-72	19	4		0.6 (0.2)	-
	1971-72	22	15		1.1 (0.4)	-
	1968-69	(4 coveys)	-	Mean:	2.6 (1.1)	-
	1969-70	(1 covey)	-		0.6 (0.2)	-
	1970-71	(1 covey)	-		0.5 (0.2)	-
	1971-72	(11 coveys)	-		5.6 (2.3)	-
	1972-74	(3 coveys)	-		1.7 (0.7)	-
	5-Winter Total	(22 coveys)		Mean:	3.5 (1.4)	-

winter range was 0.3 a (0.1 ha) and the largest was 13.9 a (5.6 ha). The smallest covey, 4 partridge, ranged over 0.6 a (0.2 ha) while the largest, 17 birds, covered 0.8 a (0.3 ha). Both coveys inhabited the same wintering area and individual covey ranges overlapped considerably.

Covey size was not correlated with size of the covey's winter range ($r = 0.085$, $N = 21$, P .05). Winter range size appeared to vary independently of the number of birds in a covey.

A significant, positive relationship ($r = 0.437$, $N = 21$, P .05) was found between numbers of locations mapped for a covey and covey winter range size. A combination of covey size and numbers of locations per covey was tested against covey winter range size; results were intermediate between the first two tests and no significant relationship ($r = 0.297$, $N = 21$, P .05) could be detected.

Known minimum winter home ranges were determined for seven coveys and represented 38-50 percent of the size of individual covey minimum winter ranges. No significant correlation ($r = 0.201$, $N = 6$, P .05) was found between covey size and known minimum winter range size.

In southeastern Michigan, Yeatter (1934:40) reported 20 percent of the winter coveys had cruising radii of not more than 1/8-mi (0.20 km); 50 percent averaged about 1/5-mi (0.32 km) and 25 percent moved up to 1/2-mi. Respective areas included in these circular winter ranges were 31.4 a (12.7 ha), 80.4 a (32.6 ha) and 502.7 a (203.4 ha). In Washington, Yocom (1942:20) thought 75 percent of coveys moved not more than 1/5-mi during the winter. A few coveys had movement radii of 1/2-mi. McCabe and Hawkins (1946:67), in southern Wisconsin, stated winter coveys had an average mobility radius of 1/2-mi; some coveys moved less than 1/4-mi (0.40 km) while others moved more than 1-mi (1.6 km). Winter ranges of 1/4-mi radius encompassed 125.7 a (50.9 ha).

Upgren (1969), in North Dakota recorded the winter home range for a covey of 8 partridge as 150 x 450 yd (137 x 411 m). This range included 12.8 a (5.2 ha). Schulz (1974), also in North Dakota, reported an average winter home range for 6 coveys, each of which included radio-instrumented birds, of 0.21 mi x 0.45 mi (0.34 km x 0.72 km); an average range then comprised 60.5 a (24.5 ha). The smallest home range measured was 0.13 mi x 0.19 mi (0.21 km x 0.31 km) and encompassed 15.8 a (6.4 ha) while the largest home range was 0.25 mi x 0.81 mi (0.40 km x 1.30 km) and included 129.6 a (52.5 ha).

The smallest minimum winter ranges reported for partridge in the United States were larger than the largest such winter range found in the present study. It is possible that either the limited numbers of locations for individual coveys or the limited capacity of individual winter areas on the Agawam Study Area were responsible for the small winter ranges. The interpretative circular home ranges cited in earlier studies undoubtedly included unused areas. This study and those in North Dakota revealed non-circular ranges so exclusion of unused portions would reduce the apparent range sizes.

Spring Ranges

Nine female partridge, four adults and five subadults, were instrumented with radio transmitters during January-February 1974. Each female was released at her original capture site with some of the partridge captured with her. Movements of each female were monitored through late winter and early spring, until their death or until the transmitter unit ceased functioning.

Five females yielded no movements information. One adult was killed by a farm dog and the transmitter on another failed shortly after release. A subadult was apparently killed by a coyote and the fates of two others remain unknown.

Channel 4. This 1+-year-old female was trapped 0915 hrs, 7 February and released in early afternoon the following day. She was located 21 times during 8-16 February (Fig. 18a) and ranged widely to the north and northeast of her winter range (WR); she was located twice on the WR. She was noted southwest of the WR 18-19 February but returned to the north area 19 February. She spent 19-21 February on the northeast area and 25-28 February on the southwest area. Her minimum home range on the northeast area included 46.0 a (18.6 ha), while the known minimum home range was 29.7 a (12.0 ha). Five of 10 locations in this area seemed to indicate an activity center. The distance between the two closest points identifying this center and her WR was 283 yd (259 m). The southwest area minimum home range covered 3.7 a (1.5 ha)

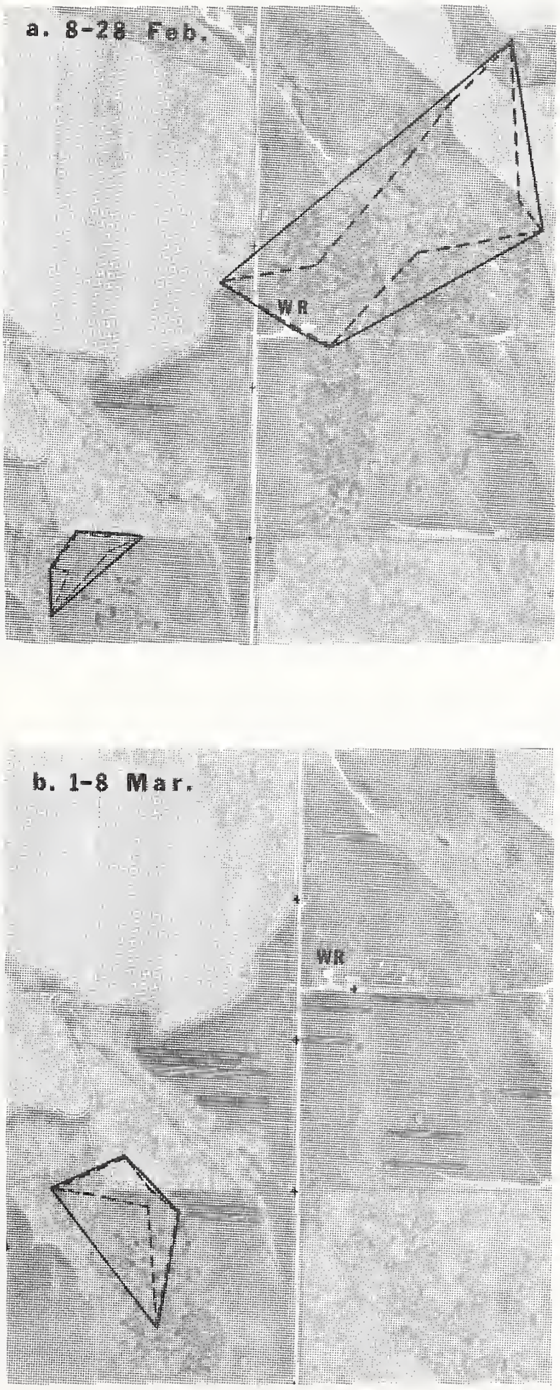


Figure 18. Early spring ranges of a yearling female partridge (Channel 4) during February-March, 1974.

and the known minimum home range was 2.6 a (1.1 ha). The distance between the activity center (4 of 8 locations) of this area and the closest part of her WR was 566 yd (518 m).

Channel 4 remained active in the southwest area 1-7 March. Little movement was noted 8 March. She was found dead near her last active site on 9 March, an apparent victim of harness malfunction. Her crop contained some grain indicating she had fed until shortly before death.

Channel 4's movements yielded 11 locations during 1-8 March, indicating a minimum home range of 11.1 a (4.5 ha) and a known minimum home range of 4.8 a (1.9 ha) (Fig. 18b). The closest point from these ranges to her WR was 601 yd (550 m).

Channel 10. This 1+-year-old female was trapped 0917 hrs, 8 February, instrumented and released 6 hours later. During 8-28 February this female was located 20 times in a minimum home range of 44.8 a (18.1 ha) southwest of her WR; the known minimum home range covered 25.6 a (10.4 ha) (Fig. 19a). The distance from an activity center to her WR was 343 yd (314 m).

Channel 10 remained localized on a minimum home range of 14.3 a (5.8 ha) in the southwest area through 15 March (Fig. 19b). The known minimum home range was 9.3 a (3.8 ha), the edge of which was 182 yd (166 m) from the WR. However, the region within this area in which she was located most frequently was 333 yd (304 m) from her WR.

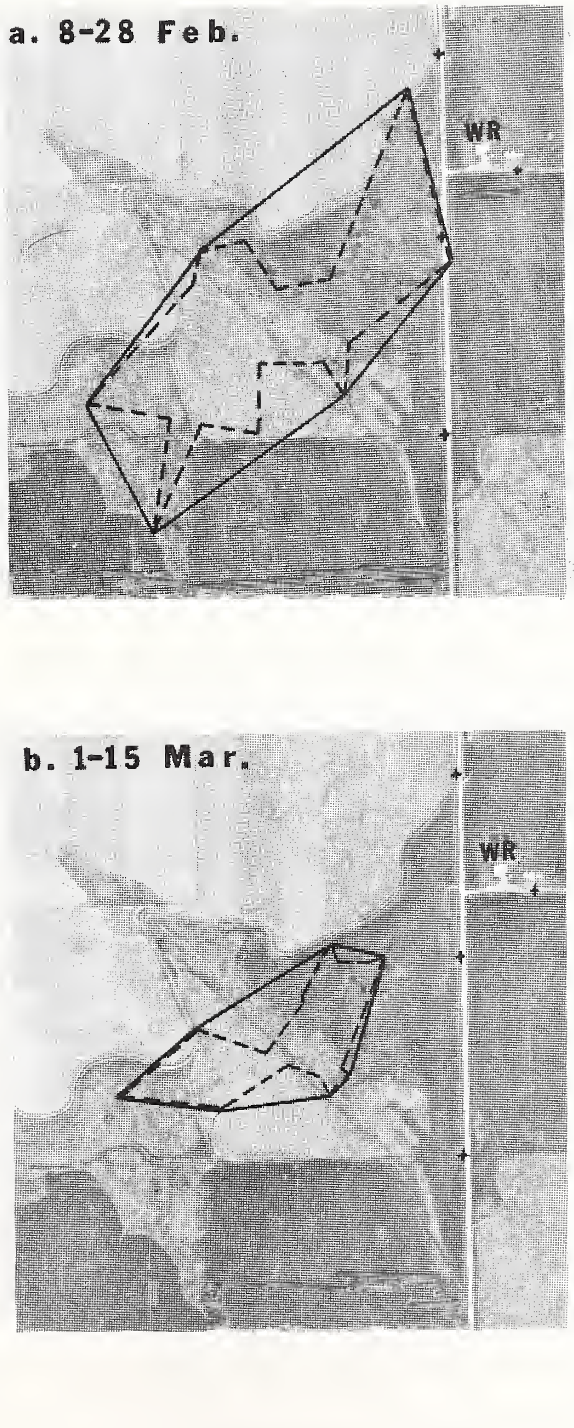
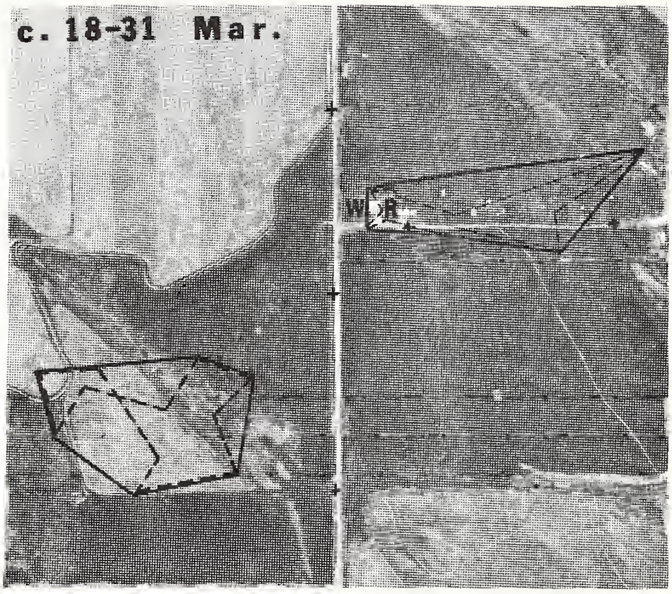


Figure 19. Early spring ranges of a yearling female partridge (Channel 10) during February-April, 1974.



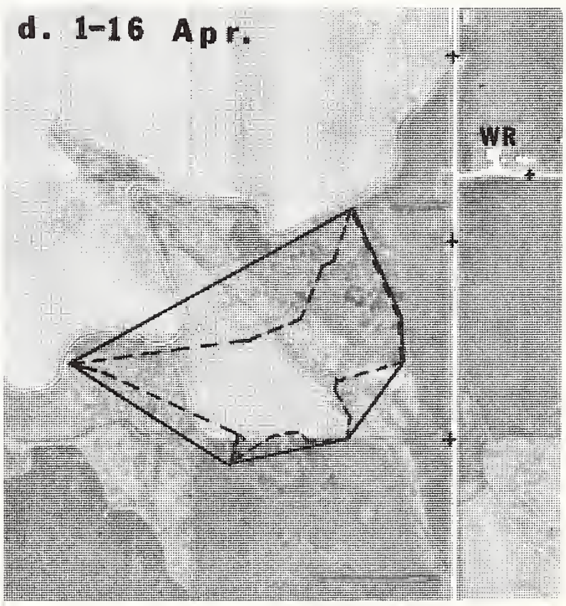


Figure 19. Continued.

During 18-19 March, this female moved back to the WR where she remained until about 24 March. Eleven locations during 19-24 March showed she covered a minimum home range of 10.0 a (4.1 ha) and a known minimum home range of 4.6 a (1.9 ha) (Fig. 19b).

Channel 10 returned to the southwest area by mid-morning, 25 March where she remained through 30 March. Thirteen locations revealed her minimum home range covered 5.4 a (2.2 ha) (Fig. 19b).

Thirty-four locations were obtained for Channel 10 during 1-16 April. During this period her minimum home range included 28.0 a (11.3 ha) and a known minimum home range of 16.5 a (6.7 ha) (Fig. 19c). The closest point of an activity center to her WR was 425 yd (389 m). She remained in the southwest area through 16 April, when the battery in her instrument unit expired.

Channel 1B. This bird was trapped the morning of 7 February, instrumented and released that evening. Eighteen locations were obtained from Channel 1B during February. She remained on her WR 8-13 February, then moved to the north until 16 February when she reappeared in the WR. Between 16 and 21 February she moved southeast of the WR where she remained through the end of February. While in the southeast area, this female covered a minimum home range of 34.5 a (14.0 ha) and a known minimum home range of 21.5 a (8.7 ha) (Fig. 20a). The closest edge of this area to her WR was 995 yd (910 m).

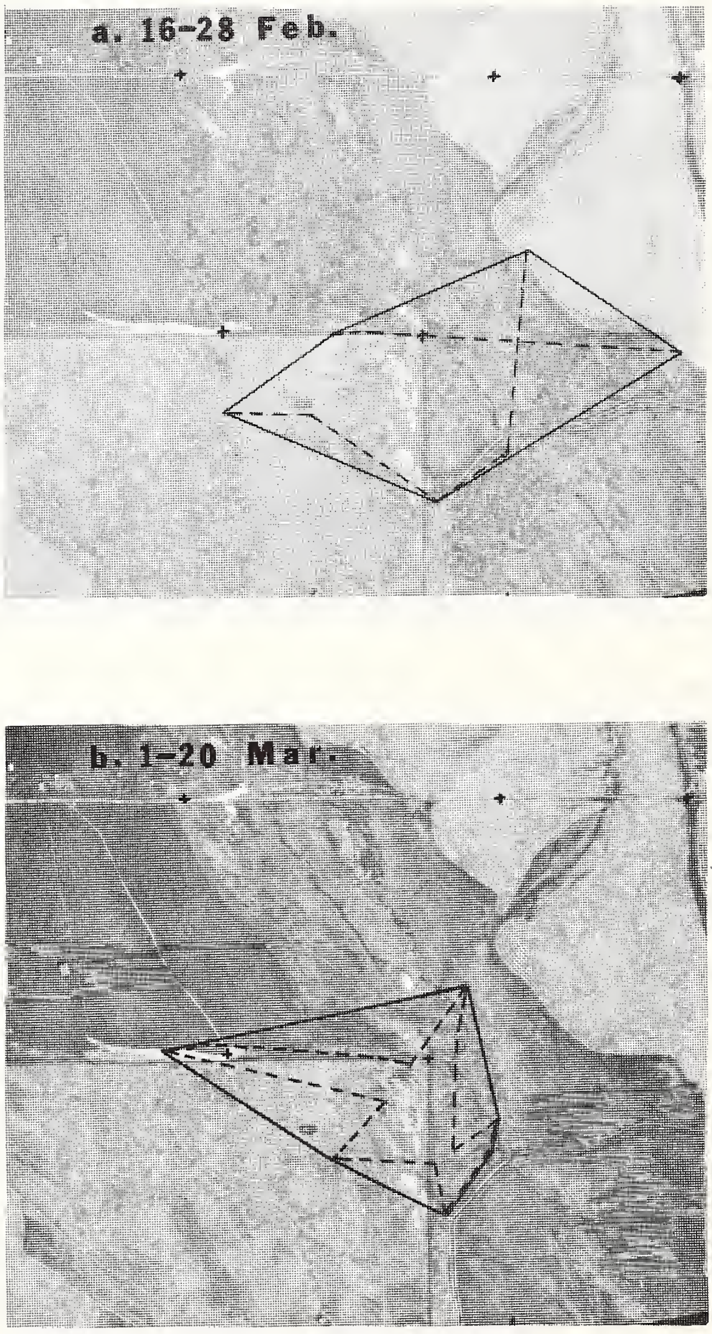


Figure 20. Early spring ranges of a subadult female partridge (Channel 1B) during February - March, 1974.

Twenty-two locations of this bird showed she remained in the southeast area 1-20 March and covered about 24.4 a (9.9 ha) on her minimum home range; her known minimum home range included 11.4 a (4.6 ha) (Fig. 20b). The closest edge of this area was 818 yd (748 m) from her WR. On 20 March she was found dead under 5 in (12.7 cm) of snow in a barley stubble field.

Channel 11. This subadult female was trapped 5 February but was not released until 7 February. Five days after release she was located north-northeast of her WR. She remained in this area during 12-28 February on a minimum home range of 46.7 a (18.9 ha) and a known minimum home range of 27.6 a (11.2 ha) (Fig. 21a). The closest edge of these ranges was 848 yd (775 m) from her initial capture site. Twenty locations were obtained during this period.

During 1-15 March, 26 locations revealed she traversed a minimum home range of 16.8 a (6.8 ha) and a known minimum home range of 10.7 a (4.3 ha) in this same area (Fig. 21b). The closest edge of this area was 596 yd (545 m) from her winter capture site. She continued residence in the north-northeast area 16-30 March but her minimum home range decreased to 11.5 a (4.7 ha) and known minimum home range was reduced to 3.8 a (1.5 ha) (Fig, 21c). She was located 24 times during this period.

Except for single, erratic movements on 6, 12, and 16 April, Channel 11's movements during 1-16 April were confined to a minimum

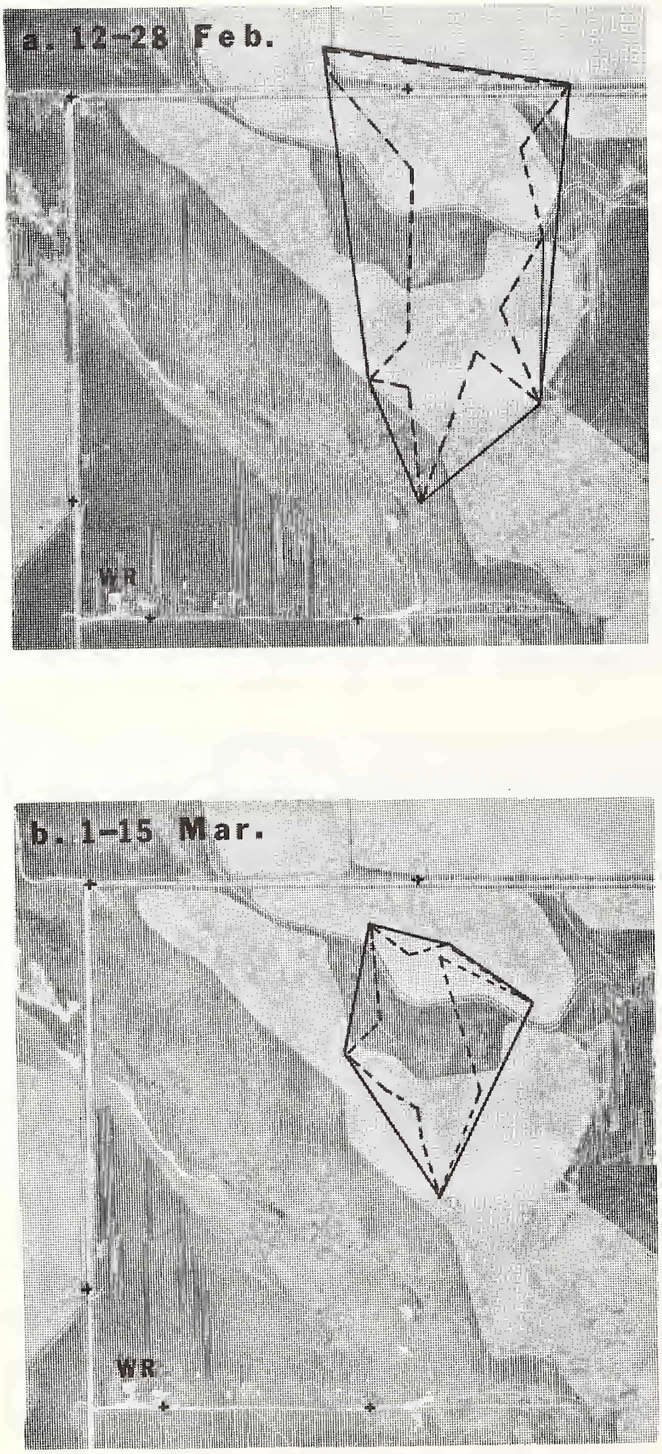
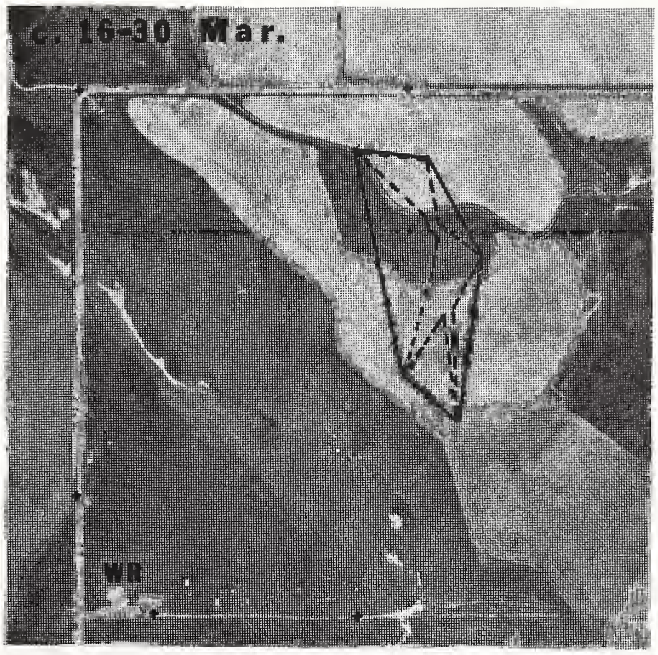


Figure 21. Early spring ranges of a subadult female partridge (Channel 11) during February-April, 1974.



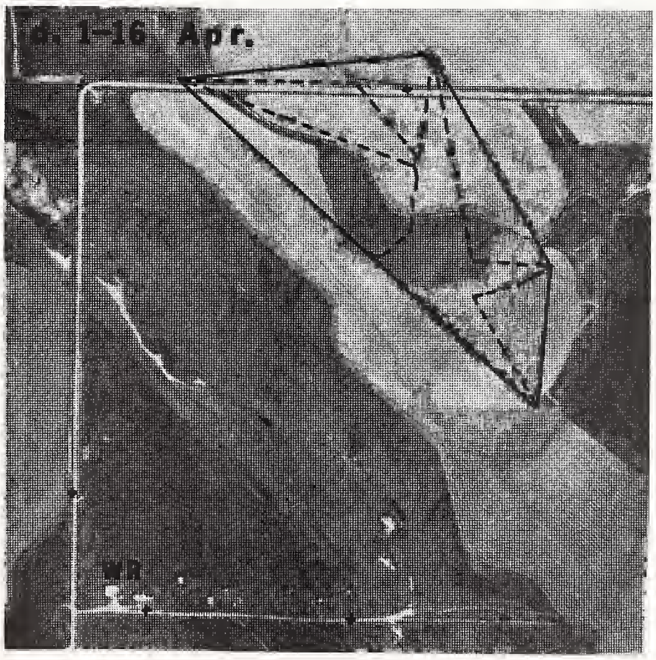


Figure 21. Continued.

home range of 34.2 a (13.9 ha) and a known minimum home range of 13.1 a (5.3 ha) (Fig. 21d). The closest edge of her activity center within this area to her WR was 717 yd (656 cm). Thirty-two individual locations were obtained in April. The battery in her instrument unit expired 16 April.

All of the spring ranges determined for four successfully monitored females were larger than the smallest winter range for an entire covey. Sixty-eight percent of the coveys had winter ranges smaller than the smallest spring range.

Spring ranges of the instrumented female partridge decreased noticeably from 7-28 February to 1-15 March. Ranges of the two adults decreased 87 and 63 percent. Decreases in ranges for the two subadults were 32 and 63 percent. Adult-Channel 10 and subadult-Channel 11, representing the two individuals which survived at least until mid-April, showed the closest agreement in February-early March range size reductions. During the last half of March, adult-Channel 10 frequented two areas, both of which were smaller individually than her early-March range. Subadult-Channel 11 frequented only one area during late March; it was 57 percent smaller than her early-March range. Both birds increased their ranges from late March through the first half of April; adult-Channel 10 increased her range 236 percent and subadult-Channel 11, 282 percent. The early reduction in spring range was interpreted as the localizing of the females into potential nesting areas. This interpretation seemed valid until the first half of April when large range size increases were recorded. Whether both birds lost their mates during early April, vegetation green-up changed potential nest site perspectives, or whether the instrumented birds were displaced from these areas by other territorial birds, is unknown.

Jenkins (1961), in Great Britain, found pairs during February-April in low density populations (> 5a per pair) or on limited visibility terrain had the smallest home ranges. Some pairs remained in a circle of 30 yd (27.4 m) radius for weeks; the area of this circle was 0.6 a (0.2 ha). Pairs in high density populations (< 5a per pair) or in wide visibility terrain moved 400 yd (365.8 m) or more; these early spring ranges included 103.9 a (42.0 ha). While conditions in the current Montana study fitted Jenkin's "wide visibility terrain" description, the partridge population was not considered to be of high density except in a discretely local sense. Spring ranges of the instrumented females were intermediate in size between those posed by Jenkins.

Population Dynamics

Seasonal Densities and Population Trends

Numbers of observations, partridge and broods per mile, obtained during various times of the day were treated separately so that comparable data were used to plot population trends.

Early morning and evening data for July were compared in 1969 and 1971. None of the three indices differed significantly between survey periods for combined study area data in 1969. In 1971, however, birds per mile on the study area and Route B were significantly higher in early morning than evening. Evening data were not included in summer densities. Indices from late morning surveys were incorporated into early morning indices summer densities.

Early morning survey densities in August 1969-73 were significantly higher than those from evening surveys during 2 years on the entire study area and along each route in one or more years. Evening survey data were excluded from summer density calculations. Early and late morning surveys in August 1973 showed no significant differences for indices on the study or along two routes, so late morning data were included in determining summer densities.

Although indices from evening surveys in September 1970 did not differ significantly from early morning indices from three routes, each was significantly less along Route A. The area along Route A supported highest partridge densities so evening data were excluded in determining fall densities. Densities did not differ significantly between early and late morning surveys for the entire area and two routes during September 1973. Late morning data were therefore incorporated into density determinations.

Observations Per Mile

Peak observation densities were recorded during the spring of 1970 and winters of 1971 and 1972 (Fig. 22). A successive decrease in peak densities was noted during the 3-year period; the 1971 peak was 5 percent below that of 1970 and the 1972 peak was 24 percent less than that for 1971.

Minimum observation densities were indicated during the summer, 1969-71. The low densities of 0.09 in 1969 and 0.08 in 1970 and 1971 suggested relatively stable summer densities.

The minimum density in 1970 was 64 percent lower than the peak density; in 1971 the difference was 62 percent. Densities available for 1972 suggested a 50 percent decrease, winter to spring.

Reduction of vegetative cover and the addition of a snow background, yielding more observable partridge groups, were believed responsible for higher observation densities in winter. Spring observations were probably higher than those in summer due to less concealing vegetation and active searching for territories by partridge during spring dispersal.

Partridge Per Mile

Peak annual densities were recorded in winter during 2 of 3 years while annual low densities were recorded in spring during 2 of 3 years (Fig. 22). Winter-spring density declines were 79 percent in 1971 and

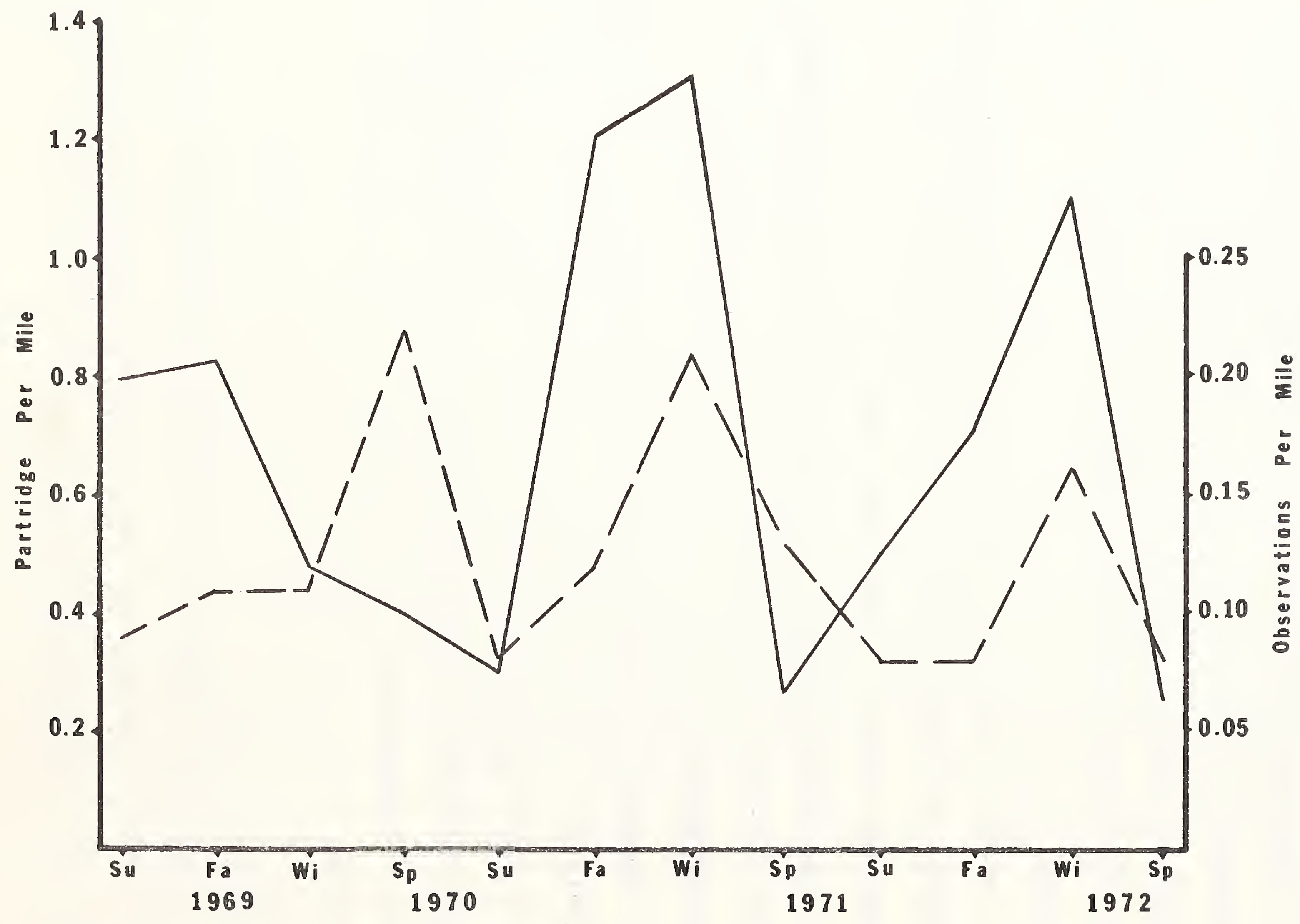


Figure 22. Seasonal partridge population indices on the Agawam Study Area, 1969-72.

and 77 percent in 1972. The fall, 1969 to summer, 1970 decline was 74 percent. Minimum relative densities, perhaps reflecting population security levels, were 0.25-.30 birds per mile.

Middleton (1949), in Great Britain, stated "Careful counting of stock and recording of nests on a number of well-keepered shoots has shown that most areas suffer an extraordinary loss of partridges at pairing time (late January and early February)." He thought documenting the degree of this loss tended to be confused by the shuffling and dissolution of coveys in spring. Winter-to-spring losses noted for 2 years in the current Montana study were almost twice that experienced by partridge populations in Great Britain. Jenkins (1963) postulated late winter decreases in red grouse *(Lagopus lagopus scaticus)* populations were due to expulsion of unestablished (i.e. non territory-owning), surplus birds into "interspaces". Surplus partridge, except for bachelor male flocks, in Montana in spring did not occupy interspaces *per se* but were probably excluded from prime spring territorities and resided in more marginal habitats or emigrated from the study area. Emigration from and immigration to the study area were assumed equal in terms of maintaining the area's breeding popluation. A majority of birds residing in marginal habitats or involved in extensive spring movements were probably removed from the population through predation.

The apparent increase in population density from summer to fall may have resulted from a combination of the following: low recorded population levels in early June and July due to nesting and low visibility of young broods; maximum vegetative cover in June and July; and, the reduction in vegetative cover during late summer and early fall through crop harvests and fallowing of grain stubble. Indicated fall to winter density increases were possibly due to further reduction of vegetative cover in winter, addition of snow and concentration of birds on limited winter ranges.

Population Densities Along Routes

Highest seasonal densities (birds per mile) were recorded along Route A in the western portion of the study area (Fig. 23). Greatest spring and summer densities in all 3 years and in winter during 2 years occurred along this route. Highest fall densities were divided among Routes B, C and D. Lowest fall and winter densities in 2 of 3 years occurred along Routes C and D, respectively.

Summer population indices were compared for individual routes and for the entire study area, 1969-73 (Table 35). The three parameters tested were highly correlated ($r \geq 0.850$, P .05) for each route except Routes B (two indices) and C (one index). These results suggest that either birds per mile or broods per mile in August may be utilized to reflect late summer population trends.

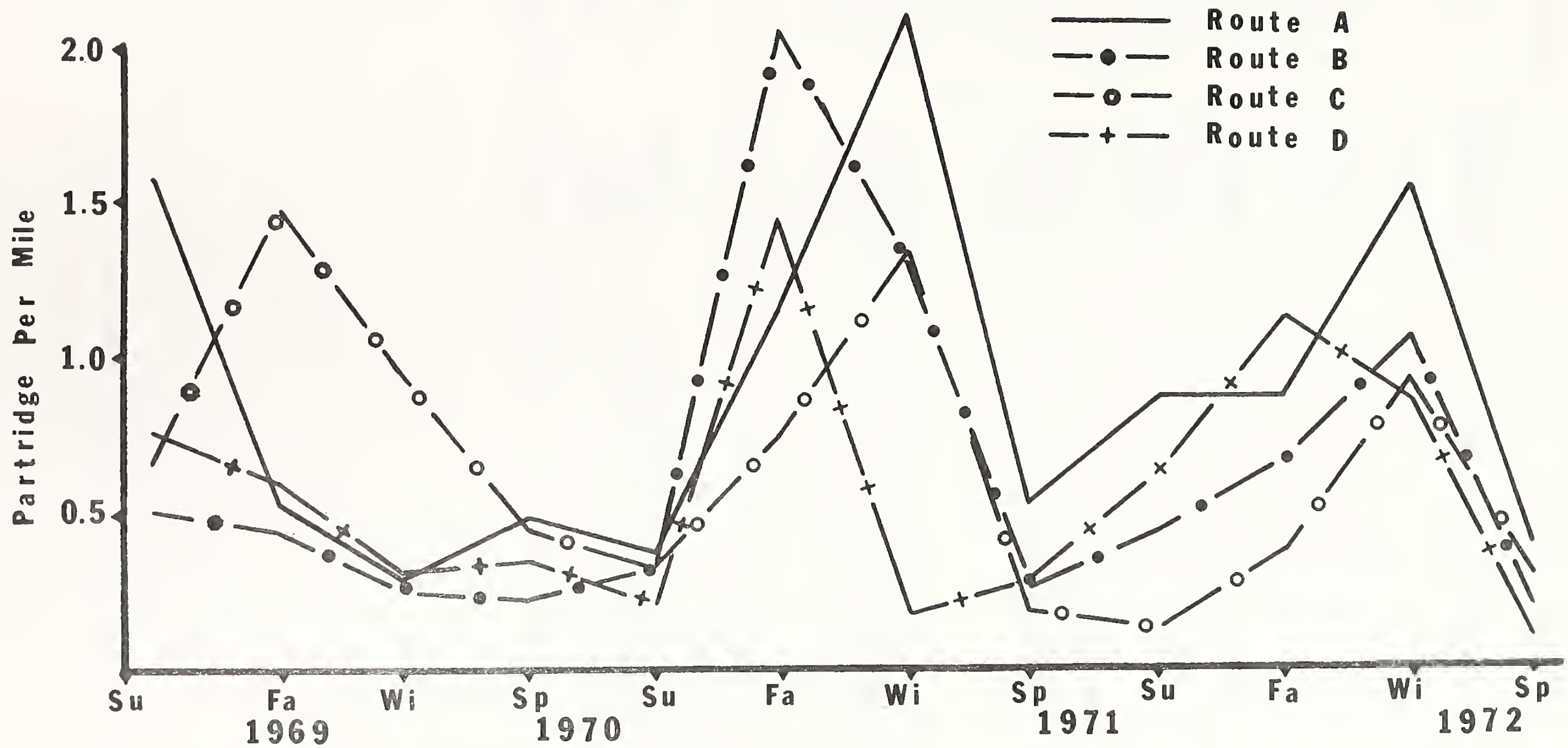


Figure 23. Relative partridge population densities on the Agawam Study Area by route and season, 1969-72.

Table 35. Linear regression comparisons of August, 1969-73, population indices by observation route and all routes combined.

Route	Compared Indices	Correlation Coefficient	Slope	Y-Intercept
A	Observations vs. Birds	0.916	11.082	- 0.054
	Observations vs. Broods	0-892	0.682	- 0.002
	Birds vs. Broods	0.990	0.626	- 0.000
B	Observations vs. Birds	0.626	6.167	0.230
	Observations vs. Broods	0.686	0.583	0.000
	Birds vs. Broods	0.886	0.076	- 0.010
C	Observations vs. Birds	0.875	6.478	0.188
	Observations vs. Broods	0.620	0.360	0.010
	Birds vs. Broods	0.895	0.070	- 0.009
D	Observations vs. Birds	0.965	7.934	0.032
	Observations vs. Broods	0.894	0.722	- 0.002
	Birds vs. Broods	0.967	0.095	- 0.007
Study Area Totals				
	Observations vs. Birds	0.976	11.136	- 0.129
	Observations vs. Broods	0.853	0.727	- 0.008
	Birds vs. Broods	0.944	0.071	- 0.004

Relative density of partridge broods on the study area, 1969-73, was highest in 1969 and lowest in 1970 and 1972. Brood densities were greatest along Route A during 4 or 5 years and lowest in 3 years along Route D.

Productivity

Productivity of the studied partridge population was measured by four indices: number of young per 100 adults; percent of adults with young; mean brood size; and, percent of females with young. Data for each index was determined for 10- or 11-day periods between 1 July and 30 September (Table 36).

Number of young per 100 adults increased throughout the summer with the addition of young into the population. Four years' data for 21-31 July showed 1973 had the highest index (284 young per 100 adults) while no young were recorded in 1971 (Appendix XIV). The highest August index was recorded in 1971 and the lowest was in 1969. September indices were highest in 1970 and lowest in 1969.

The trend for percent of adults accompanied by young compared favorably with that of young per 100 adults. These data implied incorporation of single adults and unsuccessful pairs into family coveys. Percentages from 4 years for 21-31 July revealed the highest percent of adults with young occurred in 1973 while the lowest was in 1971. In August, the highest percentages were recorded in 1971 and

Table 36. Summary of partridge productivity by 10-day periods, 1969-73.

Time Period		Years	Number Birds Observed				Young Per 100 Adults	Adults with Young		No. Broods	Young Per Brood	Hens[1] with Young	
			Males	Females	Unk.-Sex Adults	Young		No.	Percent			No.	Percent
July	1-10	1970-71	12	8	18	11	29	1	2.6	1[3]	11.00	1	12.5
	11-20	1970-73[2]	18	11	25	70	130	9	16.7	5[4]	14.00	2	18.2
	21-31	1969-73[2]	32	18	73	215	175	42	34.1	19	11.32	6	33.3
Totals		-	62	37	116	296	138	52	24.2	25	11.84	9	24.3
August	1-10	1969-73	91	57	148	608	205	154	52.0	61	9.97	33	57.9
	11-20	1969-73	125	73	83	660	235	180	64.1	70	9.43	48	65.8
	21-31	1969-73	123	104	89	706	223	205	64.9	80	8.83	64	61.5
Totals		-	339	234	320	1,974	221	539	60.4	211	9.36	145	62.0
September	1-10	1969-73	106	66	41	528	248	158	74.2	63	8.38	49	74.2
	11-20	1969-73	39	38	20	222	227	66	68.0	25	8.88	19	50.0
	21-30	1970-73[2]	11	9	0	58	290	19	95.0	6	9.67	6	66.7
Totals		-	156	113	61	808	245	243	73.6	94	8.60	74	65.5

[1]Productive status of hens determined at time of observation.
[2]No data for 1972.
[3]One clutch of 11 hatched eggs.
[4]Includes one clutch of 17 hatched eggs.

1973 and the lowest was in 1972. September percentages were highest in 1973 and lowest in 1972.

Mean brood sizes were maximal in July, declined through 1-10 September and increased again through the end of September. While hunting pressure was light in September, increased brood sizes beyond 10 September could have reflected incorporation of adultless young from harvested coveys into family coveys. It may also have reflected some combination of smaller coveys. The greatest mean brood size in July was recorded in 1969 (11.9) while the lowest was in 1970 (10.5). The highest mean brood size in August occurred in 1972 (11.0) and the lowest was in 1971 (8.3). In September the greatest mean brood size was determined for 1972 (10.9) while the lowest occurred in 1969 (5.9).

Porter (1955:104), in Utah, recorded 41 broods, July-September, 1950 ranging from 3 to 21 young and averaging 12.1 young. In southeast Wisconsin, Gates (1973) determined partridge broods in August ranged in means from 4.8 ± 1.6 to 10.6 ± 1.1 young, 1960-65.

The percent of females with young included only data from broods in which a female could be assigned as the female "parent" of the brood. Percent of females with young, 21-31 July, were recorded in only 2 years; 40 percent in 1970 and 36 percent in 1969. Five years' data for August showed the greatest percentage (74) occurred in 1970 and the lowest (52) was in 1973. The highest September index (75) occurred in 1971 with the lowest (57) in 1970. This trend was attributed to progressive hatching of chicks through late summer.

This study indicated veritable total pairing and reproductive efforts by females, thus the maximum percent of hens with young, recorded in late summer, should provide a measure of the pairs successful in producing a brood. Maximum percentages for the five years were: 82 percent during 21-31 August 1969; 80 percent, 11-20 August 1970; 64 percent, 21-31 August 1971; 59 percent, 21 August-10 September 1972; and, 64 percent, 1-10 September 1973.

Westerskov (1957), in New Zealand, found 42 percent of observed partridge nests hatched successfully whereas 66 percent of all hens observed had reared a brood. This compared faborably with 40 percent nest hatching success and a mean 66 percent of hens with young in Montana. Westerskov thought these differences were due to renesting.

Brood Size Reduction

Numbers of young were obtained from 342 complete brood counts during July-September, 1969-73. The mean brood size for July (4 years only) was 11.7 young (Table 37). Utilizing a mean clutch of 15.5 eggs in this study and an approximate mean 92 percent egg-hatching success from Middleton (1935, 1936, 1937), the mean brood at hatching should have contained 14.3 young. The reduction in mean brood size between time of hatching and of observation in July would have been 18 percent. Mean brood sizes were reduced an additional 21 percent between July

Table 37. Reduction in partridge brood sizes between July and September, 1969-73.

	1969	1970	1971	1972	1973	Totals
July						
No. Broods	11	5	2	-	7	25
No. Young	126	59	27	-	80	292
Young per Brood	11.45	11.80	13.50	-	11.43	11.68
August						
No. Broods	37	42	47	27	69	222
No. Young	326	350	458	281	654	2,069
Young per Brood	8.81	8.34	9.75	10.41	9.48	9.20
Change in Mean Brood Size from July	-23.1	-29.3	-27.8	-	-17.1	-21.2
September						
No. Broods	9	31	7	13	35	95
No. Young	56	286	49	142	281	814
Young Per Brood	6.22	9.23	7.00	10.92	8.03	8.57
Change in Mean Brood Size from August	-29.4	+10.7	-28.2	+ 4.9	-15.3	- 6.8
Change in Mean Brood Size, July to September	-45.7	-21.8	-48.1	-	-29.7	-26.6

and August and another 7 percent between August and September. The reduction from time of hatching through September was 46 percent.

Partridge productivity indices in Great Britain, 1933-36, were: mean clutch size, 15.3; mean brood size at hatching, 14.0; and, mean brood size in early August, 8.9 (from Middleton 1935, 1936, 1937). The range in brood size reduction between time of hatching and early August was 28-41 percent annually and the mean was 36 percent compared to 39 in Montana. In Ohio, Westerskov (1949:211) reported 10 coveys contained 123 young at hatching and 104 young at the beginning of the fall hunting season for a loss of 16 percent. Gates (1973), in southeast Wisconsin, found a mean clutch size of 12.5 eggs and an average 8.3 young at least half-grown for a minimum loss of 34 percent.

Brood Size-Adult Relationships

Mean brood sizes of the various adult groups were compared statistically to detect significant differences (P .05). Only broods with complete counts of young were included. Only observations of broods with 1 to 5 adults yielded sufficient data to generate statistical parameters.

Positive correlations were found between mean young per brood and numbers of adults accompanying broods for individual months (Table 38). Mean brood sizes in July showed high significance (r = 0.989) when compared with 1-, 2- and 3-adults. No significant correlation (r = 0.329) was detected between mean brood sizes and numbers of

Table 38. Comparison of partridge brood sizes and adult group sizes by month, 1969-73.

Month	Number of Adults with Brood: 1	2	3	4	5
July					
No. Broods	5	17	4		
Range in Brood Size	3-17	2-18	12-18		
$\bar{X}$ Brood Size	9.60	11.53	15.00		
± Std. Dev.	5.27	4.64	2.45		
August					
No. Broods	18	113	39	38	9
Range in Brood Size	1-18	1-24	1-15	1-20	2-26
$\bar{X}$ Brood Size	9.17	9.81	6.87	10.00	12.56
± Std. Dev.	5.22	4.16	4.53	4.27	8.2
September					
No. Broods	13	44	17	13	5
Range in Brood Size	2-14	3-16	2-15	2-22	3-26
$\bar{X}$ Brood Size	6.38	9.14	7.82	8.31	12.80
± Std. Dev.	4.03	3.69	4.28	4.87	8.41

adults per brood in August. However, although 1-adult broods were not significantly smaller than 2-adult broods (Q = 0.83, df = 129), 2-adult and 4-adult broods were significantly larger than 3- adult broods (Q = 5.26, df = 150, and Q = 4.41, df = 75, respectively) and 4-adult broods were not significantly smaller than 5-adult broods (Q = 1.88, df = 45). In September, brood sizes were significantly correlated with numbers of adults per brood, (r = 0.789), the main difference occurring between 1- and 2-adult broods (Q = 3.28, df = 55).

These data indicated one or more events occurred. Large broods may have resulted from combining of two or more broods and their respective adults, although brood combining occurred infrequently. Large broods may have attracted unsuccessful pairs and/or single adults more than small broods. A third possibility was that chick survival was greater in large than in small broods. The latter two explanations appeared complementary and may have been the most plausible reason for the positive associations. Single adults and/or unsuccessful pairs joining large broods could have benefited chick survival by providing additional adult perception to the group.

Mean brood sizes were compared among adult groups of different social composition. Since all designated adult groups were not represented in July observations, only data in August and September were tested. Comparisons were made among groups within these months to minimize influences of chick mortality. Broods containing a male-only, female-only or an unknown sex adult were combined into a single-parent category; this also aided in increasing the sample for 1-adult broods. Although 2-adult broods were suspected to contain a pair, 2-male broods were identified in the study and 2-female broods could also have existed. Data from these categories were not combined with pair data to avoid biased interpretations. Three-adult and pair-accessory unknown-sex adult brood data were not included for similar interpretative reasons.

The total data (Tables 39 and 40) suggested larger broods were associated with single parents, individual pairs or pair-2 adult groups. The smaller brood size in the pair-accessory male coveys as compared to the pairs-only coveys may have resulted from continuous harassment by the accessory male; this may have lowered egg fertility. A corollary hypothesis might be that accessory males were linked with subadult male-pairs, resulting in more persistent attempts to usurp the equally inexperienced pair-male from his mating role. Two-pair-accessory male broods tended to be larger than most other adult-brood groups. However, only two such broods comprised each month's sample and each was field-judged to contain two broods; they represented the only known brood-combining during the study. Apparently broods at population densities in this area did not unite to any appreciable extent. Porter (1955), in Utah, noted only 2 (5%) of 41 broods had combined into one large group.

Table 39. Comparison of partridge brood sizes and adult group composition, in August and September, 1969-73.

Month	Years	Broods With:							
		Single Parent	Pair	Pair + Access. Male	Pair + Access. Female	2- Pairs	Pair + 2 Males	Pair + 2 Females	2 Pairs + Access. Male
August	No. Broods	18	63	22	5	15	10	2	2
	Range in	1-	1-	1-	1-	2-	1-	10-	11-
	Brood Size	16	17	15	15	17	20	14	26
	$\bar{X}$ Brood Size	9.17	9.25	6.23	7.20	9.27	11.50	12.0	18.5
	$\pm$ Std. Dev.	5.22	4.17	4.40	5.07	3.94	5.25	2.83	10.61
September	No. Broods	30	34	8	7	10	1	0	2
	Range in	2-	3-	2-	6-	2-	-	-	14-
	Brood Size	14	16	13	18	22			26
	$\bar{X}$ Brood Size	8.17	9.50	5.63	10.57	7.80	10.00	-	20.00
	$\pm$ Std. Dev.	4.88	3.83	3.34	4.47	5.49	-	-	8.49

Table 40. Statistical comparison[1] of partridge mean brood sizes and adult group composition, in August and September, 1969-73.

	Pair	Pair + Access. Male	Pair + Access. Female	2 Pairs	Pair + 2 Males	Pair + 2 Females	2 Pairs + Access. Male
August:							
Single Parent	0.10	2.74**	1.06	0.09	1.60	1.05	3.13*
Pair		4.09*	1.48	0.02	2.16	1.30	2.35
Pair + Acc. Male			0.62	3.04*	4.84*	2.55	4.19*
Pair + Acc. Female				1.34	2.14	1.72	2.91
2 Pairs					1.72	1.32	3.70*
Pair + 2 Males						0.18	2.13
Pair + 2 Females							1.18
2 Pairs + Acc. Male							
September:							
Single Parent	1.73	1.96	1.68	0.28	-	-	4.55*
Pair		3.72*	0.93	1.58	-	-	5.04*
Pair + Acc. Male			3.47*	1.39	-	-	5.94*
Pair + Acc. Female				1.56	-	-	3.18***
2 Pairs					-	-	3.80*
Pair + 2 Males						-	-
2 Pairs + Acc. Male							-

[1] Q- values.

* Indicates significance at P .05

** Insignificant Q- value but F-value (3.74) significant at P .20.

*** Insignificant Q- value but F-value (5.05) significant at P .20.

Spring Densities vs. Summer Productivity

Spring densities of partridge, from route surveys, for the entire study area were compared with three productivity indices, 1969-72. The mean percent females with young in August was directly and highly correlated with spring densities (r = 0.996, N = 3, P .01). Mean brood sizes in August and for the entire summer were inversely correlated (r = -0.981, N = 3 and r = -0.857, N = 3, respectively) but only the August indices were significantly correlated (P .05). Errington (1945:12) found summer gains were inversely related to spring densities of bobwhite quail *(Colinus virginianus)*. Jonas (1966) reported summer gains in a Merriam turkey *(Meleagris gallapavo merriami)* population in southeast Montana were inversely related to spring densities. Gates (1973:Table 2) presented spring densities and mean brood sizes for partridge, 1960-65, in southeast Wisconsin. Treating his data statistically, no significant correlation was found between these parameters (r = 0.454, N = 6, P .05); the two indices appeared to operate independently of one another. Gates' data were collected incidental to that for pheasants while this study emphasized partridge ecology.

Effects of Weather

Amounts of precipitation received and temperatures experienced during nesting and early brooding seasons were compared with three productivity indices and times of hatching for each year, 1969-73.

Weather data are summarized in Table 41.

Considerably below normal precipitation and above normal temperatures in April and May, 1969, promoted normal nest initiation and brood hatching. Twice-normal rainfall and normal temperatures occurred in June and 4.27 in (10.85 cm) of rain was received during 24-28 June, 4 days after commencement of the peak hatching week. Minimum temperatures ranged from 43^{o} to 50^{o}F (6.1 to 9.9^{o}C) during this period. Since 25 percent of all broods hatched by 22 June and 50 percent by 26 June, a significant portion of the chicks would have been exposed to the rainy period. The latest brood recorded during 5 summers, hatched 20 August in 1969 indicating some incubated nests were adversely affected in June and renesting occurred. Mean brood sizes approximated 5-year means in July and August but were 31 percent below the 5-year mean for September. Percent of hens with young were 12 and 1 percentage points above respective means for July and August; the September mean was 17 percent below the 5-year average for that month. Young:adult ratios were 41 percent above the 5-year mean for July but were 13 and 41 percent below respective means for August and September.

The 4-month period, April-July, 1970 was the wettest such period in 5 years. Considerably above normal precipitation in April and May with below normal temperatures apparently delayed nesting. Although the peak week of hatching approximated the 5-year average, the first hatching date (11 June) was the latest in 5 years. Only 25 percent

Table 41. Monthly summaries of precipitation and temperatures recorded at Choteau, Montana during partridge nesting and early brood seasons, 1969-73.

Year: Month	Precipitation in Inches (Cm) Normal	Precipitation in Inches (Cm) Departure from Normal	Temperatures in °F (°C) Normal	Temperatures in °F (°C) Departure from Normal
1969:				
April	0.74(1.88)	-0.55(1.40)	42.4(5.7)	+6.1(3.4)
May	2.00(5.08)	-1.18(3.00)	52.0(11.2)	+2.4(1.3)
June	3.07(7.80)	+3.22(8.18)	58.4(14.8)	-0.3(0.2)
July	1.32(3.35)	-0.32(0.81)	66.4(19.3)	-0.1(0.1)
1970:				
April	[1]	+1.33(3.38)	[1]	-4.6(2.6)
May		+1.53(3.89)		+1.7(1.0)
June		-0.29(0.71)		+5.9(3.3)
July		+1.11(2.82)		+1.9(1.1)
1971:				
April	[1]	+0.20(0.51)	[1]	+2.0(1.1)
May		0(0)		+1.7(1.0)
June		-2.24(5.69)		+0.8(0.5)
July		-0.80(2.03)		+0.1(0.1)
1972:				
April	[1]	-0.55(1.40)	[1]	+0.1(0.1)
May		-0.35(0.89)		+0.2(0.1)
June		-0.86(2.18)		+5.2(2.9)
July		+0.41(1.04)		-3.8(2.1)
1973:				
April	[1]	+0.10(0.25)	[1]	-1.7(1.0)
May		-1.25(3.18)		+3.0(1.7)
June		-2.33(5.92)		+3.6(2.0)
July		-0.95(2.41)		+2.6(1.5)

[1] Normal precipitation and temperature records were the same for each year.

of all broods hatched prior to 24 June (near the end of the peak week) and it was 3 July before 50 percent of the broods hatched. Mean brood sizes were 1 percent below the 5-year mean in July and 11 percent in August; mean brood size in September was 11 percent above the 5-year mean for that month. Proportions of hens with young were 3 percentage points below the July mean, 12 above the August mean and 9 below the September mean. Young:adult ratios were 33 percent below the mean for July but were 7 and 18 percent above the respective August and September means. Precipitation in June was 9 percent below normal but was 84 percent above normal in July. Except for 1.00-in (2.54-cm) rain received 28-29 June, no precipitation was received between 19 June and 8 July. Apparently rainfall during the 2 days in June adversely affected chick survival but renesting efforts started earlier in June and resulted in the overall above-normal production in 1970.

April-July, 1971 was the second driest of these 4-month periods. Rainfall in April was about 25 percent above normal and normal rainfall was received in May. Both months experienced slightly above normal temperatures. Earlier-than-normal nesting occurred in 1970 and the peak week of hatching was 10 days early. One-fourth of the broods hatched by 11 June and one-half by 17 June. Precipitation in June and July was 73 and 60 percent below their respective monthly means. Daily precipitation in June did not exceed 0.29 in (0.74-cm) and total rainfall was distributed over 12 days. Mean brood sizes were above 5-year means in July (+14%) and August (+5%). The indicated 24 percent decrease from the 5-year-mean brood size in September was probably the result of only six brood observations during the month. Proportion of hens with young was 10 percentage points below the 5-year mean in July was 6 and 9 points above the August and September means, respectively. Young:adult ratios for each month revealed no interpretative patterns. Precipitation received this spring did not seem to interfere with nesting activities, the dry early brooding period favored chick survival and the result was above normal chick production.

Although April-July, 1972 was intermediate in precipitation, rainfall in each of the first 3 months was below normal. Temperatures were normal in April and May but were 9 percent above normal in June. The earliest hatching brood in 5 years was recorded in 1972. The peak week of hatching was 4 days earlier than the 5-year average and the greatest proportion (35%) of broods hatching in a peak week occurred in 1972. Twenty-five percent of all broods hatched by 9 June and 50 percent hatched by 16 June. The earliest last-hatching brood was also noted this year. No population surveys were conducted in July. Mean brood size in August was 18 percent above the 5-year August mean; the September mean brood size was 27 percent above that month's 5-year mean. Brood sizes were the largest in 5 years for these respective months. Proportions of hens with young in August and September were 6 and 1 percentage points above their respective monthly 5-year means.

Young:adult ratios in August and September were -9 and +5 percent from their respective monthly means. Apparently the below normal precipitation in spring and early summer; combined with normal temperatures, resulted in the most successful production season in 5 years.

April-July, 1973 was the driest such 4-month period in 5 years; rainfall was 62 percent below normal for this period. However, precipitation in April was 14 percent above normal. Temperatures in April were slightly below normal while they were slightly above during the other 3 months. The peak week of hatch was 2 days earlier than the 5-year mean and the lowest proportion of all broods (25%) hatched during this week. The second, earliest hatching brood and second, latest hatching brood were recorded in 1973. Monthly mean brood sizes, July-September, did not differ substantially from 5-year means. No females were identified in July; proportions of females with young were 11 and 7 percentage points below monthly means for August and September, respectively. Young:adult ratios were 70 percent above the monthly mean in July and 6 and 5 percent below respective August and September means. These data suggested a longer than normal hatching season. Field conditions were extremely dry during this summer; soil moisture was low as a result of low precipitation during late 1972 and early 1973. Effects of this drought on farming activities will be examined later; it seemed there was additional and continuous disruption of nesting activities in 1973.

Twomey (1936) proposed the use of climographs in evaluating the relationship of animals to their environments. Natural factors employed in examining an animal's range or distribution were monthly mean temperatures and amounts of precipitation received during a 1-year period. He presented a climograph for Hungarian partridge ranges in Europe and in Havre and Great Falls, Montana (cf his Fig. 2); these climographs and that for Choteau are reproduced in Figure 24. They suggest that part of the reason for successful partridge establishment in north-central Montana is that with minor exceptions climatic regimes are within those of optimum European partridge range.

In southeastern Michigan, Dale (1941) reported mean June-July precipitation was 82 percent of normal (9.98 in or 25.35 cm) during 1916-29 when partridge were becoming established in that area. Sixty-five percent of normal precipitation during these months, 1930-39, resulted in noticeable increase of partridge while normal or above summer precipitation, 1937-39, resulted in partridge decreases. Mosely (1947), in northern Ohio, reported partridge became rare following wet springs, 1943-45.

In Great Britain, Middleton (1950) stated: "There are indisputable figures, from counts and records accumulated over many years, which show that far more than half of all partridge chicks never reach the first of September, and the primary factor controlling their survival is weather in June and early July -- or the first three weeks of

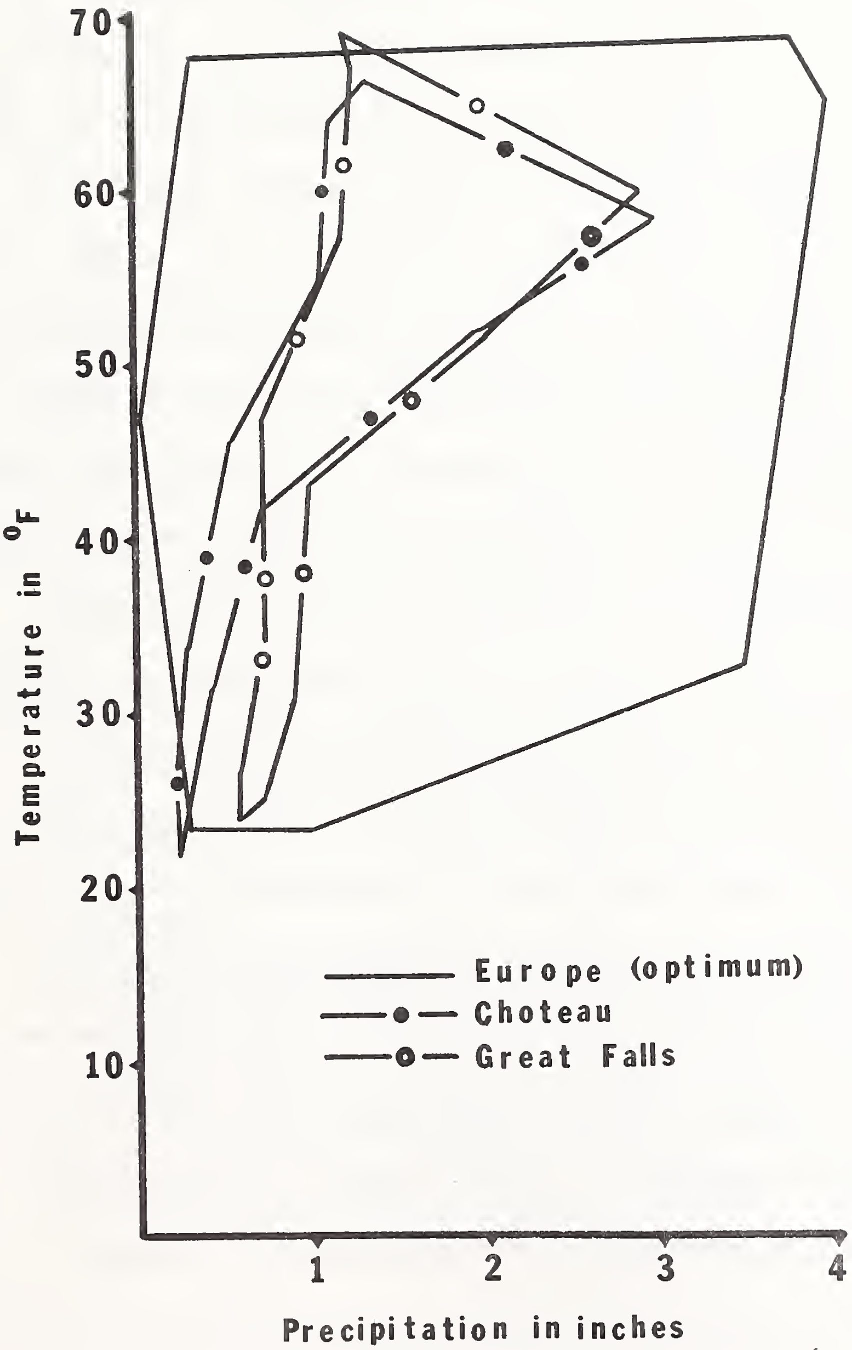


Figure 24. Climographs for Hungarian partridge ranges in Europe and for Choteau and Great Falls, Montana.

hatching." He noted that if the sunshine recorded during June and July is below 350 hours "a good partridge year is almost impossible, while anything over 450 hours is equally certain to result in a high production of young birds...". Matheson (1953), in Wales, cited 1879 as having the worst annual partridge harvest on three of eight estates for which partial or total records were kept, 1793-1933; total summer precipitation exceeded that of any other year and temperatures showed the lowest overall mean. He contrasted this with notably high partridge bags in 1887; rainfall during May-July that year was 72 percent below normal.

Findings of the Montana study generally agreed that weather conditions, particularly amounts of precipitation, in late spring-early summer influenced partridge production. A dry spring results in early nesting which yields above-average production unless heavy and/or prolonged rainfall is received during the first 3 weeks after peak hatching periods. The latter conditions will effectively reduce anticipated population gains. Above-average precipitation in April will probably delay or interfere with early nesting but low precipitation received during post-hatching will permit greater chick survival and reasonably good, overall production. Heavy rainfall during nesting and hatching probably precludes any reasonable degree of successful production for that year.

Mortality

Attempts were made to locate and examine partridge which died on the study area. The majority of the birds subsequently handled resulted from hunter harvests (Table 42). Reduction in numbers and proportions of partridge in annual mortalities due to hunting, 1973 and 1974, were attributed to reduced hunting pressure on the study area.

Collections of partridge for determination of mercury levels in the birds, 1969-70, and for food habits data, 1973-74, resulted in the second-largest known mortality factor. Collisions of partridge with motor vehicles along roads accounted for 89 percent of the accidental deaths recorded. One bird died apparently due to collision with a utility wire and another after hitting a shrub.

Eight of 15 trap casualties were the result of attacks by other partridge in the traps. Complete scalping, sometimes midway down the dorsal neck, was characteristic in these cases. Domestic dogs and cats killed six birds in traps. One bird was killed by harassment by an unknown predator.

Five of eight partridge succumbing to predators were killed by raptors; prairie falcons *(Falco mexicanus)* killed 2 birds and one each were killed by a female marsh hawk *(Circus cyaneus)*, a rough-legged hawk *(Buteo lagopus)*, and an unknown raptor. Unknown causes of death resulted from location of heavily scavenged bird remains or the retrieval of already dead partridge by farm dogs.

Paludan (1963), in Denmark, found 9 percent of 399 marked partridge recoveries died from accidents and predators; dogs and cats

Table 42. Known partridge mortalities on the Agawam Study Area, 1969-74.

Year	Hunters No.	Hunters %	Collections No.	Collections %	Accidents No.	Accidents %	Trap Casualties No.	Trap Casualties %	Predators No.	Predators %	Unknown No.	Unknown %	Totals No.	Totals %
1969	39	73.6	5	9.4	1	1.9	2	3.8	4	7.5	2	3.8	53	100.0
1970	48	57.8	22	26.5	5	6.0	3	3.6	2	2.4	3	3.6	83	99.9
1971	45	81.8	0	-	4	7.3	5	9.1	0	-	1	1.8	55	100.0
1972	19	67.9	0	-	3	10.7	4	14.3	1	3.6	1	3.6	28	100.1
1973	4	18.2	15	68.2	2	9.1	0	-	0	-	1	4.5	22	100.0
1974	9	22.5	22	55.0	3	7.5	1	2.5	1	2.5	4	10.0	40	100.0
Total	164	58.4	64	22.8	18	6.4	15	5.3	8	2.8	12	4.3	281	100.0

had killed 6 percent. Five percent of the accident victims had collided with utility wires while 1 percent were traffic fatalities.

Only 7 percent of 484 banded partridge were recovered during the study (Table 43). The largest recovery was by hunters, 3 percent of the total banded birds afield. A high rate of band returns by hunters was anticipated due to the novelty of banded birds in the area and local interest in the study. In Denmark, Paludan (1963) determined 60 percent of 399 partridge bands were recovered by hunters. Trap casualties were a second major mortality factor in Montana but represented only 1 percent of the total birds banded. Mortality due to natural or unrecorded artificial factors (hunting and trapping excluded) accounted for 96 percent of the total birds banded and a disproportionate 34 percent of the bands recovered.

Hunting and Harvests

Partridge hunting during the current study included two fall seasons annually; the first coincided with that for sharptails and the second ran concurrently with that for pheasants. Season lengths for partridge were 52.5 days in 1969 and 1970, 73.5 days in 1971 and 65.5 days in 1972 and 1973. Daily bag and possession limits were 6 and 12, respectively.

Partridge on the study area were harvested by hunters incidentally to the more popular sharptails and pheasants; a total of five partridge-only hunters were interviewed during 4 years. Since the area contained

Table 43. Fates of banded partridge as determined by band recoveries, 1969-74.[1]

Year Banded	No. Banded	Number and Percent of Recoveries										Total Final Recoveries	
		Hunters		Trap Casualties		Predators		Accidents		Unknown			
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%[2]
1968-69	141	6	46.1	2	15.4	3	23.1	0	-	2	15.4	13	9.2
1969-70	35	4	66.7	1	16.7	0	-	0	-	1	16.7	6	17.1
1970-71	69	1	100.0	0	-	0	-	0	-	0	-	1	1.4
1971-72	239	4	33.3	3	25.0	2	16.7	2	16.7	1	8.3	12	5.0
Totals	484	15	46.9	6	18.8	5	15.6	2	6.3	4	12.5	32	6.6

[1]None banded 1972-73; band records from 1973-74 not included due to termination of field work in 1974.
[2]Percent of total banded.

only small, local sharptail populations, it attracted few hunters during sharptail/partridge seasons. Resident landowners stated the area was historically popular for pheasant hunting. They remembered up to 30 hunting parties along one 4-mi (6.4-km) road segment on opening day of pheasant seasons in the mid-1960's.

Roads on the study area were traveled during opening weekends of the 1969, 1970 and 1971 grouse/partridge seasons. Hunting parties and numbers of hunters interviewed ranged from 4 to 5 and 6 to 10, respectively. The combined species harvest ranged from 0.4 to 3.0 birds per hunter per day and 0.7 to 3.0 hours were expended to harvest each bird. Post-opening weekend field checks yielded little additional harvest data.

Aerial survieys were conducted to document hunter density on the study area during the opening hour of the opening day of the 1969-71 pheasant/partridge seasons. Hunter density was also recorded about 1 hour after sunrise on second days of the 1970 and 1971 seasons. Hunters were counted by an assistant in a truck during the opening 1½ hours on opening days, 1969-71. Due to the close agreement in numbers of hunting parties and of hunters found between the surveys, a ground-only survey was conducted in 1972 (Weigand 1973a).

Hunter densities on opening days increased from 0.5 to 1.1 hunters per square mile, 1969-71, and decreased to 0.2 hunters per square mile in 1973. A declining pheasant population, 1971-73, and coincidental openings of general big game and pheasant/partridge seasons, 1973-74, were considered major factors in reducing bird hunting pressure.

Hunter density decreased from opening day to the following morning each season. Reductions of 59 and 73 percent were recorded in 1970 and 1971, respectively.

Field interviews with hunters on opening weekend provided information on hunting success, 1969-73 (Table 44). Second-day data in 1972 reflected hunting on a partial-holiday rather than a Sunday. Numbers of hunters and hunting success were so low opening day, 1973, no field survey was conducted the second day although it also was a partial holiday.

Ninety-five parties, totaling 245 hunters, were checked during opening weekends, 1969-72. They expended 748 hours in harvesting 35 partridge and 195 pheasants, or 3.3 hours per bagged bird. Hunters were most successful in 1970 and the least in 1973.

Teton County residents comprised 25 percent of hunters checked during opening weekends, 1969-72 (Weigand 1973a). Cascade and Pondera Counties, which border Teton County, contributed an additional 28 percent of the hunters. Hunters traveled up to an estimated 196 mi (315 km) to hunt on the study area.

Partridge wings collected from hunters each fall in northcentral Montana, 1962-72, showed production ratios ranged from 247 to 503

Table 44. Hunting success on the Agawam Study Area during opening weekends[1] of the 1969-73 pheasant/partridge seasons.

Dates	Number Parties	Number Hunters	Number Hours	Birds Bagged Partridge	Birds Bagged Pheasant	Hours per Bird	Birds per 100 Hunters
1969							
Oct. 25	18	35	127.5	2	41	3.1	117
Oct. 26	11	29	121.0	8	26	4.7	90
Totals	29	64	248.5	10	67	3.7	105
1970							
Oct. 24	12	37	77.0	4	37	1.9	111
Oct. 25	12	35	66.5	11	27	1.8	109
Totals	24	72	143.5	15	64	1.8	110
1971							
Oct. 23	17	49	173.0	7	44	3.4	101
Oct. 24	11	27	95.0	0	8	11.9	30
Totals	28	76	268.0	7	52	4.5	78
1972							
Oct. 22	12	27	80.0	2	11	6.2	48
Oct. 23[2]	2	6	8.0	1	1	4.0	33
Totals	14	33	88.0	3	12	5.9	45
1973							
Oct. 26	3	7	13.0	0	1	13.0	14
4-Year[3] Totals and Means:							
1st Day	59	148	457.5	15	133	3.1	100
2nd Day	36	97	290.5	20	62	3.5	85
Totals	95	245	748.0	35	195	3.3	94

[1]Season opened on Sunday, 1972 and 1973.
[2]Veteran's Day (holiday).
[3]1973 data omitted.

juveniles per 100 adults (Weigand, 1973c). Data for the current study years plus northcentral Montana data for 1973 and 1974 (Weigand, 1975) are reproduced in Table 45. None of the production ratios showed meaningful statistical significance between adjacent years. Percent juveniles in fall harvests in northcentral Montana averaged 74 percent (range, 71-77%) during 1969-74. This mean corresponded very closely to the 5-year mean of 73 percent subadults in winter, marked bird samples from the study area.

Table 45. Hungarian partridge production ratios from northcentral Montana[1] as determined from hunter-submitted wings, 1969-74.

Year	Number Birds			Juveniles Per		
	Juveniles	Adults	Total	100 Adults	x^2-value[2]	P
1969	310	114	424	272	-	-
1970	177	63	240	281	0.008	.93
1971	198	80	278	247	0.295	.51
1972	229	78	307	294	0.678	.42
1973	235	81	316	290	0.745	.98
1974	438	132	570	332	0.553	.46

[1]Includes 11-1/2 counties.
[2]Includes continuity correction factor.

Production ratios from limited samples of partridge harvested in Teton County ranged between 100 and 280 juveniles per 100 adults (Table 46). Statistical significance ($P \leq .10$) between ratios of adjacent years was found for 2 of the 5 comparisons. Percent juveniles in Teton County harvests ranged from 35 percent in 1973 to 74 in 1972; the 6-year mean percent was 60 and differed noticeably from the mean 73 percent subadults in marked bird samples on the study area. Fifteen (25%) of the adults harvested on the study area were winter-marked birds.

Table 46. Hungarian partridge production ratios from Teton County and the Agawam Study Area[1] as determined from hunter-submitted wings, 1969-74.

Year	Number Birds Adults	Juveniles	Total	Juveniles Per 100 Adults	x^2-value[2]	P
1969	25(15)[1]	38(23)	63(38)	152(153)	-	-
1970	16(14)	44(32)	60(46)	275(229)	1.794	.18
1971	34(25)	47(19)	81(44)	138(76)	2.892	.09
1972	5(5)	14(14)	19(19)	280(280)	0.996	.32
1973	17(0)	9(0)	26(0)	189(-)	5.233	.02
1974	5(0)	5(0)	10(0)	100(-)	0.218	.64

[1]Numbers in ( ) apply to Agawam Study Area.
[2]x^2 for Teton County only; includes continuity correction factor.

Agreement between regional and study area production ratios and disagreement between Teton County and study area ratios may be explained by intensity and areas of sampling. The study area partridge population was trapped each winter as intensively as field conditions and work schedule permitted. The area attracted relatively few hunters and the annual known harvest was 19 to 46 birds from populations of 500 to 800 resident partridge. Harvests could have occurred in areas containing no marked birds. Wing samples from Teton County could have been from only a few areas, with no samples from some populations or habitat types. Wing samples from northcentral Montana appeared sufficiently large that most habitat types were sampled even though some populations probably were not. Larger wing numbers from annual hunter harvests on the study area and from Teton County would be necessary to minimize non-representation of local populations and habitat types in fall samples.

The proportion of a partridge population harvested by hunters was obtained by comparing band recovery data with production ratios reflected in marked winter populations and fall harvests. Banded partridge surviving to succeeding hunting seasons would all be adults; hunters harvested 3 percent of this group. Three assumptions were made: there was minimal or no marker loss between time of marking and time of harvest; marked and unmarked birds were equally vulnerable to mortality factors; and, marked and unmarked birds were randomly mixed within the social structure of local populations. It is doubtful random mixing of marked birds occurred over the entire area's population due to restricted movements of the birds. Since 27 percent of average winter populations on the study area and 6 percent of regional fall harvests were adults, there was only 1 percent difference in proportions of adults or juveniles between these seasonal populations. The proportion of juveniles harvested, although only 7 were marked and none were recovered by hunters, should have approximated that of adults. If proportions of adult and juvenile segments were harvested at equal rates, hunters harvested 3 percent of the partridge population.

Production ratios were obtained from partridge harvested by hunters in Teton and three adjacent counties. The combined county ratios for each year, 1969-72 showed a decrease between September and October but there was an increase from October to November (Table 47). The 241 juveniles per 100 adults recorded in November was only slightly greater than the 233:100 ratio obtained for September-October combined data. These results suggest greater juvenile vulnerability to hunting in September than October but by November, juveniles are no more vulnerable than adults.

Distribution of partridge harvests within annual hunting seasons in northcentral Montana were determined from information submitted by hunters via the statewide wing-envelope survey. Data from 1,197 wings, 1969-73, revealed 18-41 percent (mean 31%) of any given season's

Table 47. Vulnerability of partridge sex-age groups to hunting[1] in four northcentral Montana Counties[2], 1969-72.

Month	Year	Males		Females		Unk. Sex		Total	Juv. per
		Ad.	Juv.	Ad.	Juv.	Ad.	Juv.	Birds	100 Adults
September	1969	5	13	5	10	1	14	48	336
	1970	9	17	7	12	4	30	79	295
	1971	14	32	18	23	3	29	119	240
	1972	8	30	12	28	1	11	90	329
	Totals	36	92	42	73	9	84	336	286
October	1969	9	15	8	4	3	5	44	120
	1970	5	9	2	6	4	8	34	209
	1971	8	15	13	11	3	9	59	146
	1972	1	8	4	3	-	-	16	220
	Totals	23	47	27	24	10	22	153	155
November	1969	5	12	8	15	-	3	43	231
	1970	2	3	-	4	-	5	14	600
	1971	5	1	-	1	-	-	7	40
	1972	2	6	-	3	-	-	11	450
	Totals	14	22	8	23	-	8	75	241

[1]Data from wings submitted by hunters in the statewide wing-envelope survey plus season-long field checks.
[2]Teton County plus 3 adjacent counties: Cascade, Chouteau and Pondera.

harvest occurred during the opening weekend (Fig. 25). Seventy-five percent of the average season's harvest occurred by the third or fourth week of annual, 10-week seasons. These periods generally coincided with hunting season lengths of several counties' seasons on sharp-tailed grouse. Less than 16 percent (range, 3-16%) of partridge bagged in any given year were taken during the pheasant season; pheasant hunting opened the sixth week of partridge hunting each year.

Weigand and Janson (1976) reported over 60 percent of hunter pressure and more than 70 percent of annual pheasant harvests occurred the first week of pheasant seasons in Montana. Ninety percent of 1969-73 partridge harvest levels could have been attained by closing hunting of partridge after the first week of the pheasant season. In Wisconsin, Hickey and McCabe (1953) found 20 percent of 298 partridge were harvested the first 2 days of a 29.5-day season. Seventy-five percent of this harvest was reached between the third and fourth weeks of the season.

Winter Mortality

Changes in the sizes of 38 winter coveys were documented from subsequent observation or recapture of bibbed with other partridge and from intra-group coefficients of association. A minimum contact period of 5 days was established for this comparison; two groups were contacted periodically for maximums of 64 days each. Since intracovey membership is close, a member's disappearance strongly suggested its demise; it was unlikely this member successfully joined another winter group.

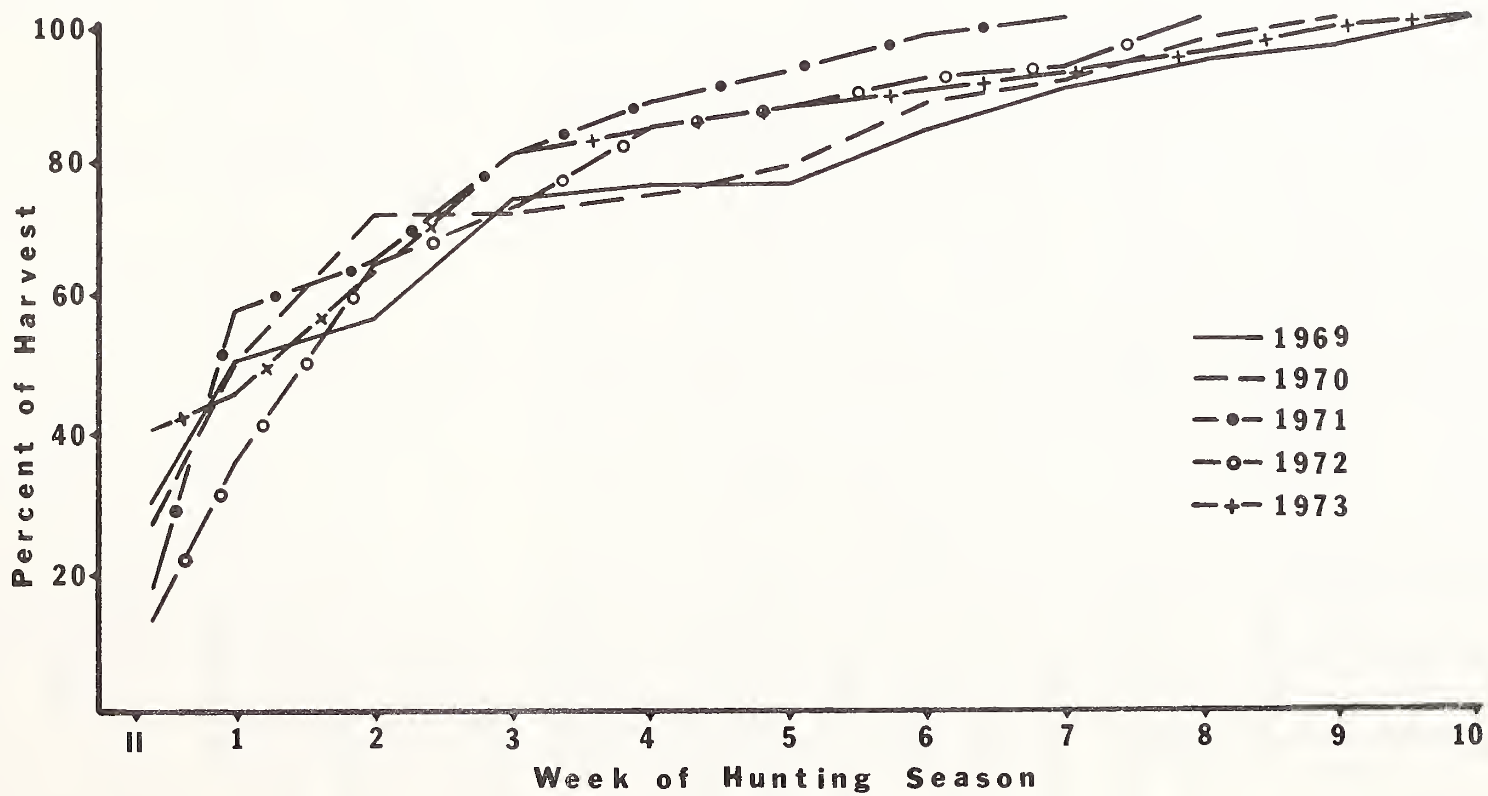


Figure 25. Annual partridge harvest chronology, by week, in north-central Montana as determined from the upland game bird wing envelope survey, 1969-73.

Reduction in this identifiable portion of the population averaged 16 percent from late December until group dissolution prior to pairing in late February-early March (Table 48). This loss averaged about 8 percent per month during the severest weather period of the year. Eleven groups (37%) lost none of their members; a maximum loss of 43 percent was recorded for one group. No obvious relationship was noted between group size and the proportion of the group lost.

Winter losses expressed from mean covey sizes revealed a different loss rate. Mean size of 62 coveys in November was 10.8; in December there were 8.4 birds per covey, 7.8 in January and 5.9 in February. Respective month-to-month losses were 23, 7 and 24 percent, or a 3-month total of 45 percent. This yielded a mean monthly loss, December-February, of 15 percent compared to 8 shown by individual, identifiable coveys. Two factors contributing to overestimated losses by using mean covey sizes were: duplicate observations of individual coveys and covey breakup during February. The largest overestimates would be expected when both factors are included during a given winter's observations.

Ordal (1952), in Minnesota, used mean monthly covey sizes from 159 covey observations during November-February to demonstrate a 32 percent over-winter loss. In southeast Wisconsin, Gates (1973) determined a 6 percent loss in average covey size between early January and late February 1962 based on initial observations of 96 birds. That

Table 48. Mortality within winter groups of partridge, by site and year, 1969-74.

Winter	Location		Original Contact Date	Original Contact Birds	Final Contact Date	Final Contact Birds	Group Size Reduction Birds	Group Size Reduction %	Total Days Obs.	Reduct. (Birds/ Covey/ Day)
Jan.-Mar. 1969	Breding	(1)[1]	13 Feb.	3	5 Mar.	2	1	33.3	21	.05
		(2)	20 Feb.	8	11 Mar.	6	2	25.0	20	.10
	D. Rice	(1)	28 Jan.	11	6 Mar.	7	4	36.4	38	.11
		(2)	11 Feb.	10	18 Feb.	6	4	40.0	8	.50
		(3)	18 Feb.	9	12 Mar.	9	0	0	23	0
		(4)	6 Feb.	10	18 Feb.	9	1	10.0	13	.08
		(5)	11 Feb.	13	18 Feb.	11	2	15.3	8	.25
		(6)	12 Feb.	5	20 Feb.	5	0	0	9	0
	Sub-Total	(8)	-	69	-	55	14	20.3	140	.10
Jan.-Feb. 1971	Klette	(1)	13 Jan.	14	11 Feb.	12	2	14.3	30	.07
	Rauscher	(4)	6 Feb.	11	11 Feb.	7	4	36.3	6	.67
		(5)	6 Feb.	11	10 Feb.	9	2	18.2	5	.40
	D. Rice	(1)	9 Jan.	9	6 Feb.	8	1	11.1	29	.03
	P. Rice	(1)	9 Jan.	10	10 Feb.	10	0	0	33	0
	Sub-Total	(5)	-	55	-	46	9	16.4	103	.09
Dec. 1971-Mar. 1972	Breding	(1)	14 Jan.	12	17 Feb.	9	3	25.0	35	.09
	Keller	(1)	15 Feb.	10	29 Feb.	10	0	0	10	0
		(2)	17 Feb.	6	1 Mar.	6	0	0	6	0
	Klette	(2)	8 Jan.	13	3 Feb.	13	0	0	27	0
		(3)	30 Dec.	19	10 Feb.	13	6	31.6	43	.14
		(4)	28 Dec.	12	28 Jan.	9	3	25.0	32	.09
	Munyon	(1)	27 Jan.	9	17 Feb.	8	1	11.1	22	.05

Table 48. Continued.

Winter	Location	Original Contact Date	Original Contact Birds	Final Contact Date	Final Contact Birds	Group Size Reduction Birds	Group Size Reduction %	Total Days Obs.	Reduct. (Birds/ Covey/ Day)
Dec. 1971- Mar. 1972 (cont.)	Rauscher (1)[2]	24 Dec.	22	30 Dec.	19	3	13.6	7	.43
	(1)[2]	30 Dec.	13	2 Mar.	13	0	0	64	0
	(4)[2]	30 Dec.	6	24 Feb.	6	0	0	57	.03
	(2)	20 Jan.	7	17 Feb.	6	1	14.3	29	.03
	(3)	28 Dec.	11	8 Feb.	9	2	18.2	43	.05
	(5)	29 Dec.	8	6 Feb.	7	1	12.5	40	.03
	D. Rice (1)	27 Jan.	11	6 Feb.	11	0	0	11	0
	(2)	4 Feb.	11	8 Feb.	11	0	0	5	0
	(3)	5 Feb.	12	9 Feb.	12	0	0	5	0
	P. Rice (1)	9 Feb.	8	29 Feb.	6	2	25.0	21	.10
	D. Stott (1)	29 Dec.	13	2 Feb.	8	5	38.5	36	.14
	(2)	30 Dec.	7	2 Mar.	4	3	42.9	64	.05
	Thomas (1)	2 Feb.	7	8 Feb.	7	0	0	7	0
	Tschantre (1)	25 Jan.	17	29 Feb.	13	4	23.5	36	.11
	(2)	28 Jan.	4	29 Feb.	3	1	25.0	33	.03
	(3)	25 Jan.	3	5 Feb.	2	1	33.3	12	.08
	Sub-Total (23)	-	241	-	205	36	14.9	658	.05
Jan.-Feb. 1974	L. Stott (1)	3 Jan.	13	5 Feb.	11	2	15.4	34	.06
	Tschantre (2)	10 Jan.	15	6 Feb.	13	2	13.3	28	.07
	Sub-Total (2)	-	28	-	24	4	14.3	62	.06
4-year Totals & Averages	(38)	-	393	-	330	63	16.0	963	.07

[1]Group Number; Sub-totals = Number of groups. / [2]Larger group of 22 was reduced to 19 by 30 Dec., after which it split into two groups; each new group maintained its integrity for the remainder of the winter.

winter was judged the most severe during 6 years of observation.

Partridge populations have been adversely affected by severe ice storms (Brown 1954) and deep snow in winter (Porter 1955 and Sulkava 1965). Open, cultivated fields with little topographic relief maintained only thin snow cover and partridge could forage successfully, (Sulkava 1965). Pulliainen (1966a), in Finland, reported average partridge flock losses of 19 percent when snow hardened late in the winter, 1964-65, whereas losses averaged 49 percent when snow hardened early in the winter, 1965-66.

Oil Facilities

Reports from landowners of oil-coated ducks and upland game birds in fields prompted monthly inspections of 20 oil sumps from May, 1970 through November, 1972. Sumps were associated with oil-water separation facilities in the northeast part of the study area. They had been dug into the soil to depths of 6-10 ft. (1.8-3.0 m) and encompassed surface areas averaging .04 a (0.10 ha). Their function was to dissipate water, through percolation and evaporation, separated from oil piped in from nearby oil pumps.

Although the bulk of sump contents was water, surfaces were covered to varying degrees (up to 100%) by: free-flowing crude oil; thick but penetrable oil sludge; or, a dry, impenetrable oil crust. The first two classifications appeared similar to water surfaces.

Surfaces were snow and/or ice covered between November and March.

Totals of 92 small birds, 63 ducks, 15 pheasants, 8 partridge, 7 unidentified upland game birds, 6 small mammals and various large insects were counted on sump surfaces during the 31-month period. Monthly totals for partridge were 3 in September, 2 each in April and May and 1 in October. Spring and fall months corresponded to periods of greater movements by partridge. Two partridge in September were recognizable juveniles; the remaining birds were too oil-coated to distinguish anything but species. Unidentified upland game birds were young of either pheasants or partridge.

Birds and mammals apparently decomposed rapidly as only individual larger ducks and pheasants persisted for more than 1 month post-discovery. The losses listed for all species were therefore considered minimal. Oil sumps were not considered a major deterrent to the study area's partridge population. However, several sumps had rank vegetation about their perimeter and seemed attractive to partridge because of the associated cover and abundant insects.

Pesticides

Only partridge-mercury fungicide relationships were investigated during the current study; details are available in Weigand (1971a). Sources of mercury in partridge were judged to be: (1) treated seed grain spilled during spring and fall seeding operations; (2) surplus treated seed dumped in idle areas; (3) chemical translocated from treated seed to caryopses (spilled during harvesting); and, (4) in winter, mercury translocated into leaves of winter wheat.

Breast muscles from 69 partridge collected October, 1969-October, 1970, representing all sex-age classes, were tested for mercury content. Attempts were made to obtain one bird each month from each of two sites on the study area and from three locations within 35 mi (56 km) of the area. Mercury was detected in breast muscle of each specimen; 22 percent contained $\leq$ 0.05 ppm and none of the samples exceeded 0.40 ppm mercury. Mean mercury content in muscle from males and females was 0.17 ppm and 0.13 ppm, respectively, and from adults and juveniles/subadults, 0.16 ppm and 0.15 ppm, respectively. Maximum mercury levels in muscle occurred in December, February and July whereas lowest levels were found in April and May. Mercury concentrations in two of three eggs extracted from oviducts exceeded those found in muscles of the tested females. Mercury in muscle of 5- and 7-week-old birds was less than that found in eggs.

This limited sampling indicated mercury levels in partridge were insufficient to result in widespread mortality or to interfere with reproductive physiology. Mortality or lowered reproduction may have occurred in coveys localized about a concentrated source of mercury fungicide.

Predation

Relative densities of potential partridge predators were recorded during route surveys. Greatest seasonal densities were noted during the summers, 1969 and 1970, and in the spring, 1971. Lowest densities occurred in winter each year. Relative partridge densities were compared with those of predators for individual routes (Fig. 26). Slight, inverse correlations were noted but none were statistically significant at P .05; the highest correlation ($r = -0.328$, $N = 12$) was along Route A.

Random observations of predators were included in determining population composition; certain species were noted during periods of the day other than early morning when routes were surveyed. One species of eagle, 6 hawk species, 4 owl species and 6 species of mammalian predators were recorded during the study. Common crows *(Corvus brachyrhynchos)*, which nested in very few places on the study area, and black-billed-magpies *(Pica pica)*, resident throughout the year and the area, were not included in predator tabulations. In addition, the study area was frequented each season, except winter, by feeding California gulls *(Larus californicus)*, ring-billed gulls *(L. delawarensis)* and Franklin's gulls *(L. pipixcan)*.

Raptors comprised 87 percent of spring predator populations (Table 49). Hawks were the largest raptor category but short-eared owls *(Asio flammeus)* were the most frequently observed. Marsh hawks were second in numbers and the most common hawk species. The record of only 1 marsh hawk in March, 19 in April and 21 in May indicated this

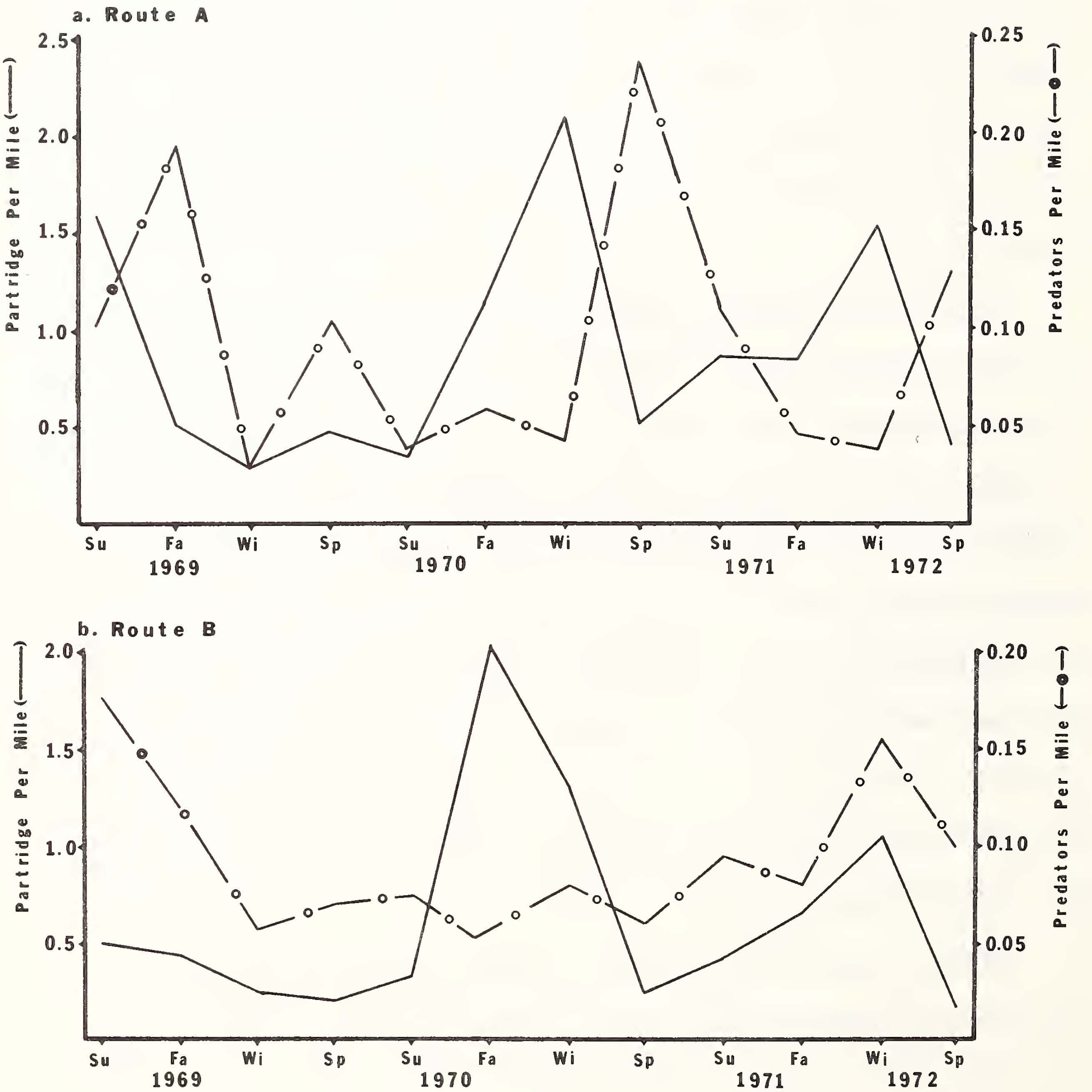
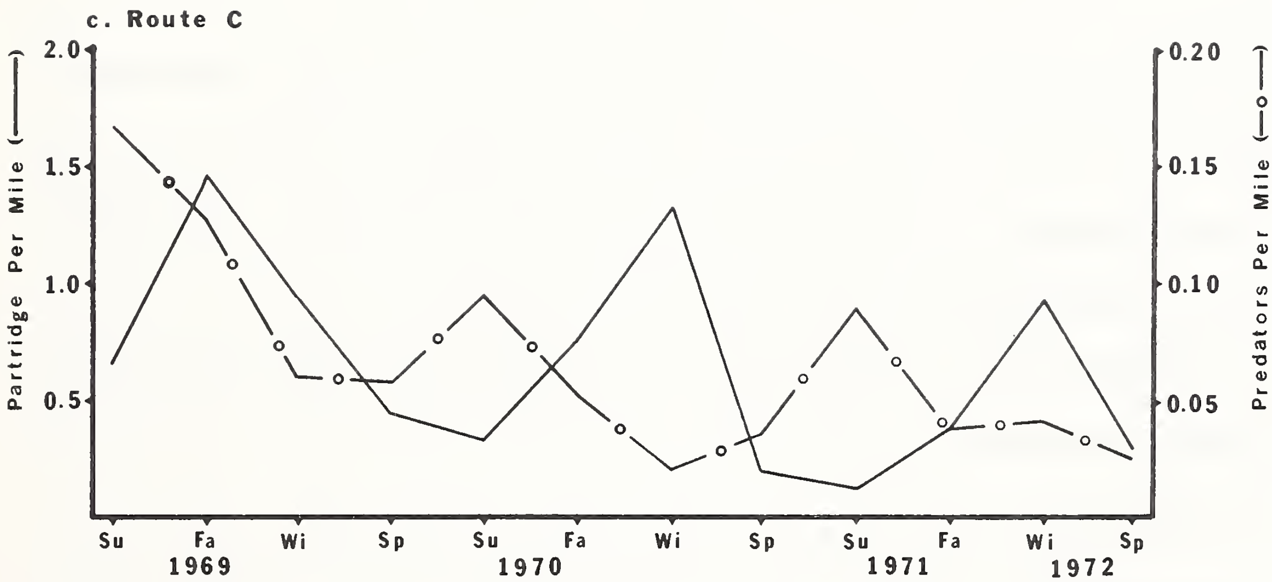


Figure 26. Seasonal trends in partridge and predator densities on the Agawam Study Area, by route, 1969-72.



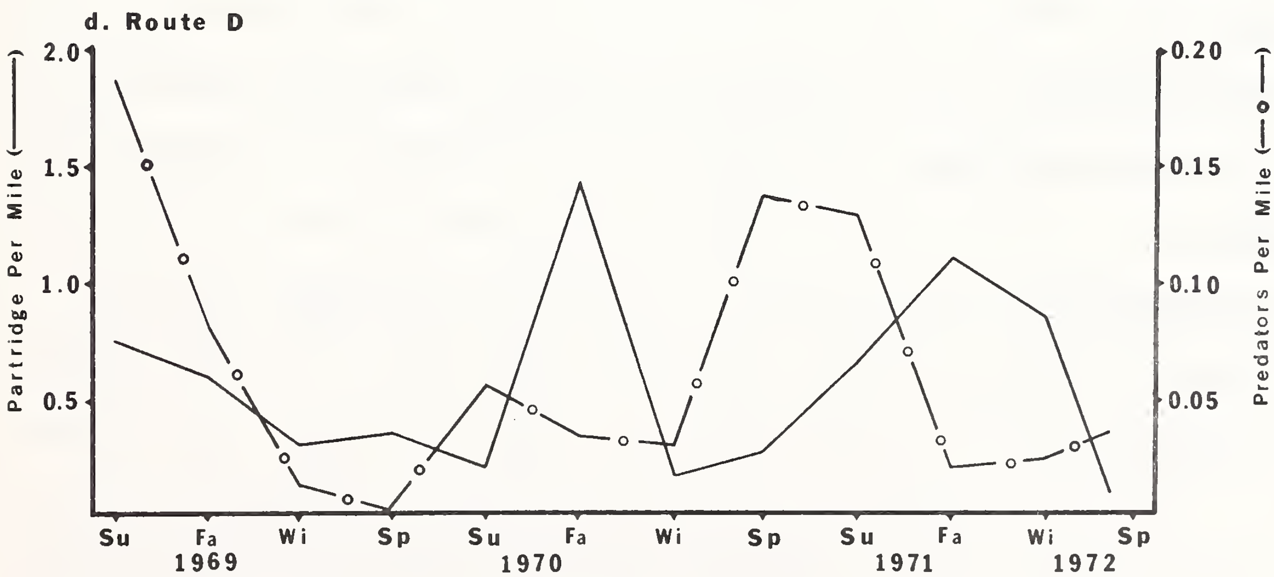


Figure 26. Continued.

Table 49. Species composition of spring predator populations on the Agawam Study Area, 1970-72.

Species	1970		1971		1972		Totals	
	No.	%	No.	%	No.	%	No.	%
Eagles								
Aquila chrysaetos	4	12.1	5	7.6	4	9.3	13	9.2
Hawks								
Circus cyaneus	11	33.3	20	30.3	11	25.6	42	29.6
Buteo swainsonii	5	15.2	2	3.0			7	4.9
B. lagopus			3	4.5	4	9.3	7	4.9
Falco mexicanus	1	3.0	1	1.5	2	4.7	4	2.8
F. columbarius					1	2.3	1	0.7
Unknown Spp.			1	1.5			1	0.7
Owls								
Asio flammeus	6	18.2	28	42.4	13	30.2	47	33.1
Speotyto cunicularia	1	3.0					1	0.7
Mammals								
Canis latrans					1	2.3	1	0.7
Mephitis mephitis	3	9.1	4	6.1			7	4.9
Vulpes vulpes	2	6.1	2	3.0	7	16.3	11	7.7
Totals	33	100.0	66	99.9	43	100.0	142	100.0

species was largely migratory and April was the major arrival month. The substitution of wintering rough-legged hawks for summering Swainson's hawks *(Buteo swainsonii)* apparently occurred in late April; roughlegs were recorded to mid-April and no Swainson's were noted before May. Observations adjacent to the study area showed spring migrations of these two species overlapped, rather than the non-occurrence of either species for a 3-week period as suggested by study area data. The only record of a pigeon hawk *(Falco columbarius)* was recorded 3 March 1972, the date indicating this bird was a spring migrant. Earliest short-eared owl records were 22 and 23 March with most arriving on the study area in April. Red foxes *(Vulpes vulpes)* apparently were the most abundant mammalian predator; proportion of observations increased more than five times between the springs, 1971 and 1972. Striped skunks were noted most frequently in May; early observations on 10 and 18 March and 27 April 1972 suggested this species resumed consistent foraging activities no earlier than about mid-March.

Raptors comprised 84 percent of the predators observed during the summer (Table 50). Marsh hawks constituted almost half of all predator observations; observations of this species decreased, 1970-72, in proportion of predators. Swainson's hawks and short-eared owls were second and third in proportion of observations. Prairie falcons reached their lowest proportion of seasonal predator observations during summer. Sparrow hawks *(Falco sparverius)* were present only in low

Table 50. Species composition of summer predator populations on the Agawam Study Area, 1969-71.

Species	1969		1970		1971		Totals	
	No.	%	No.	%	No.	%	No.	%
Eagles								
Aquila chrysaetos			5	4.2	5	4.2	10	2.6
Hawks								
Circus cyaneus	77	52.7	54	45.4	51	43.2	182	47.5
Buteo swainsonii	25	17.1	12	10.1	19	16.1	56	14.6
Falco mexicanus	4	2.7					4	1.0
F. sparverius	1	0.7	2	1.7			3	0.8
Owls								
Asio flammeus	28	19.2	1	0.8	23	19.5	52	13.6
Bubo virginianus	1	0.7	4	3.3	1	0.8	6	1.6
Speotyto cunicularia	2	1.4	7	5.9			9	2.3
Mammals								
Canis latrans	6	4.1			1	0.8	7	1.8
Mephitis mephitis			11	9.2	14	11.9	25	6.5
Mustela frenata	2	1.4			1	0.8	3	0.8
Taxidea taxus			2	1.7			2	0.5
Vulpes vulpes			21	17.6	3	2.5	24	6.3
Totals	146	100.0	119	100.0	118	99.9	383	100.0

numbers in summer; migrations of this species through the region were noted. Short-eared owl observations showed a severe decrease between the summers of 1969 and 1970 but returned to 1969-levels in 1971. Great horned owl *(Bubo virginianus)* observations were in their greatest proportion during the summer. Striped skunks and red foxes were the most common mammalian predators. The only two records of badger *(Taxidea taxus)* and of three long-tailed weasels *(Mustela frenata)* were recorded during summer.

Raptors continued to comprise the greatest proportion (78%) of study area predators in fall (Table 51). Fewer raptors were observed in the fall, 1971, than any other season during the study. Marsh hawks were the most frequent predator recorded. No Swainson's hawks were observed after 17 September and no rough-legged hawks were noted before 15 October; the 1-month interim between these dates was probably the period of interchange between the two species. Short-eared owls were the only owl species recorded in fall and fall was the season of lowest proportion of all predators. Striped skunks were the most common mammalian predator observed in fall. The only mink *(Mustela vison)* recorded on the study area was noted the fall of 1969.

Winter predator populations were limited to 10 active species. Raptors remained the most prominent category with golden eagles *(Aquila chrysaetos)* comprising the greatest proportion (Table 52). Prairie falcons were observed most frequently in winter. While snowy owls

Table 51. Species composition of fall predator populations on the Agawam Study Area, 1969-71.

Species	1969[1] No.	1969[1] %.	1970 No.	1970 %	1971 No.	1971 %	Totals No.	Totals %
Eagles								
Aquila chrysaetos	1	3.7	7	21.2	1	4.3	9	10.8
Hawks								
Circus cyaneus	18	66.7	11	33.3	2	8.7	31	37.3
Buteo lagopus			1	3.0	3	13.0	4	4.8
B. swainsonii	3	11.1	2	6.1	1	4.3	6	7.2
Falco mexicanus	1	3.7	4	12.1	4	17.4	9	10.8
F. sparverius			1	3.0			1	1.2
Unknown Spp.	1	3.7					1	1.2
Owls								
Asio flammeus			1	3.0	3	13.0	4	4.8
Mammals								
Canis latrans			1	3.0	1	4.3	2	2.4
Mephitis mephitis	1	3.7	2	6.1	6	26.1	9	10.8
Mustela vison	1	3.7					1	1.2
Vulpes vulpes	1	3.7	3	9.1	2	8.7	6	7.2
Totals	27	100.0	33	100.0	23	99.9	83	100.0

[1]September only.

Table 52. Species composition of winter predator populations on the Agawam Study Area, 1969-72.

Species	1969-70		1970-71		1971-72		Totals	
	No.	%	No.	%	No.	%	No.	%
Eagles								
Aquila chrysaetos	15	39.4	10	41.7	14	41.2	39	40.6
Hawks								
Circus cyaneus	5	13.2					5	5.2
Buteo lagopus	7	18.4	7	29.2			14	14.6
Falco mexicanus	5	13.2	3	12.5	8	23.5	16	16.7
Owls								
Asia flammeus	2	5.3	1	4.2	2	5.9	5	5.2
Bubo virginianus			1	4.2			1	1.0
Nyctea scandiaca					7	20.6	7	7.3
Mammals								
Canis latrans	2	5.3					2	2.1
Mephitis mephitis	1	2.6	1	4.2	1	2.9	3	3.1
Vulpes vulpes	1	2.6	1	4.2	2	5.9	4	4.2
Totals	38	100.0	24	100.0	34	100.0	96	100.0

(Nyctea scandiaca) were the most abundant owl species in winter, they only occurred during the winter of 1971-72. A rancher, near whose homesite most 1971-72 observations occurred, reported snowy owls were also present the winter of 1968-69.

Although marsh hawks were the most abundant predator on the present study area, only one observation of this species killing a partridge (a male adult) was observed though several instances of attacks on broods in summer were noted. One female hawk made three unsuccessful dives on two partridge broods which had taken shelter under a farm implement. With reference to partridge in Ohio, Price (1922) stated "Marsh hawks find them, especially the young, an easy prey as they seem to frequent the more exposed places in fields, roadsides and open woods." In the mid-western U. S. during 1933-35, Errington and Breckenridge (1936) noted partridge comprised only 1.6 percent of 557 food items brought to the nests and in the gullets of tethered nestling and juvenile marsh hawks. Six of these partridge were young, one was full grown and two were of unknown age. Blank and Ash (1956), in Great Britain, listed hen harriers as one of the two most important partridge predators on their study area. This seemingly contradictory evidence indicates marsh hawks are capable of killing partridge and will do so as opportunities arise. Marsh hawks, by their abundance, therefore represented the largest predator threat to partridge on the present study area.

Buteo hawks were represented in the current study by Swainson's and rough-legged hawks. Together they constituted 13 percent of predators observed; Swainson's were 73 percent of the combined observations suggesting this area supported more nesting birds and their young in summer than fullgrown birds in winter. A roughleg was observed capturing a bibbed partrdige; no other capture or capture-attempts were recorded for buteos. Porter (1955), in Utah, found two 2-3-day-old partridge chicks on 17 June 1950 in a Swainson's hawk nest but no evidence of partridge was found in nests of red-tailed *(Buteo jamaicensis)* or ferruginous hawks *(B. regalis)*. Errington and Breckenridge (1938) thought buteos were opportunistic in prey selection; this feeding behavior included feeding on a traffic-killed partridge by a redtail.

Prairie falcons comprised one percent or less of spring and summer observations; in fall and winter they were 11 and 17 percent, respectively. This species was credited with killing two of eight known predator-killed partridge on the study area. During the winter, 1971-72, two partridge coveys flew chattering about the author and a rancher while we stood among cattle in a feedlot. The birds landed among and scurried under the cattle. Seconds later, a prairie falcon arrived but veered away when it sighted us. Graefl (1932), in Hungary, observed a peregrine falcon *(Falco peregrinus)* following a hunting marsh hawk until the latter flushed a covey of partridge; the falcon then captured a partridge in flight. Though reported observations of falcons preying on partridge are sparse, there appears little doubt that they are quite able to do so.

Golden eagles were resident on the study area and the major potential predator species in winter. The abundance of white-tailed jackrabbits *(Lepus townsendii)* and some cottontails on this area probably contributed to no recorded mortality nor harassment of partridge by eagles. McGahan (1968) found partridge comprised 2.7 percent of 980 eagle-prey specimens in Park County, Montana, 1962-65. Eighty-seven percent of the items was mammals and 80 percent of these was lagomorphs, chiefly white-tailed jackrabbits.

Although short-eared owls constituted 13 percent of observed predators, they were considered an insignificant partridge predator. They were often seen in close proximity to active partridge but seemed to ignore the coveys. Craighead and Craighead (1969:134), in Michigan, found small birds comprised only 0.2 percent of the respective shortear annual diets.

Great horned owls formed a minor part of the study area's predator community; none were observed during spring or fall. Individual owls frequented several shelterbelts which were within 2 mi of Muddy Creek. No partridge mortality was attributed to horned owls on the study area. Seidenstecker (1948), in southcentral Montana, reported partridge were only 0.3 percent by occurrence and 0.7 percent of the biomass of 131 horned owl pellets. Partridge remains occurred in 6.2 percent of 729 horned owl pellets collected between spring, 1933 and summer, 1935 in Iowa with the highest seasonal occurrence (10.5%) taking place during a severe drought. McCabe and Hawkins (1946:14) stated the horned owl was one of two major partridge predators in winter on their southern Wisconsin study area.

Two snowy owls occupied one ranch site and surrounding fields within a 2 mi radius of the ranch. One attempted capture of partridge by a snowy owl was observed one evening. The covey flushed from a grain-stubble field, flew to and landed in a shelterbelt less than 100 yd (91.4 m) away. The owl continued its flight over the shelterbelt and then returned to hunting over the stubble field. Hicks (1932), in Ohio, found partridge remains in one of nine pellets collected during a snowy owl invasion the winter of 1930-31. Gollop (1965) in Saskatchewan, detected no relationship between concentrations of owls and those of partridge during the winter, 1963-64, and recorded no attempts by owls to capture them.

A single colony of burrowing owls formed the smallest proportion of the owl component present on the study area. Their den site was not disturbed at any time so food habits were not determined. Burrowing owl food habits information cited by Bent (1961:389-390) suggested the largest bird items eaten were horned larks *(Octocoris alpestris)* and sparrows, which would exclude partridge except chicks up to about 5 weeks of age.

Crow and magpie populations were rated infrequent and common, respectively, during partridge nesting and brooding. Blank and Ash (1956), in Great Britain, listed rooks *(Corvus fugilegus)* and carrion crows *(C. corone)* among the important partridge nest predators. In Czechoslovakia, Turček (1948) determined partridge remains comprised part of the 2.9 percent of vertebrate matter identified in 250 pellets of the European magpie *(Pica pica)*.

California, ring-billed and Franklin's gulls visited irrigated or flooded fields, primarily alfalfa and other hay, on early morning feeding excursions. They moved onto the study area about 15 min before sunrise (range, 6-27 min) in April and about 30 min before sunrise (range, 9-50 min) during May-July. Gulls also followed moving farm machinery during cultivation and hay harvesting during the entire day and evening. Gulls were observed mostly coming from Arod Lakes on the southeast border of the study area; others probably traveled from Bynum Reservoir (8 mi or 12.9 km southwest) and Freezout Lake Waterfowl Management Area (21+ mi or 33.6 km south).

Reports of gull predation on upland game birds were received from rural county landowners throughout the study. Two farmers related the larger gulls species preying on partridge and pheasant chicks; these predations occurred during hay-harvesting when chicks became exposed by removal of rank vegetation. Eggs in one sharp-tailed grouse and several pheasant nests were destroyed by larger gulls in alfalfa fields after mowing exposed the nests.

Rothweiler (1960), at Freezout Lake, Montana, reported bird remains or eggshells in 4.2 percent of 71 California gull stomachs, in 8.0 percent of 25 ringbills and in none of 108 Franklin's gulls. Principal gull food items in spring and summer were insects. Partridge were present at Freezout at the time of his study. In Yugoslavia, Bruyns (1958) had records of eggs and/or young partridge eaten by herring gulls *(Larus argentatus)*. These studies suggested potential partridge population losses due to gull predation. Clutches of eggs exposed by haying are probably deserted by hens unless they are in the final days of incubation. Portions of pre-flight-aged broods may be eaten by gulls as the result of farming activities removing vegetative cover. The exact impact of gull predation on this partridge population remained unknown.

Mammals provided 15 percent of the total predators observed during the study; their greatest abundance occurred in fall. Red foxes and skunks comprised 83 percent of the mammalian predator community.

Red fox food habits documentation was limited on the study area to four scat and/or debris collections during 3 summers. Scats from a road culvert 25 August 1969 contained 99 percent grasshoppers; bone fragments and teeth of *Microtus* sp. and *Peromyscus* sp. plus a few unidentified feather fragments were also present. Scats from a second road culvert, 20 July 1970, contained 28 percent insect fragments (some grasshoppers), a similar amount of mouse fur, teeth and bones and 44 percent grass fragments. The lower mandible of a jackrabbit, some pheasant feathers and a fish operculum were found at one of the latter culvert's entrances. A den inspection, 21 May 1971, revealed four duck wings (one from *Anas platyrhynchos)*, a meadowlark wing, and various parts of a pheasant, unidentified birds, a cottontail, a fox pup and a Richardson's ground squirrel *(Spermophilus richardsonii)*. Rodent fur and bone fragments comprised the entire volume of 8 scats at the den-site. Pheasant, jackrabbit, duck and rodent body parts were recorded at this den 29 September 1971. Food items in 97 scats, by occurrence, were: fur, feathers and bones, 75 percent; grasshoppers, 14 percent; and, vegetation and soil, 11 percent. Only ground squirrel, grasshoppers and six barley caryopses were readily identified. These limited findings indicated red fox were not a threat to partridge populations on the study area in summer.

Errington (1937) reported wild birds averaged 36.4 percent of 3,858 food items from red fox dens during the summers of 1933 and 1934 in Iowa. Partridge were 4.8 percent of bird and 1.7 percent of total items examined. Foxes were listed among the important partridge nest predators in Great Britain (Blank and Ash 1956).

Skunks inhabited the study area year round and were most frequently noted hunting along roadsides, in agriculturally idle parcels and hay and grain fields. No partridge nor nest destruction was attributed to skunks. In southern Michigan, Yeatter (1934:63) listed mammals as responsible for destroying 17 of 24 partridge nests, especially those in fencerows. He found 3.6 percent of 112 skunk droppings contained partridge eggshells.

Coyotes traveled through the study area along the south-face of the main ridge north of Muddy/Jones Creeks and along Farmers Coulee and an active den was found along the first ridge. No partridge mortality was attributed to this species. Schladweiler (1975, 1976) found no partridge in 602 stomachs of coyotes examined from Montana during winters of 1974-75 and 1975-76.

Weasels were highly secretive and apparently of low density on the present area. Weasels were given as a chief mammalian predator of partridge in winter in southern Wisconsin (McCabe and Hawkins 1946:14).

Badger predation on partridge may have occurred at one northcentral study area site. Blank and Ash (1956) in Great Britain observed 10 partridge nests destroyed in one night by a single badger *(Meles meles)*.

Life Expectancy

Life expectancy was determined from observations, recaptures and final recoveries of 422 marked partridge. Normally, final recoveries-only would be utilized in this calculation but such records were available from only 32 partridge. Since observations and recapture data were included in this determination, ages obtained probably represented minimum life expectancies.

The age of each bird was calculated by comparing its age at time of last observation, recapture, or death with that at the time of initial capture. Base time for hatching for subadults was the peak week of hatch during the preceding summer; this would tend to maximize calculated mean ages since a majority of chicks hatched after the peak week each summer. Adults were assumed to be at least 1+ year-old and to have been hatched the peak week of hatch during the second summer preceding initial capture. Hatching time for both age classes captured January-March, 1969 was taken as the 5-year peak week of hatch, June 19-25.

Life expectancy for each sex-age class was 1.8+ years for adult males and females, 0.9 for subadult males and 0.8 for subadult females (Table 53). Maximum life expectancies were recorded for partridge captured the winter of 1969-70 while minimums were established from birds captured the winter of 1971-72.

Based on 207 band recoveries in Denmark, Paludan (1963) reported mean longevity (his terminology) for 3-week-old chicks released in July-August and adults and subadults released in November as 5.5 months from their time of release. It appeared that chicks released (in groups of 10 with either 2 adult partridge or a domestic hen, Paludan 1957) had little chance for surviving their first winter.

Table 53. Life expectancies of Hungarian partridge, by sex and age, as determined from observations and recaptures of 422 bibbed birds.

Trapping Period	Sex	Age	No. Birds	Age[1] at Last Observation/Recapture Min.	Max.	Mean
January-March 1969	Male	Adult[2]	10	1.7	2.1	1.8
		Subadult	57	0.6	1.7	0.9
	Female					
		Subadult	30	0.6	1.4	0.8
January-February 1970	Male	Adult	6	1.6	3.6	2.0
		Subadult	14	0.6	3.2	1.4
	Female	Adult	3	1.6	3.7	2.3
		Subadult	9	0.6	2.8	0.9
January-February 1971	Male	Adult	12	1.6	2.9	2.0
		Subadult	25	0.6	3.6	1.0
	Female	Adult	8	1.6	2.7	2.1
		Subadult	21	0.5	1.8	0.8
December 1971-March 1972	Male	Adult	42	1.5	2.9	1.7
		Subadult	79	0.5	3.1	0.8
	Female	Adult	28	1.5	1.7	1.6
		Subadult	78	0.5	2.6	0.8
4-Year Totals	Male	Adult	70	1.5	3.6	1.8
		Subadult	175	0.5	3.6	0.9
	Female	Adult	39	1.5	3.7	1.8
		Subadult	138	0.5	2.8	0.8

[1]Age in years.
[2]Assumed minimum age of 1+-year at initial capture.

Paludan's recoveries from chicks reflected mortality during a period from which no information was available for Montana birds; none of the bands from summer-banded chicks were recovered.

Mean longevity for adult partridge in Denmark, assuming at least 1.4 years of age during November releases, was 1.9 years. This closely agreed with the mean life expectancy of adults in Montana. Paludan (1963:40-41) also calculated birds surviving to their second year (i.e. 1+ year adults) had a mean further life of 8.3 $\pm$ 0.5 months while those attaining their third year could expect to live an additional 9.4 $\pm$ 1.7 months.

Longevity

Maximum longevity for adult males and females was the second winter following initial capture. Assuming a minimum age of 1.5 years at initial capture, adults were removed from the population during their fourth year of life (Table 54). Subadult males were also removed from the population during their fourth year, or probably during their third winter after initial capture. Subadult females showed the shortest longevity of all sex-age classes; they disappeared from the population during their third year, or their third spring after initial capture.

Paludan (1963:41) found the longest-lived, marked and recovered partridge in Denmark was 62 months, or 5.2 years. The expected distribution of age groups from 142 recoveries was 0.08-bird in the fifth year compared to the single bird actually found. It appears that

Table 54. Longevities of 422 bibbed partridge, by sex and age, on the Agawam Study Area.

Observation-Recapture Period		Males		Females	
		Adults	Subadults	Adults	Subadults
No Further Contact:	No.	14	34	12	41
	%	20.0	19.4	30.8	29.7
First Year:					
Winter[1]	No.	38	92	20	69
	%	54.3	52.6	51.3	50.0
Spring	No.	8	12	3	8
	%	11.4	6.8	7.7	5.8
Summer	No.	2	9	0	7
	%	2.9	5.1	-	5.1
Fall	No.	4	4	0	8
	%	5.7	2.3	-	5.8
Second Year:					
Winter	No.	2	11	3	1
	%	2.9	6.3	7.7	0.7
Spring	No.	1	0	0	1
	%	1.4	-	-	0.7
Summer	No.	0	1	0	0
	%	-	0.6	-	-
Fall	No.	0	2	0	1
	%	-	1.1	-	0.7
Third Year:					
Winter	No.	1	5	1	1
	%	1.4	2.8	2.5	0.7
Others	No.	0	3[2]	0	1[3]
	%	-	1.8	-	0.7
Fourth Year:	No.	0	2	0	0
	%	-	1.1	-	-
Totals	No.	70	175	39	138
	%	100.0	99.9	100.0	99.9

[1]Winter of initial capture and marking.
[2]One each during spring, summer and fall.
[3]Spring.

turnover of one cohort in a population may be expected sometime during the fourth year; some cohorts may disappear during their third year.

VEGETATIONAL STUDIES

Game management and research biologists of the Montana Department of Fish and Game map-inventoried Hungarian partridge habitat statewide by classes in 1974-75. This inventory revealed 64 percent of Montana's 147,138 mi^2 (381,087 km^2) was partridge habitat with 2 percent being Class I (high density), 21 percent Class II (moderate density) and the remainder Class III (low density). Teton County, which encompassed the present study area, included 1,737 mi^2 (2,795 km^2) of partridge habitat, none of which was considered Class I, 31 percent was Class II and the remainder was Class III. Class II habitat occurred on the study area only along Muddy and Jones Creeks.

Land Uses

Agricultural uses of land varied with soil types and topography on the study area. Cereal grains were grown almost exclusively on the loamy soils on Porter Bench; rangeland was the predominant use on loamy soils on the slopes from this plateau. Grain-growing also dominated the land use on gravelly loams on the secondary benchland south of Porter although some hay and range lands also occurred. Clay and gravelly loams supported grain and hay crops on the southwest, tertiary bench. The benchland in the southeast corner of the study area, also gravelly loams on the surface, supported approximately equal proportions of grain, hay and range. Alluvial soils adjacent to the major creeks supported livestock ranges and hay crops; grains were a minor crop on these soils.

Agricultural uses of land were listed along each side of four observation routes. Annual land-use data, obtained about 1 August, 1969-73, are presented in Appendices XV-XIX.

Grain

The most abundant land-use category was grain-fallow (Fig. 27); it decreased in extent by 3 percent 1969-71 and then stabilized 1972-73. Grain and fallow trends actually opposed each other indicating that grain was grown on most of the previously fallowed tracts. Some fallow, however, was seeded to alfalfa. Major grain species cultivated on the study area, 1969-72, were spring and winter wheat; barley (i.e. malting varieties) was the dominant grain in 1973 (Fig. 28). Spring grain, however, comprised 61-84 percent of all grain grown; barley was the most important of these species. Oats were grown as a nursery-crop for alfalfa and as a cover crop by landowners contracting with the federal government in the Feed Grain Program (Weigand and Janson 1976:62). Barley appeared to be more popular than oats as an alfalfa nursery-crop probably because of its ready cash market upon harvesting.

Hay

Hayland comprised six categories: alfalfa (>75% alfalfa, <25% grass); alfalfa-grass (50-75% alfalfa, 25-50% grass); grass-alfalfa

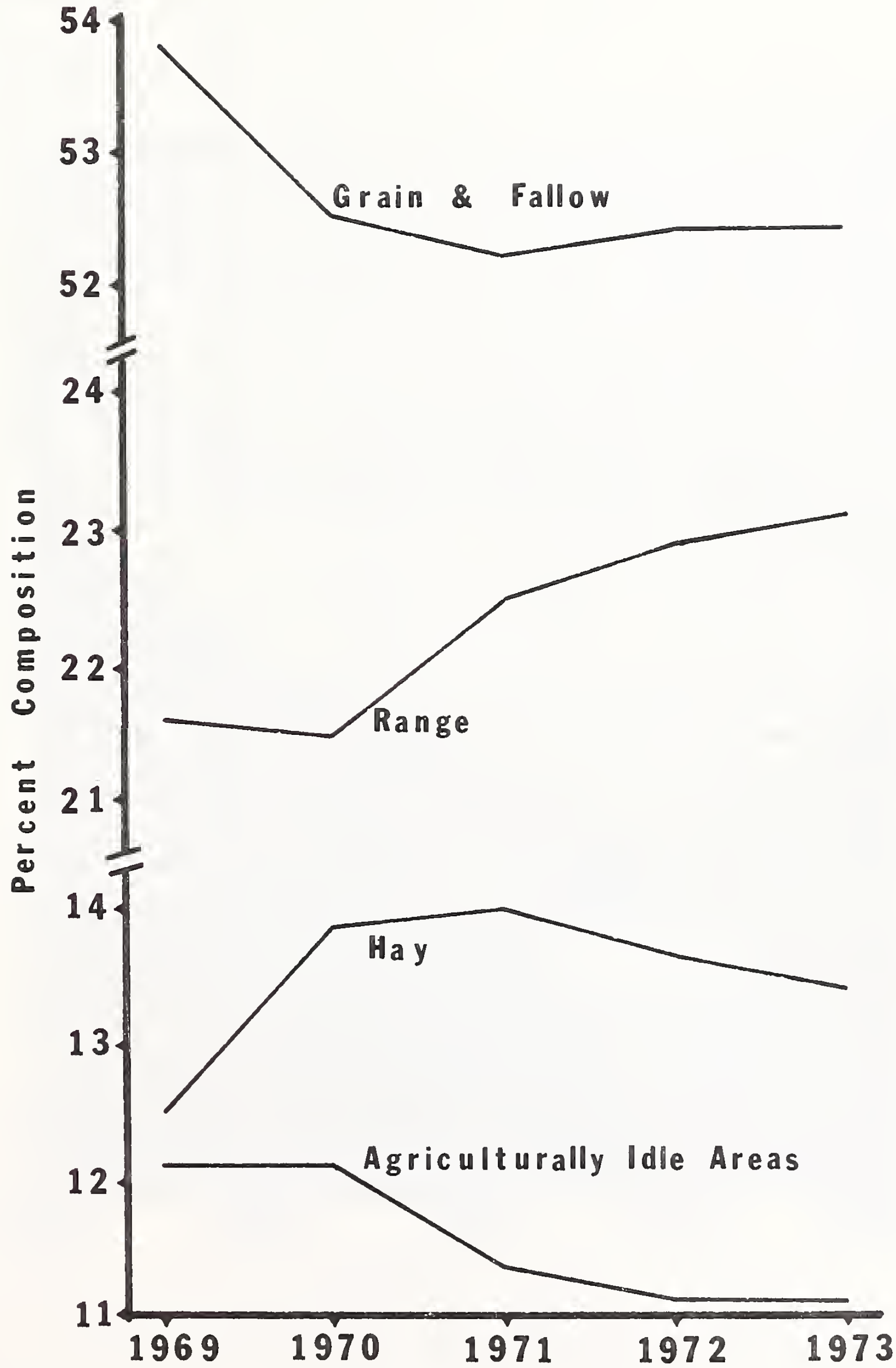


Figure 27. Trends in percent composition of agricultural land uses on the Agawam Study Area, 1969-73.

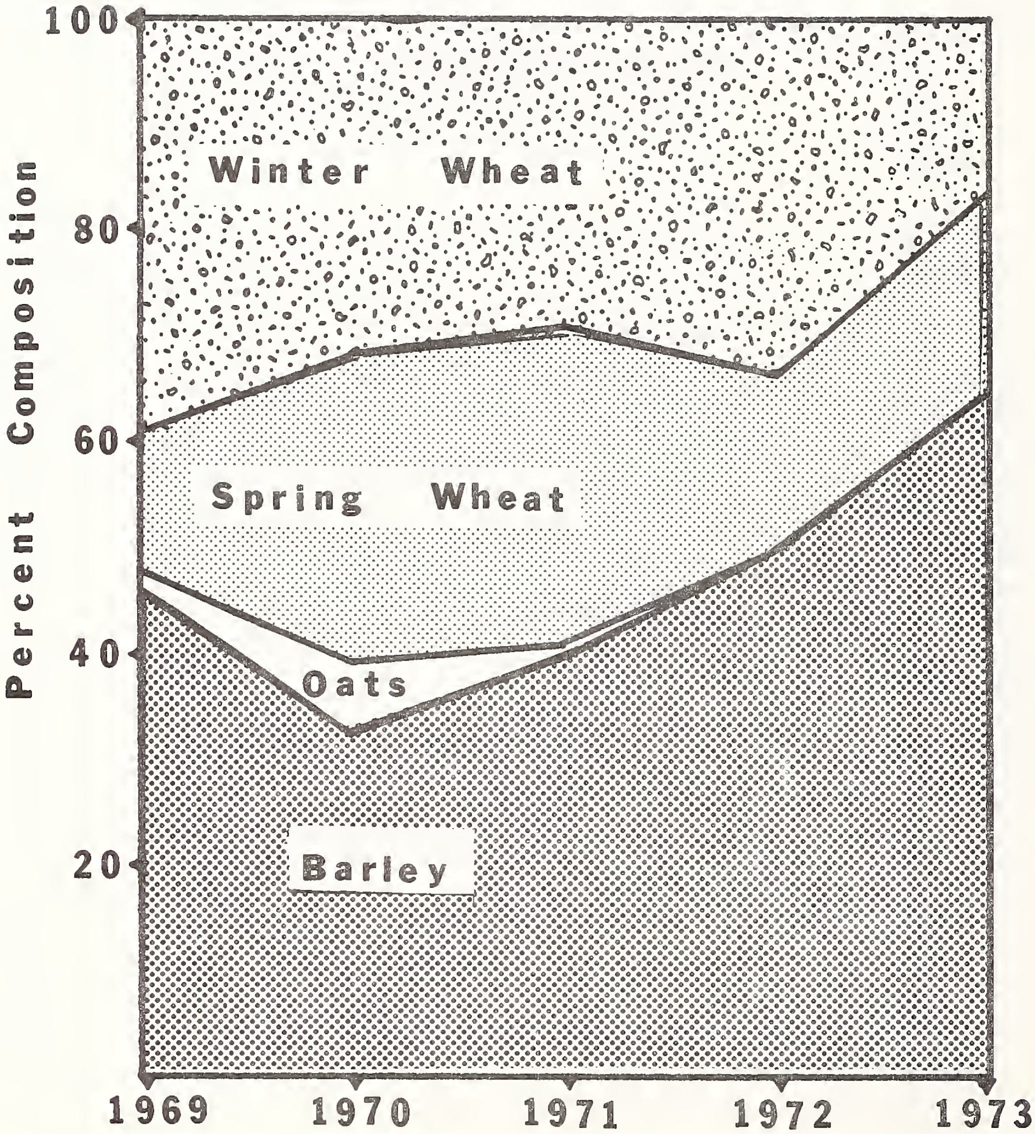


Figure 28. Species composition of grain cultivated along four observation routes on the Agawam Study Area, 1969-73.

(50-75% grass; 25-50% alfalfa); grass (>75% grass); sanfoin; and, yellow sweetclover (clover shared equal dominance or was the dominant species in combination with alfalfa or grass). The extent of hay lands increased by 11 percent, 1969 to 1970, and then decreased gradually through 1973. Severity of the winter, 1968-69, may have depleted local hay reserves for anticipated increased cattle numbers for 1970.

The primary hay crop on the study area was alfalfa (Fig. 29). Reduction in alfalfa tracts were more than compensated for by increases in alfalfa-grass and grass-alfalfa combinations. Sequences in alfalfa-growing were:

Year 1 : fallow;

Year 2 : multiple seeding of grain nursery-crop and alfalfa in spring and harvest of the grain in summer;

Years 3-4 : alfalfa

Years 6-7 : alfalfa-grass

Years 8+ : grass-alfalfa; eventual return to grass unless the sequence is repeated.

Weather conditions influenced timing of this sequence; several consecutive wet years tended to extend alfalfa domination whereas a series of dry years tended to hasten dominance by grass. Some fields were planted directly to alfalfa. The overall increasing trend in alfalfa associations resulted from increased numbers of new alfalfa plantings, 1971-73, in concert with the above ecological progression of old alfalfa plantings.

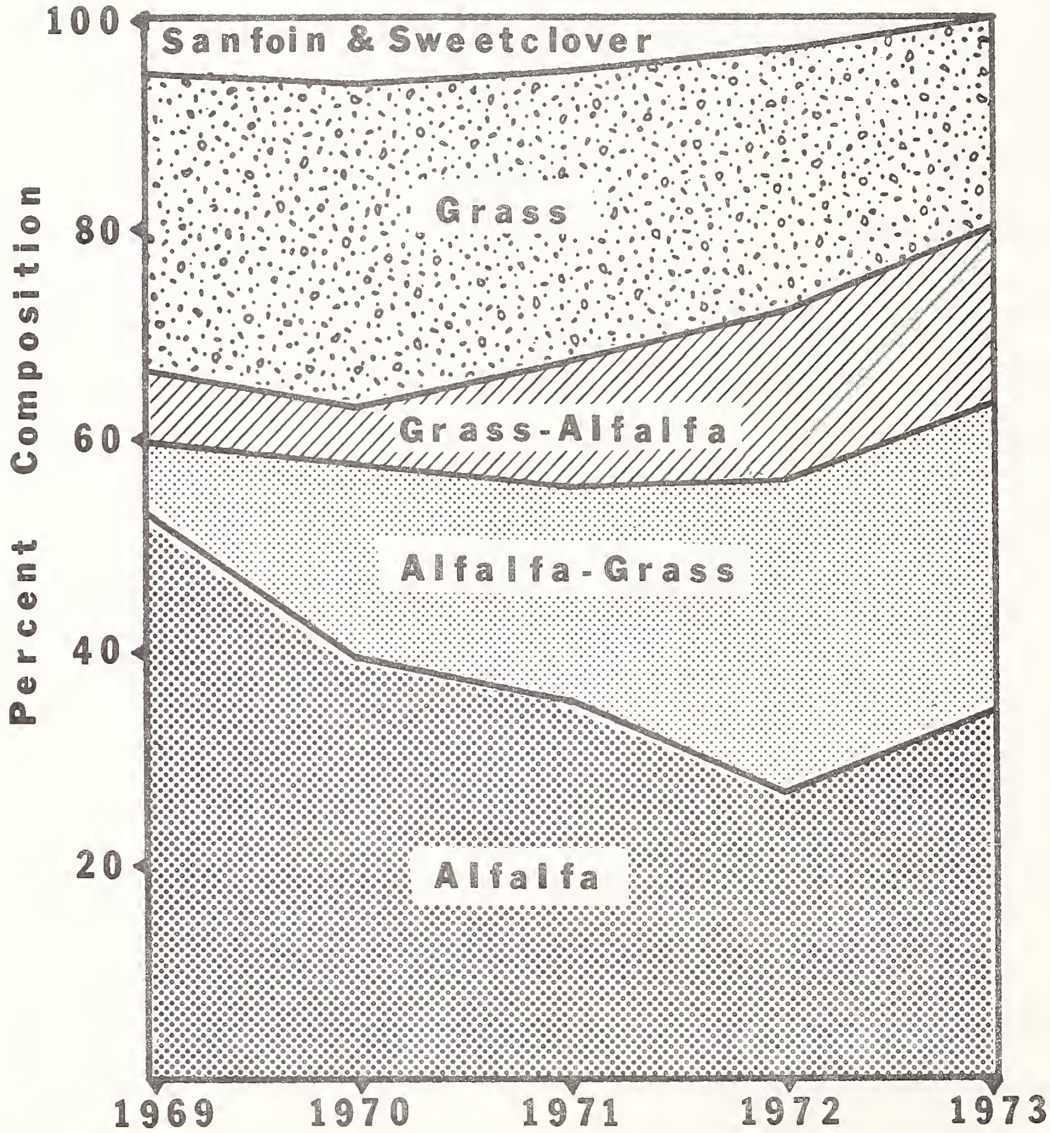


Figure 29. Composition of types of hay along four observation routes on the Agawam Study Area, 1969-73.

Tracts of grass hay, native or domestic species, ranged from 28 percent of all hay in 1969 to 30 percent in 1970 and then declined to 20 percent in 1973. The 33 percent loss, 1970-73, was attributed to cultivation for grain and new alfalfa crops plus conversions to rangeland. No native grass hay was known to have been lost to cultivation.

Sanfoin was cultivated as a hay crop on non-irrigated lands. It apparently yields higher quality and greater yields of hay than grass on the same tract and grows on dryland areas which will not yield profitable crops of alfalfa. It was experimentally grown for 3 years on a previous grain tract and returned to grain production in 1973. A second tract was seeded but not harvested during 1969-70 and cattle grazed the area 1971-73; apparently this seeding was intended as a pasture crop.

Sweetclover tracts were also limited in extent. They were included in hay categories only if they comprised one-third or more of a standing hay crop and were the result of naturally-occurring seed. Sweet clover was also grown for seed on two tracts and then harvested for hay. No tracts dominated by sweet clover were recorded in 1973.

Range

Rangeland increased 8 percent between 1969 and 1970 levels and that of 1973. Each tract of rangeland was assigned one of five classifications (Fig. 30); classifications were based on range location or unique vegetative features. Lowland ranges, which varied from 61

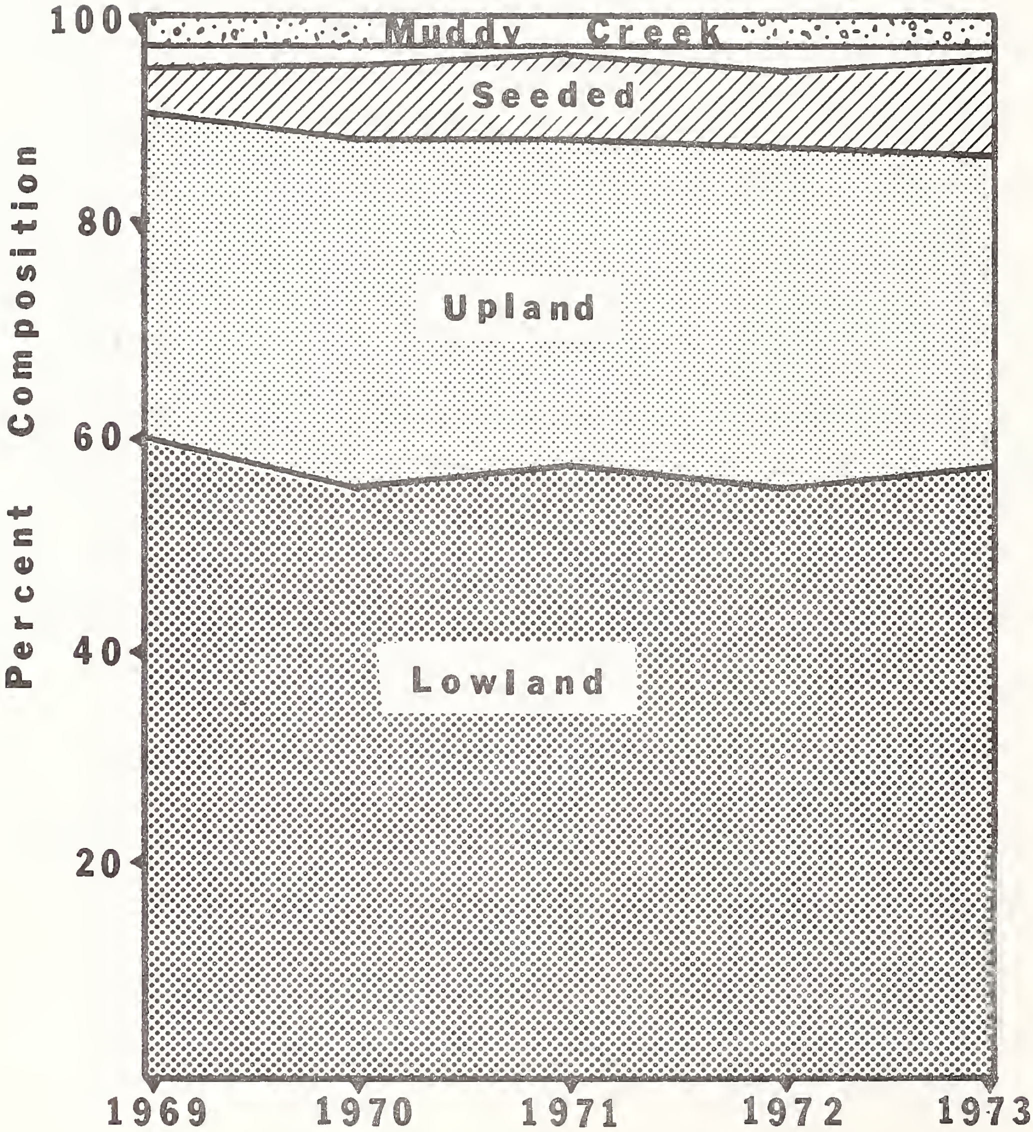


Figure 30. Composition of rangeland types along four observation routes on the Agawam Study Area, 1969-73. White area above Seeded is Feedlots.

percent of all rangeland in 1969 to 56 percent in 1970, occurred mainly in the southern one-third of the study area and along major creeks. This reduction resulted from conversion of several tracts from grazing by cattle to hayland. During 1970-73, lowland ranges comprised a rather steady 56 percent of all rangelands. Grasses on several ranges were harvested for hay prior to grazing by cattle each summer. During dry summers no grass-mowing was attempted so the ranges produced undisturbed vegetation through the partridge brood season.

Seeded ranges increased from 4 percent of all rangeland in 1969 to 10 percent in 1973. Seeding tracts for production of standing live-stock forage resulted from land too wet to annually and profitably cultivate for grain.

Proportions of feedlots and Muddy Creek wooded rangelands remained relatively constant throughout the study. Feedlots were used to winter livestock and as a result represented heavily grazed ranges dominated by forbs. Muddy Creek rangeland contained an overstory of cottonwood and/or willow trees for about one-half of its length in the study area.

Agriculturally Idle Areas

Eight categories of agriculturally idle areas were recognized (Fig. 31). Idle areas decreased 8 percent during the 5-year study. The major decrease, 1969 to 1971, was primarily due to termination of the only Soil Bank Contract (Weigand and Janson, 1976:62) on the study area.

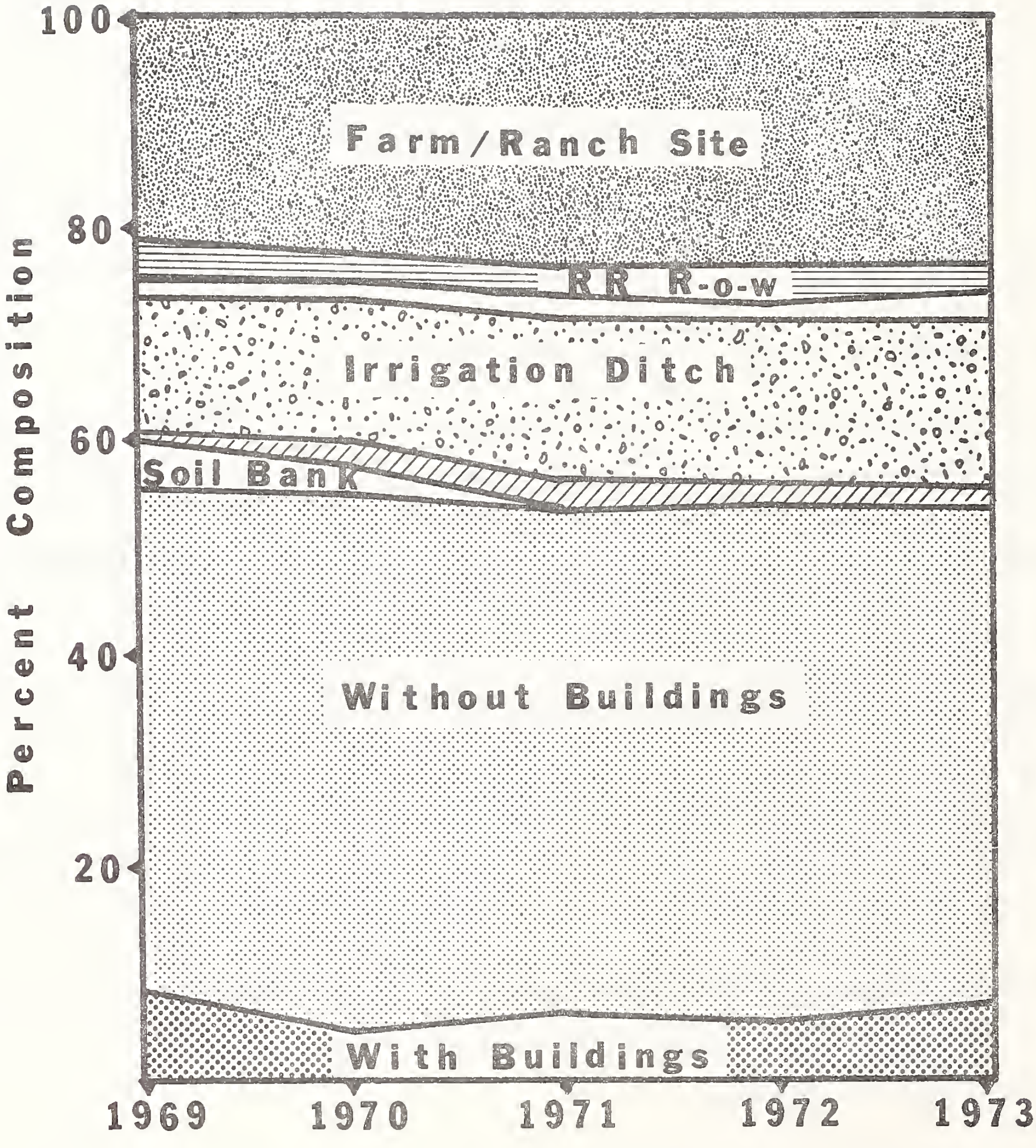


Figure 31. Composition of agriculturally idle area types along four observation routes on the Agawam Study Area, 1969-73. White area above Irrigation Ditch is Oil Facilities.

Major changes in these areas resulted from changes in the total extent rather than the number of idle areas. The most dynamic areas, those without buildings, included field corners, areas near inactive farm/ranch sites, irrigation ditch borders and areas too wet to cultivate. Some areas occurred in cultivated fields during wet growing seasons, disappeared when the fields were dry and cultivated, and then reappeared in the next wet, growing season.

The study area contained several wider-than-normal, perennially vegetated fencelines. Fencelines in contact with routes were less than 0.025-mi wide, insufficient for inclusion in these compilations.

Not all irrigation ditches rigidly met the agriculturally-idle notation because some were subject to management practices employed on adjacent tracts. Ditches on ranges were grazed seasonally and those in alfalfa and grain fields and along roads were subject to pesticide applications when adjacent areas were treated. Many irrigation ditches in alfalfa and grain fields were grazed by livestock in winter.

Along Routes

Land uses recorded adjacent to each route were compared annually because routes were located to sample different land use composition as well as different partridge populations.

Route A (Fig. 1) was characterized by approximately equal proportions of upland and lowland habitats. Grain and fallow were the major (combined) land uses (Fig. 32) and barley, the most abundant grain,

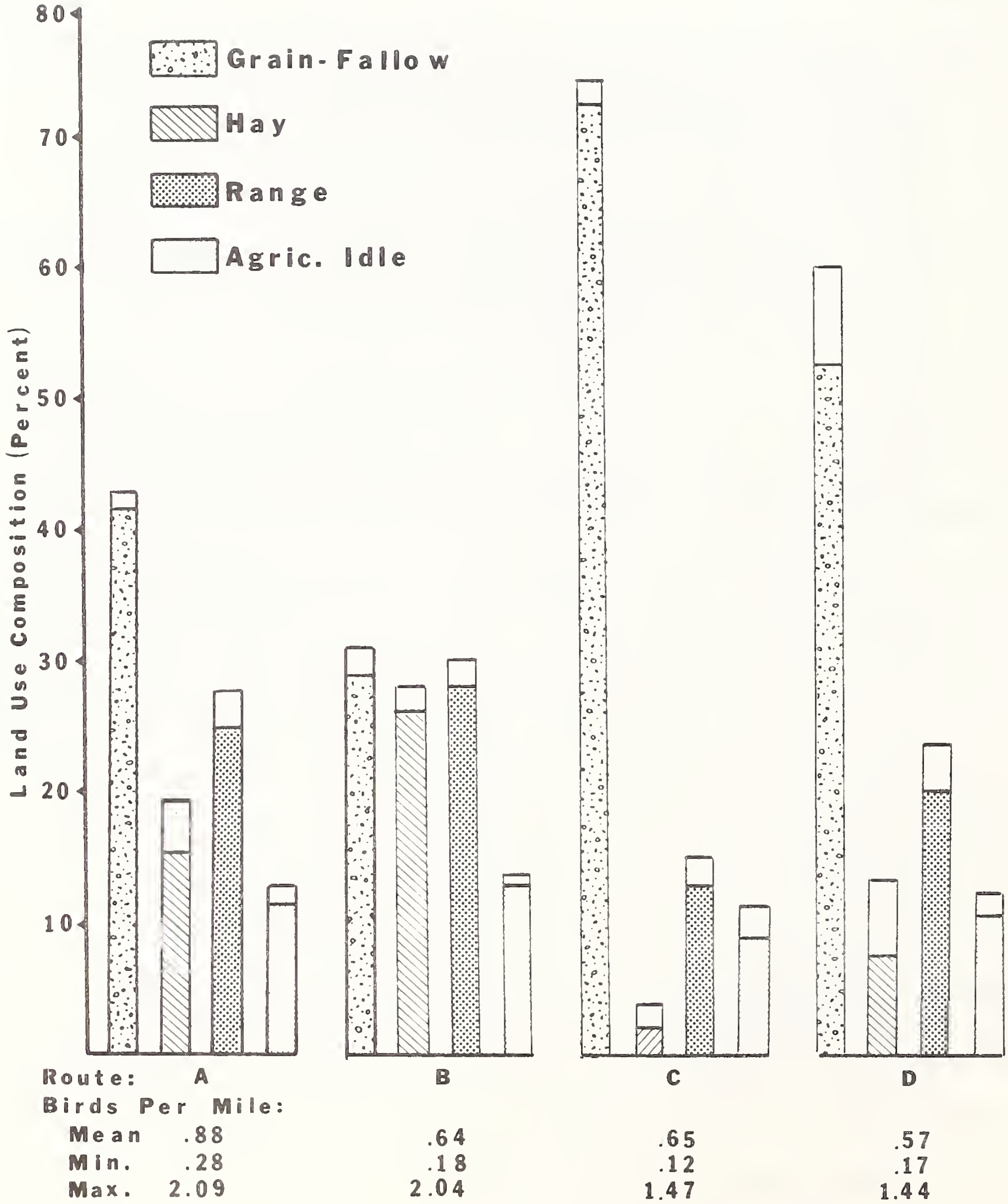


Figure 32. Comparision of land use composition and partridge densities by route on the Agawam Study Area, 1969-73, (white area at top of each bar represents composition range).

increased in extent by 104 percent, 1970-73, at the expense of winter wheat which declined 45 percent. Alfalfa, the most plentiful hay species (50-59 percent of all hay), declined 15 percent during this period. Lowland range comprised about three-fourths of the range type, upland range was second and seeded range, although a minor component, almost doubled in extent during the period. The extent of agriculturally idle areas remained relatively stable during the study; idle without buildings formed about one-half of such areas and increased by 21 percent, 1969-73.

Route B included only lowland habitats although dryland and irrigated land uses were represented. Proportionately less grain-fallow and more hay, range and agriculturally idle land occurred along Route B than on any other route. Grain and fallow were stable in extent; barley was the most abundant (46-66%) grain species grown and winter wheat was second. While the extent of hay also remained stable, alfalfa declined 75 percent with much of the loss due to natural succession. The proportion of rangeland increased slightly and lowland range comprised 79-81 percent of this type. Muddy Creek wooded range was the second-most extensive range type (i.e. it occurred only along this route), seeded range was third and feedlots were least abundant. Eighteen percent of the extent of agriculturally idle area was lost, about half of which was due to recodification of an idle seeded range to grazed seeded range. Other major idle areas were farm/ranch sites (32-38%) and irrigation ditches (mean, 20%).

Route C sampled upland and lowland habitats about equally. Dryland agriculture formed more than 95 percent of the land uses. The only mechanized irrigating system on the study area was noted on this route. Proportionately more grain-fallow (72-74%) occurred along this route than any other route. Barley, the most common grain, increased from 33 to 71 percent of all grain while winter wheat decreased from 35 to 14 percent; the extent of spring wheat absorbed only a small portion of lost winter wheat. Hay was a minor land use, grass was the major hay crop and 51 percent of all hayland was lost during the study. Upland range formed 77 percent of all ranges and six tracts of hay were converted to range. Twenty-one percent of agriculturally idle areas were lost during the study with the major cause being conversion to grain-fallow.

Route D was dominated by uplands although lowland-habitats occurred along the southern one-third and adjacent to Farmers Coulee. Dryland and irrigated habitats were represented. Grain and fallow (combined) were the most abundant land uses although they declined 13 percent. Winter wheat, the most abundant grain (47-57%), 1969-70, was replaced by barley (49-70%), 1971-73. Oats attained their greatest abundance (9%) along this and other routes in 1969. Extent of hay increased 77 percent with most of the increase due to conversions of grain crops; alfalfa-dominated hay was the most common hay crop. Upland range formed 72-85 percent of all range types but declined 15 percent during the study. Overall rangeland increased 20 percent, the increase occurring on lowlands and with the seeding of new ranges. Agriculturally idle areas decreased one-fourth during the study with one-half of this loss attributed to reclassification of a seeded and an upland range.

Land-use composition was compared with seasonal partridge densities along the four observation routes (Fig. 32). Maximum densities were noted along Route A. The proportion of grain-fallow was noticeably greater along Route A than Route B but was greatly less than that along Routes C and D. Notably less hay was grown along Route A than Route B but Route A had considerably more than Routes C or D. Proportions of rangeland were similar adjacent to Routes A and B but each had more rangeland than Routes C or D. Proportions of agriculturally idle land were similar along Routes A, B and D but each contained more than along Route C.

Associations with Partridge

The three land uses associated with partridge were compiled by month and season for most observations, 1969-72. There were 1,227 land-use associations in spring, 1,311 in summer, 678 in fall and 1,476 in winter.

All Land Uses

Partridge used roads and trails as sources of grit, waste grain and forb seeds as well as for roosting in early morning and for dusting when other dry sites were not readily available. These vehicle lanes occurred along entire route lengths. Roads and trails were 10 yd (9.1 m) and 5 yd (4.6 m) or less in width, respectively. As legitimate land uses they would have required equal representation, in cover mapping, with adjacent agricultural land uses which sometime extended 0.5 mi (0.8 km) or more away from the route. Borrow pits (roadside ditches) ranged from 2 to 5 yd wide. Since they occurred along both sides of each road and some trails, borrow pits as legitimate land uses would also have required equal representation with agricultural land uses along routes.

Inasmuch as partridge occurred in areas without roads, well-defined trails or their attendant borrow pits, these special land uses were not considered requisites to partridge habitat. Since partridge used them when they occurred, these uses were included as partridge-associated land uses on a limited basis. When partridge were observed on a road, or tail, the vehicle lane became the associated land use, the closest adjacent borrow pit was the nearest different land use and the second nearest different land use was one under agricultural management. When partridge were noted in a borrow pit, it became the associated land use, the road was excluded from partridge association and the nearest and second nearest land uses were under agricultural management.

Roads, trails and/or borrow pits (combined) comprised 21, 34, 29 and 19 percent of partridge-associated land uses in spring, summer, fall, and winter, respectively (Fig. 33). The high incidence of association in summer coincided with maximum vegetation height and density in all other land uses except fallowed fields. Partridge were more readily observed on these special land-use areas and fallowed fields. Low association in winter corresponded to many partridge observations in woody cover, some of which did not join borrow pits or roads.

Partridge association with woody cover was seasonally maximal in winter and minimal in summer. The highest monthly association occurred in February (17%) while the lowest was in July (1%). High incidence of association in winter apparently resulted from little vegetation exposed above snow on most other land uses. Uniform snow cover in winter should have made partridge, except coveys burrowing under the snow, more observable on exposed areas. Although 8 of 23 uncultivated shelterbelts were grazed by livestock in summer, partridge seemed to avoid such sites or were not normally associated with them; few partridge were observed in grazed shelterbelts in summer.

Woody cover associated with occurrences of partridge, with very few exceptions, was a shelterbelt; these were usually part of a current or former farm/ranch site. Shelterbelts and tree groves comprised

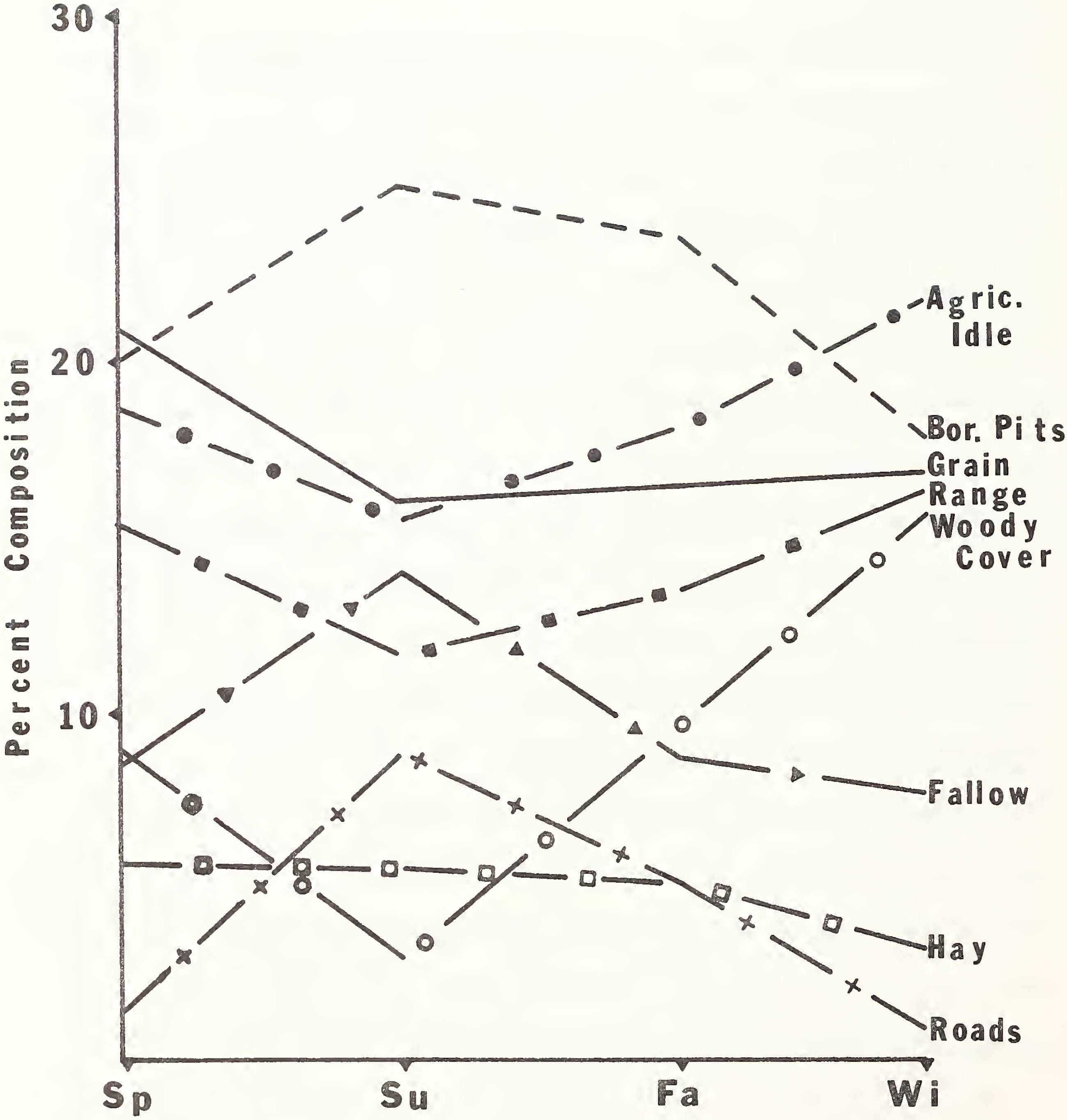


Figure 33. Seasonal proportions of all land uses associated with partridge observed on the Agawam Study Area, 1969-72.

81 percent of 423 woody cover types associated with partridge observed in spring, 71 of 430 in summer, 71 of 226 in fall and 96 of 549 in winter. Shelterbelts and tree groups were in greatest association during December-February (>95%) and least in October (60%). Low use of shrubs in winter was attributed to these types filling in with snow, thereby severely limiting their value as protective cover. When agriculturally oriented-only land uses were evaluated, partridge associations with shelterbelts were included in farm/ranch site associations whereas other woody cover types were included in appropriate agriculturally idle with or without building categories.

Agricultural Land Use/Sub-use Associations

Individually, grain and fallow ranked third and fourth, respectively, of the five agricultural land-use categories associated with partridge; when combined, they ranked first. Partridge association with grain fields was highest in spring and lowest in summer while these respective extremes for fallow occurred in summer and winter. Grain, as one of three land-use-partridge associations, was most frequently the 2NLU in all seasons except fall. Fallow, however, was the land use on which partridge were observed in summer and fall but was the 2NLU during the other seasons.

Partridge associations with individual grain species was highest for winter wheat, fall through spring (43-49%) but ranked third of four species in summer. Partridge may have been attracted to winter wheat, which is seeded and germinates in September, because it provided green plant material longer than spring-seeded grains. Partridge associations with growing (vs. stubble) winter wheat increased from 25 percent in September to 53 percent in December and then declined to 32 percent in February. In spring, partridge were on or near growing winter wheat an average of 36 percent of the time. Barley was the most frequent grain associated with partridge in summer. Oats was the least used grain during all seasons.

Partridge-hay associations showed the lowest incidence of association of any major land use. Highest association was found in summer while the lowest occurred in winter. Hay associations occurred most frequently as the 2NLU during all seasons.

Partridge associations with alfalfa-dominated hay was greater than with other hay types in every season except winter. Partridge-alfalfa associations increased from the annual low (51%) in winter to 69 percent in summer. High association with alfalfa in spring was attributed to those fields providing some of that season's earliest developing protective cover. Decline in partridge use of alfalfa in late summer and fall was probably due to removal of this cover through hay-harvesting; partridge were readily observable in harvested alfalfa fields and would have been recorded had they occupied these fields. Partridge could also have used growing alfalfa, and its indigenous insect populations, as feeding sites during brood-rearing. Low partridge-alfalfa associations in winter may have resulted from the presence of only unprotective, harvested or livestock-grazed fields; use in winter was probably due to close proximity of these fields to partridge winter ranges.

Limited data showed partridge-grass dominated hay associations increased from 32 percent in spring to 41 percent in fall and a decrease to 33 percent in winter. This could indicate increased use of grass-hay during late nesting and brooding with subsequent decrease following hay harvests and grazing by livestock. In winter, grass-dominated hay was the most frequent of the partridge-hay type associations.

Associations between partridge and sweetclover were noted only in summer (4%). Partridge-sanfoin associations ranged from 1 percent of all hay types in summer to 8 percent in winter; no such associations were observed in spring.

Partridge associations with rangeland ranked fourth of the eight major land uses and third among the five agricultural land uses. Maximum incidence of association occurred in spring and was minimal in summer. When these associations occurred, they tended to be the NLU in all seasons except fall.

Lowland and upland ranges associated with partridge comprised more than 85 percent, seasonally, of all partridge-range associations. Lowland associations increased from an annual low of 43 percent in winter to 57 percent, the annual high, in summer. Low associations in winter were due, in part, to few partridge winter ranges occurring adjacent to lowland ranges. Partridge association with upland ranges was lowest in summer (39%) and highest in fall and spring (46%). Dispersal of partridge away from winter ranges in spring and their returning in fall could account for use patterns of both types.

Vegetation on lowland ranges associated with partridge was dominated by grasses or grasslike plants (mainly sedges). The lowest proportion of grass-dominated lowland ranges occurred in summer. Lowland ranges with low forb components formed 50 (winter) to 68 percent (fall) of seasonal partridge-range associations. Grass-dominated vegetation on upland ranges exceeded 92 percent each season and was 100 percent in spring and fall. Upland ranges with low forb components comprised 15 (spring) to 35 percent (summer) of seasonal partridge-range associations. Differences in proportions of grass and grass-forb components of these two ranges was probably due to the increase of foxtail barley *(Hordeum jubatum)* on heavily grazed lowland ranges whereas fringed sage *(Artemisia frigida)* seemed to increase on similarly grazed upland ranges. No evidence was available to support hypotheses of grass vs. forb-dominated range availability. Extremely high proportions of associations with grass-dominated ranges suggested these ranges were more valuable to partridge, at least during growing seasons.

Seeded ranges were only 1 to 6 percent of seasonal partridge-range associations. High association occurred in spring and was probably due to transient use during dispersal from winter ranges.

Partridge-feedlot associations varied from 0 percent in fall to 13 percent in winter. High winter association resulted from increased feedlot use by partridge during the severe winter of 1971-72 (25% of all partridge-range associations). During the winter, 1969-70, this association was only 2 percent and no partridge were noted in feedlots the winter of 1970-71. Successful foraging by partridge for food and grit on several winter ranges was effectively precluded by deep snow on adjacent grain fields and by snow-packed roads during the winter, 1971-72. Concentrations of cattle in feedlots resulted in exposed grit sources and partridge were seen pecking at cow chips and feeding in hay and straw distributed for cattle.

Muddy Creek rangelands had no partridge associated with them during the 1969-72 evaluation. Few partridge were observed in this vicinity during the entire study.

Partridge-agriculturally idle area associations ranked between first and third among the eight total land uses and were first among the five agricultural land uses. When partridge were associated with idle areas, in each season except fall, these areas tended to be the OS.

Farm/ranch sites had more associations with partridge in all seasons (35-46%), except summer (16%), than any other agriculturally idle sub-use. Idle areas with buildings were the second most common association summer through winter; this was probably related to their frequent occurrence with farm/ranch sites. Associations with these areas ranged from 19 (summer) to 29 percent (winter) of all idle area-partridge associations. The third most frequent association was with idle areas without buildings; they ranked first among all associations in summer and ranged from 15 (winter) to 34 percent (summer). The remaining major idle area categories ranked in order: irrigation ditches, fencelines, oil facilities and the railroad right-of-way. The first three of these latter areas were most frequently associated with partridge in summer and least frequently in winter. The railroad right-of-way received its greatest observed use by partridge in spring and the least use in fall.

Vegetation composition of idle areas with buildings ranged from 78 (winter) to 93 percent (summer) in grass or grass-forb categories. Idle without buildings contained 80 (winter) to 86 percent (fall) grass-domination in these communities. Fencelines were dominated by grasses during all seasons. The heavy use of grass-dominated over forb-dominated types (primary invaders of disturbed soil surfaces) suggested partridge inhabited more stable vegetation communities.

Land use/sub-use Availability vs. Use by Partridge

Relationships between partridge associated with various land uses and sub-uses were compared with those available during July 1969-June 1972. Three land uses (OS, NLU, 2NLU) associated with each partridge observation were used in these comparisons. Observations recorded along routes and at random were combined. Non-agricultural land uses (borrow pits, roads and trails) were deleted from the total associations in these comparisons. Use and sub-use associations were then compared, by season, with the 3-year total availability of uses and sub-uses along the four routes. Numbers of partridge observations associated with a given land use/sub-use were divided by the total miles of that land use/sub-use to yield a mean index of association per mile. Means for each of the 5 agricultural land uses and 25 sub-uses were determined separately and a mean of the means was computed for each of the 2 groups. Mean partridge density for each land use/sub-use was compared statistically, using a Z-test, with the mean for its group. Since standard deviations were unavailable for individual uses/sub-uses, Hamilton (pers. comm.) suggested the data might fit a Poisson distribution (Snedecor and Cochran 1967:223) and provided the following to test for differences between the two means:

$$Z = \frac{\bar{X}_i - \bar{X}_{1,k}}{(1-2/k)\bar{X}_i + \frac{\bar{X}_{1,k}}{k}}$$

where $\bar{X}_i$ = mean partridge density of a given land use/sub-use;

$\bar{X}_{1,k}$ = mean partridge density of all land uses/sub-uses; and

k = number of land uses/sub-uses.

Partridge densities for land uses/sub-uses plus individual Z-values are presented in Appendix XX.

Partridge associations with the 5 agricultural land uses and 25 sub-uses totaled 964 in spring, 866 in summer, 187 in fall, and 550 in winter. Statistical comparisons of mean seasonal partridge association-land use/sub-use with overall mean association-land use/sub-use are illustrated in Figure 34.

Partridge associations with grain did not differ significantly ($P \leq .10$) from its availability during any season. Although grain in seasonal diets of partridge exceeded one-half of total food volumes, other nearby land uses/sub-uses apparently influenced partridge occurrence on individual fields. Partridge were associated with barley significantly less than mean association of all land sub-uses in summer. Use of spring wheat by partridge was noticeably less than its availability in spring and winter. Partridge were associated with winter wheat in its approximate availability in all seasons except winter. Oats was the only grain species which was associated with partridge in proportion to its occurrences year round.

Partridge associations with fallow, as a land use, occurred in approximate anticipated occurrences during all seasons. As a sub-use, partridge association with fallow exceeded that of mean sub-use associations in spring, though not significantly ($P \leq .10$). Partridge

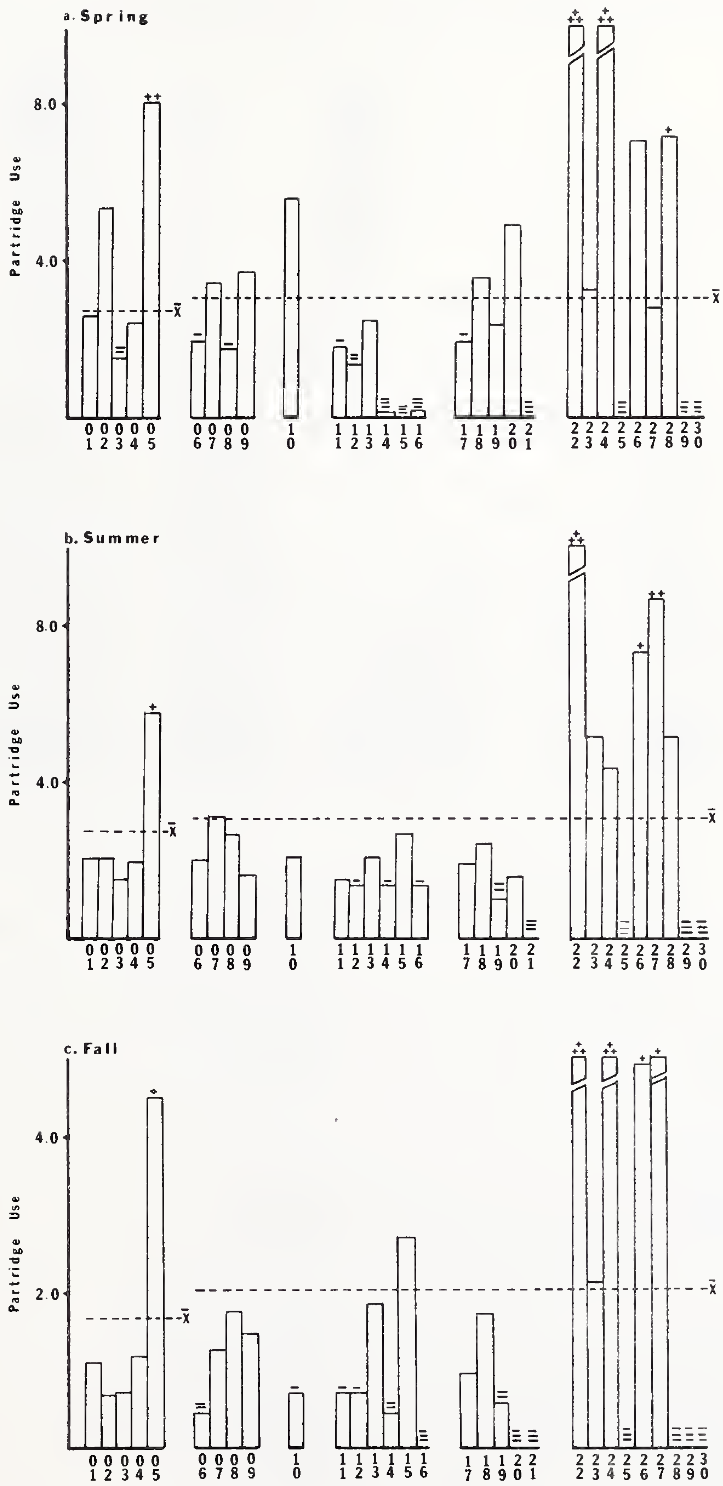
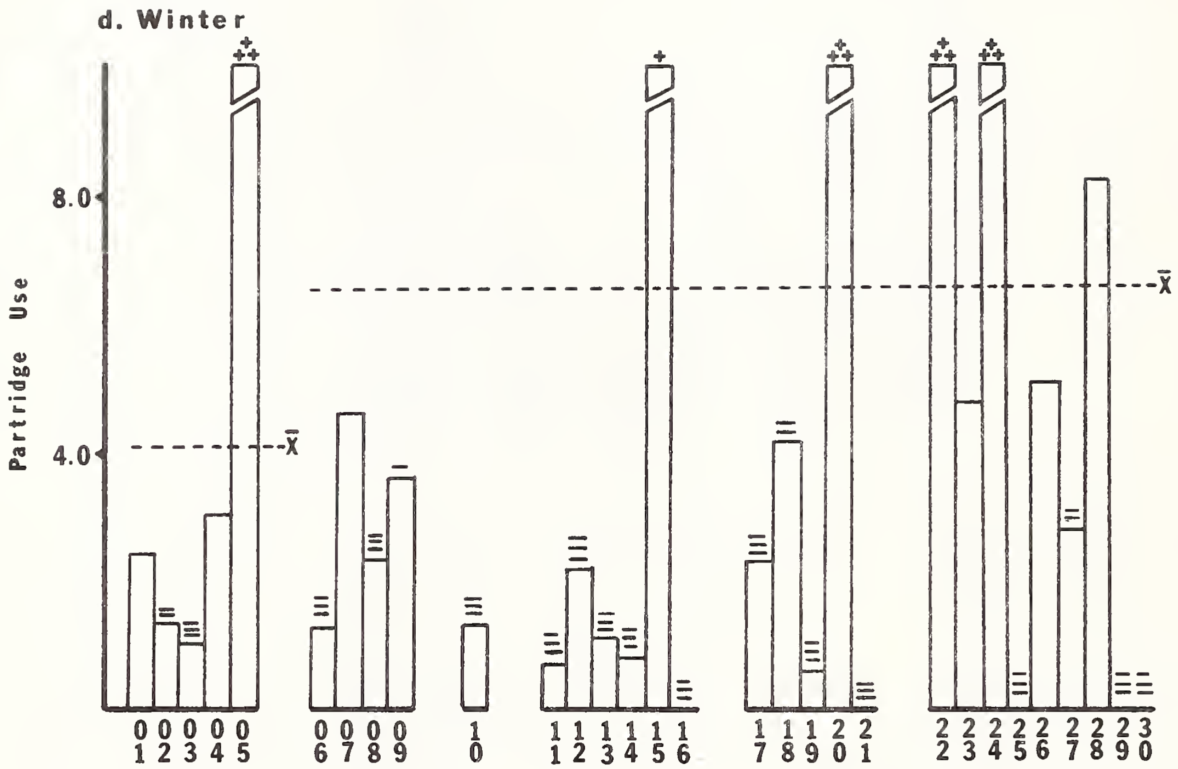


Figure 34. Partridge use - land use/sub-use relationships, by season, on the Agawam Study Area.



Key to Partridge-Land Use/Sub-use Associations

Significance Levels

	Above Mean	Below Mean
P ≤ .10	+	-
P ≤ .05	++	--
P ≤ .10	+++	---

Land Uses

01 Grain
02 Fallow
03 Hay
04 Range
05 Agriculturally Idle

Land Sub-uses
2

06 Barley
07 Oats
08 Spring Wheat
09 Winter Wheat

10 Fallow
11 Alfalfa

Sub-uses (cont'd)

12 Alfalfa-Grass
13 Grass-Alfalfa
14 Grass
15 Sanfoin
16 Sweetclover

17 Lowland
18 Upland
19 Seeded
20 Feedlot
21 Muddy Creek

22 With Buildings
23 Without Buildings
24 Farm/Ranch Site
25 Gravel Pit
26 Irrigation Ditch
27 Oil Facility
28 Railroad Right-of-Way
29 Soil Bank
30 Wetland

Figure 34. Continued.

occurred on or near fallow fields significantly less than expected with their availability in fall and winter.

Partridge were associated with hayfields less than the mean of all land uses but only in spring and winter were these associations significantly less than expected. Of the six hay types, only sanfoin was associated with partridge in greater than anticipated numbers. The partridge-sanfoin association was significantly greater than with mean land use; this was probably due to the one field of this hay species in proximity to a winter range. Alfalfa-dominated hayfields tended to be associated with the birds significantly less than expected. Partridge were associated with grass-alfalfa hay less than associations with mean land uses although only significantly so in winter. Grass and sweet clover associations were significantly less than was expected.

Range-partridge associations were less than those for overall land uses although none of the divergences were significantly different ($\pm$ P .10). Partridge showed high association with feedlots in winter, about average associations in spring and apparently used feedlots very little in fall. Partridge tended to be on or near lowland or upland ranges in less than expected frequencies; the birds showed slightly more association with upland than lowland ranges.

Partridge were associated with agriculturally idle areas in significantly greater than expected frequencies in all seasons; the highest degree of association occurred in winter. Partridge were associated more with idle areas with buildings than similar areas without buildings. Furthermore, their use of idle areas with buildings was highly, significantly ($P \geq .01$) greater than with mean land-use associations in all seasons. Associations of partridge with areas without buildings were greater than those with mean land uses in three seasons but none of these relationships were statistically significant. Greater use of areas with buildings than those without buildings was probably a function of area size, stability and human disturbances factors. Those with buildings (comprising $\geq$ 1 a or 0.40 ha), included shelterbelts, were uncultivated, ungrazed and experienced little human activity. Some also contained farming implements which provided additional protective cover. Areas without buildings were smaller (e.g. fencelines, field corners), occasionally cultivated, mowed or grazed and experienced more frequent disturbance by farming activities.

Partridge associations with farm/ranch sites were greater than for mean land-use associations in all seasons; this association was statistically significant ($P \geq .05$) in each season except summer. Partridge used these areas despite year-round disturbance by humans. Such areas, however, were "permanent" in the agricultural environment and most (90%) included one or more shelterbelts.

Irrigation ditch associations with observed partridge were greater than for mean land-use associations in every season except winter; in summer and fall, these associations were significantly greater ($P \geq .10$)

Dominant vegetational components on the ditches varied from 64 percent grasses in fall to 83 percent in summer. Partridge may have used ditches for their vegetational communities but this was probably secondary to land uses adjacent to the ditches. In spring when partridge were nesting, their association with ditches was simultaneously associated most frequently with hay and rangelands. During late nesting and brooding in summer, the other two land-use associations were grain and agriculturally idle areas. Hay and grain were most often associated with partridge and ditches in fall. Range, hay and idle areas were the other land-use associates of these birds in winter.

Partridge-gravel pit, -soil bank and -wetland associations were significantly less than with mean land-use associations. Non-use of the gravel pit and wetlands probably resulted from the lack of land-use diversity associated with each area. The soil bank area was grazed by livestock and later used as hayland (which was grazed after mowing), thus removing most of the protective value for partridge. High associations between partridge and oil facilities in summer and fall probably resulted from the undisturbed vegetative cover accompanying these sites. The railroad right-of-way in Agawam was associated with partridge observed in all seasons except fall; the abandoned townsite was used as a parking site for upland game bird hunters in fall and the birds may have retreated from this extraordinary disturbance.

Since partridge were associated with agriculturally idle areas in significantly greater occurrence than that of overall mean land uses and since none of the remaining four land uses exhibited such positive relationships, these areas appeared to be preferred or concentrated-use areas. Exceptionally high associations between partridge and idle areas in spring and winter suggested these areas were critical components of partridge habitat on the study area.

Distance to Different Land Uses

Mean distances between observed partridge and land uses other than the one on which they occurred were compared statistically (Q-test, P .05 unless otherwise specified) by month and season. These data were obtained between July 1969 and May 1972, inclusively.

Mean distances between 1,540 observed partridge groups and the nearest different land use showed little variation among months (Fig. 35). Seasonal mean distances and standard deviations were: spring, 10 ± 14 yd (9 ± 13 m); summer, 7 ± 9 m); fall, 10 ± 13 yd (9 ± 12 m); and winter, 9 ± 10 yd (8 ± 9 m). No significant differences occurred between any two monthly or seasonal means. Distances between observation site and nearest other land use ranged from 1 to 83 yd (1 to 76 m). Seasonally, 95 percent of the observed partridge were within 38 yd (35 m) of a land use different from the one on which they were observed.

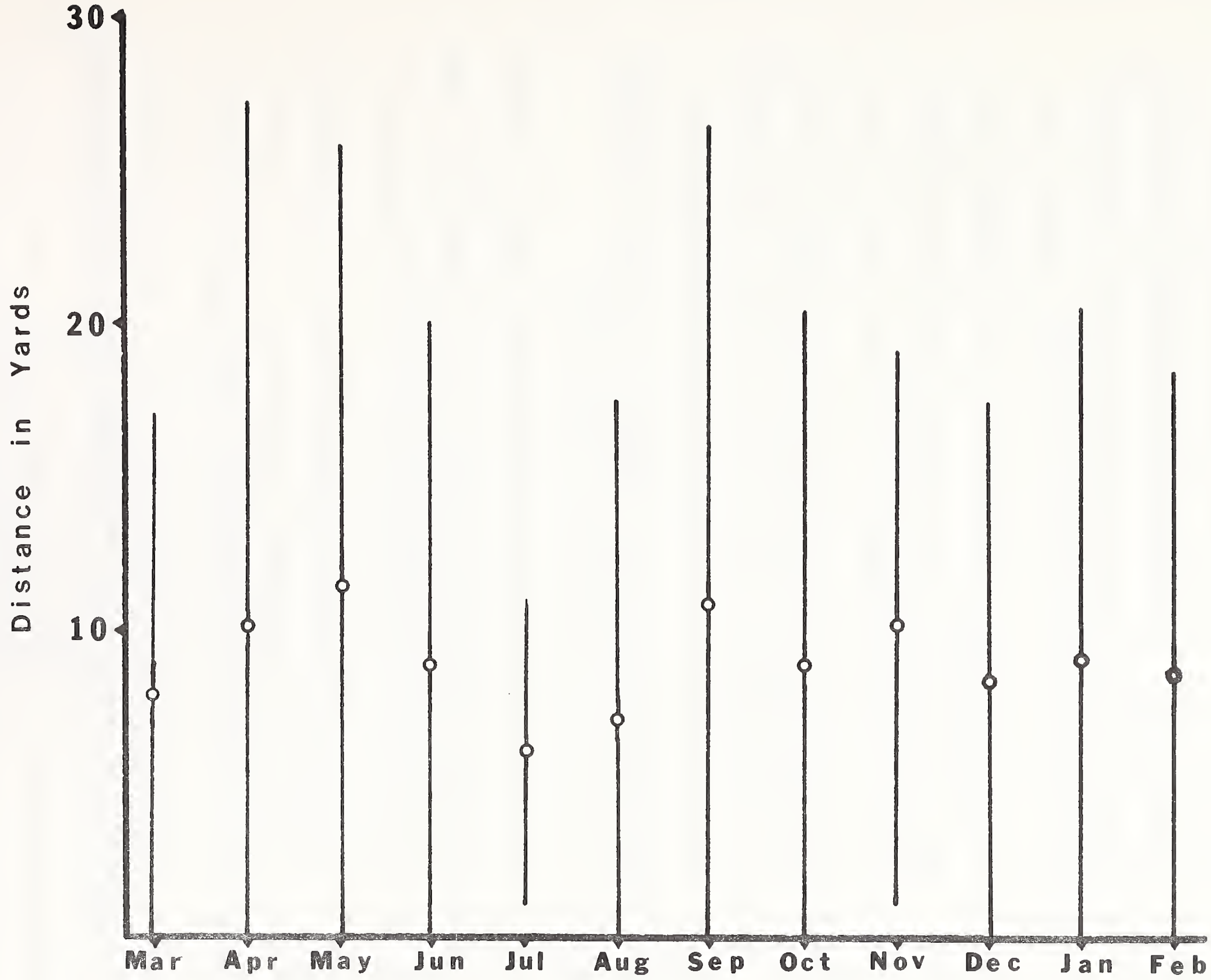


Figure 35. Mean distances (and standard deviations) between observed partridge and the nearest different land use, by month, 1969-72.

Mean distances between 1,532 partridge groups and the second, nearest different land use also showed little month-to-month variation except during spring (Fig. 36). There was a statistically significant reduction in distances between February and March while a significant increase occurred between March and April. Partridge tended to be closest to second different land uses in December and furthest from them in May. Mean distances and their standard deviations by season were: 27 ± 25 yd (24 ± 23 m) in spring; 23 ± 23 yd (21 ± 21 m) in summer; 26 ± 24 yd (24 ± 22 m) in fall; and 22 ± 18 yd (20 ± 17 m) in winter. Only the change between summer and fall was not statistically significant. Ninety-five percent of all partridge were within 77 yd (70 m) of a second different land use. Minimum and maximum distances recorded were 1 and 211 yd (1 and 193 m), respectively.

Numbers of land uses were recorded within a 100 yd (91.4 m) radius of each of 459 partridge observations during June 1971-May 1972. Similar data were enumerated for 40 additional observations beginning in November 1970. The area within each circle included 6.5 a (2.6 ha). Mean numbers of fields per observation, by season were 8.8 in spring, 7.6 in summer, 8.8 in fall and 9.7 in winter. The highest monthly mean number of fields within this circle occurred in February (10.2) while the lowest was in July (7.0). The fewest fields associated with any partridge group were 2 (April 1971) while the most were 18 (January 1971). These data plus those from distances measured to

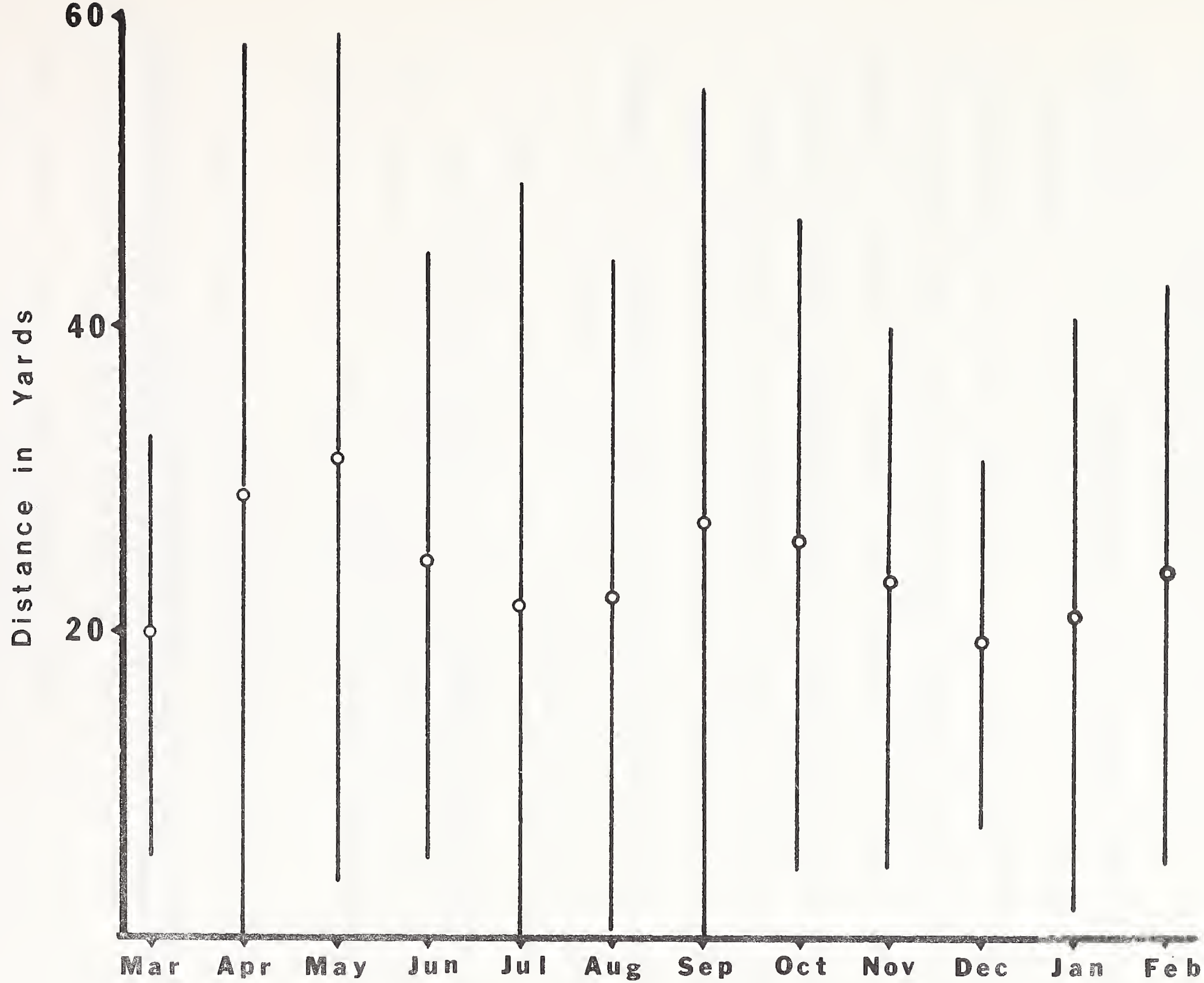


Figure 36. Mean distances (and standard deviations) between observed partridge and the second-nearest different land use, by month, 1969-72.

other land was associated with partridge supported Leopold's (1933:131) statement that "...game is a phenomenon of edges."

Due to heavy use of grain as food by partridge, distances were determined between observed birds and the nearest grain or fallow field. Partridge seemed to remain relatively close to grain or fallow during each month of the year (Fig. 37). They were closest to these types during June and July and furthest from them in March. The increase in distances from January to February, March to April and November to December were statistically significant. Maximum distances from grain occurred in August (1,338 yd or 1,224 m) and September (1,154 yd or 1,055 m). Seasonal mean distances and standard deviations to grain-fallow were: 65 $\pm$ 131 yd (59 $\pm$ 120 m) in spring; 50 $\pm$ 121 yd (46 $\pm$ 111 m) in summer; 73 $\pm$ 158 yd (67 $\pm$ 145 m) in fall; and 63 $\pm$ 125 yd (58 $\pm$ 114 m) in winter. None of the seasonal means differed significantly between adjacent seasons but the summer to fall increase was significant (t = 1.94, P .10). Ninety-five percent of 1,448 partridge groups were observed within 389 yd (356 m) of a grain or fallow field in any given season.

The mean distance 1,539 partridge groups were observed from all types of woody cover showed considerable variation from month to month (Fig. 38). Birds were closest to this type during December-March and furthest from it in July. Some groups were observed within woody cover in every month and the maximum distance from it (2,640 yd or 2,414 m)

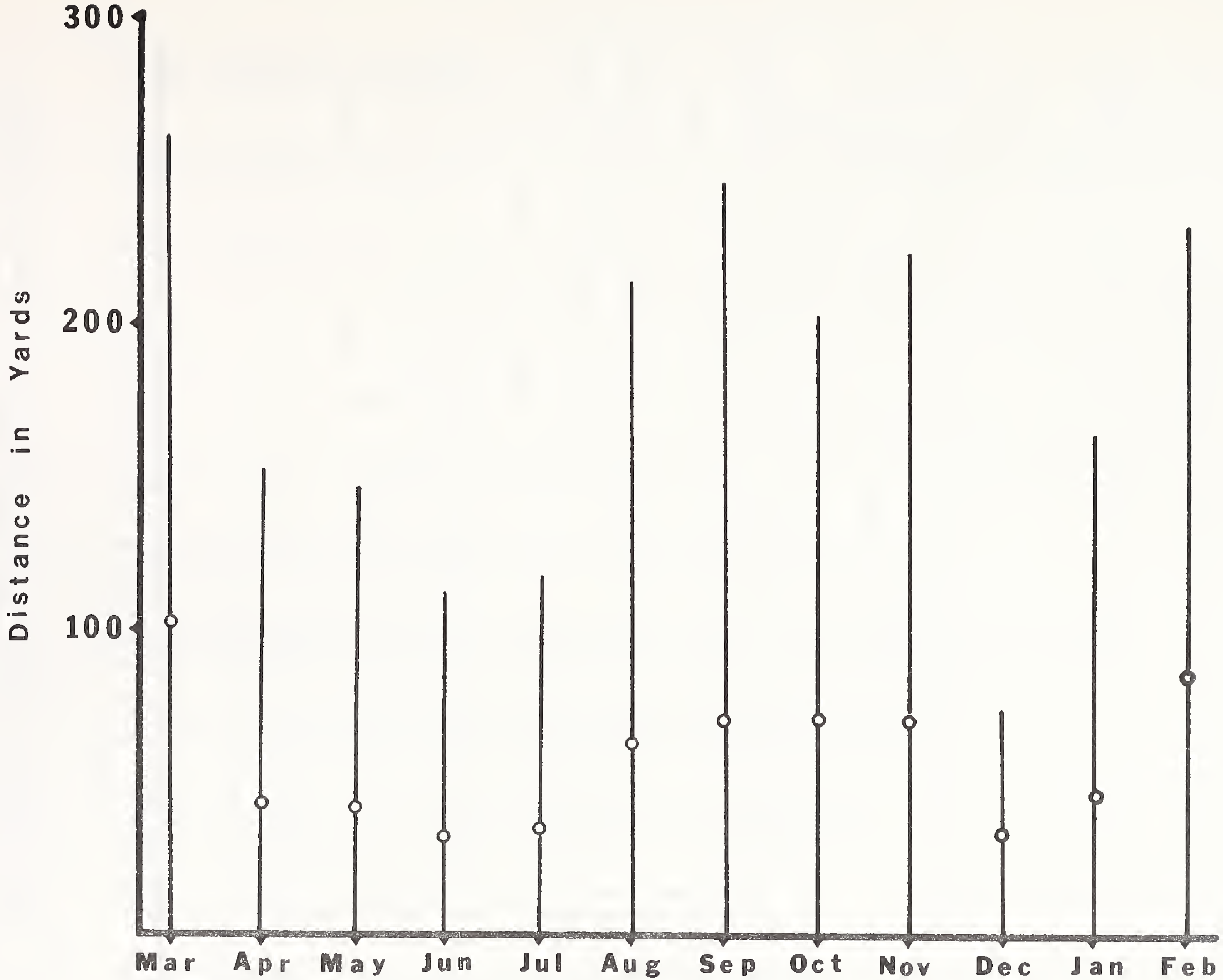


Figure 37. Mean distances (and standard deviations) between observed partridge and the nearest grain/fallow field, by month, 1969-72.

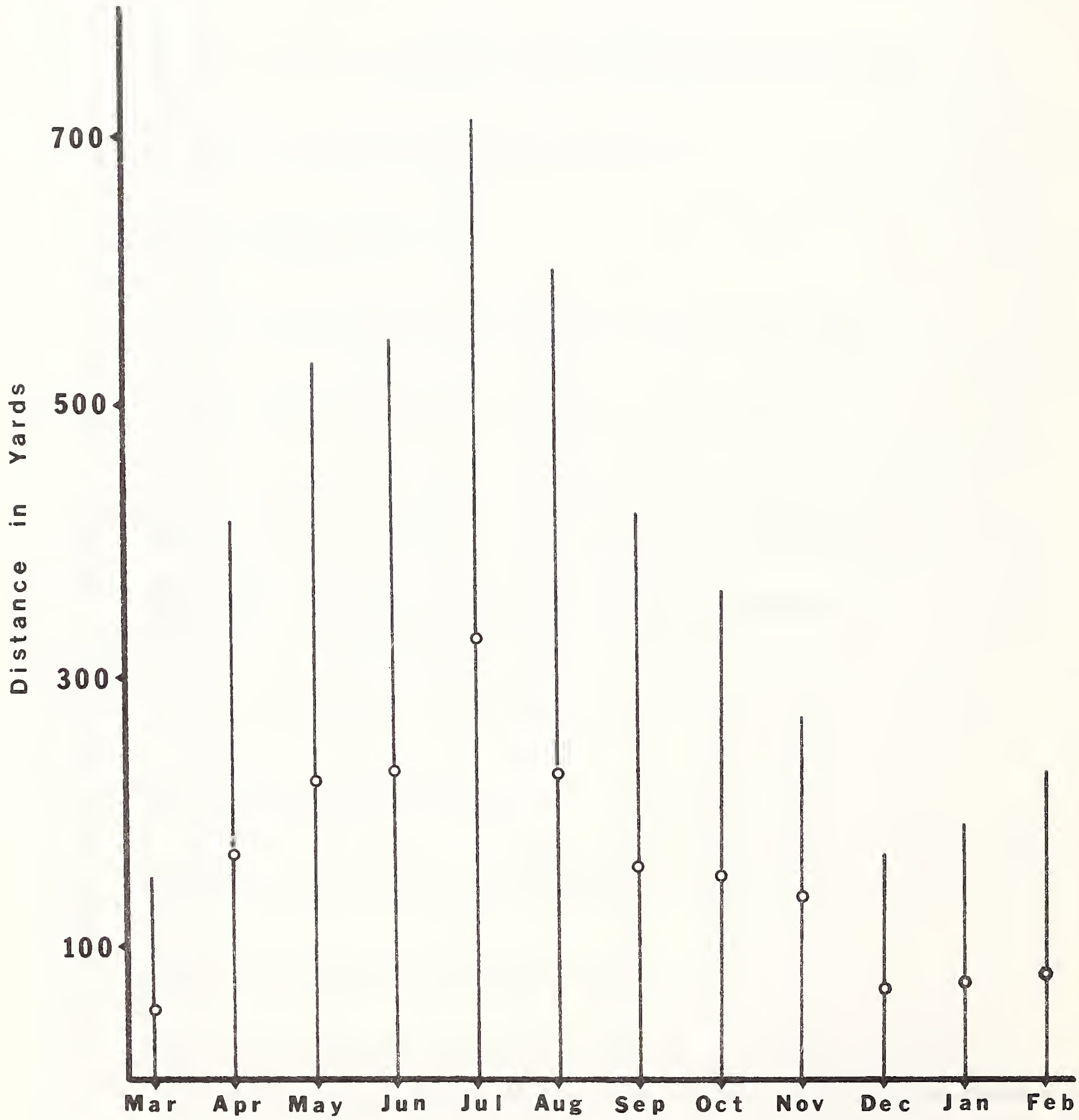


Figure 38. Mean distances (and standard deviations) between observed partridge and the nearest woody cover, by month, 1969-72.

occurred in August. Distance changes between March and April, June and July, July and August, and November and December were statistically significant. Mean distances, by season, and standard deviations were: spring, 147 $\pm$ 243 yd (134 $\pm$ 222 m); summer, 257 $\pm$ 363 yd (235 $\pm$ 332 m); fall, 150 $\pm$ 227 yd (137 $\pm$ 208 m); and winter, 76 $\pm$ 128 yd (70 $\pm$ 117 m). Each seasonal mean was significantly different from adjacent seasonal means. Ninety-five percent of partridge observed in any season were within 983 yd (899 m) of some kind of woody cover.

The increasing distances partridge were seen from woody cover between March and July with a subsequent decrease to December generally agreed with availability of other protective cover. Developing herbaceous and grass cover could have been substituted for woody vegetation in providing protective cover until late July when dessication of the former types began. Harvest of grains, beginning in late July, would have reduced available protective cover even further. In west central Saskatchewan, Hunt (1974) reported high use of single-row shrubbelts by partridge pairs in spring and use decreased as the distance from an end or break increased. Ten of 20 located nests were in these hedgerows and 7 of the 10 were within 90 m (98 yd) of an end or break. Partridge left the hedgerow communities in fall, apparently to seek more adequate woody cover in which to winter.

Partridge proximity to woody cover in winter appeared to be influenced by weather and ground conditions. Partridge were less mobile early in milder than average (1969-70) and average (1970-71) winters than in a severe winter (1971-72). December may have represented the month of least mobility. In January birds began moving away from woody cover. Recurrence of severe winter conditions caused the birds to resume close association. This association became even closer in March in each year. A more drastic reduction in distances, February-March in 1971, reflected the easing of winter conditions in February which permitted birds to move further away from woody cover that year.

Mean distances between 1,523 observed partridge groups and the nearest winter range were also determined. Considerable month-to-month changes in these distances were noted with those between March and April, July and August, August and September, and November and December being significantly different (Fig. 39). Some partridge were recorded on winter ranges during each month. Partridge were, expectedly, in closest association with winter ranges during December and January; they were furthest from these areas in July. The greatest distance a partridge group was observed from a winter range was 2,640 yd (2,414 m), in August. Mean seasonal distances to winter ranges were: spring, 221 yd (202 m); summer, 460 yd (421 m); fall 264 yd (241 m); and winter, 59 yd (54 m). Each seasonal mean was significantly different from adjacent means. These data indicated that 95 percent of the observed partridge in this low density population remained within 1,000 yd (914 m) of a winter range throughout the year.

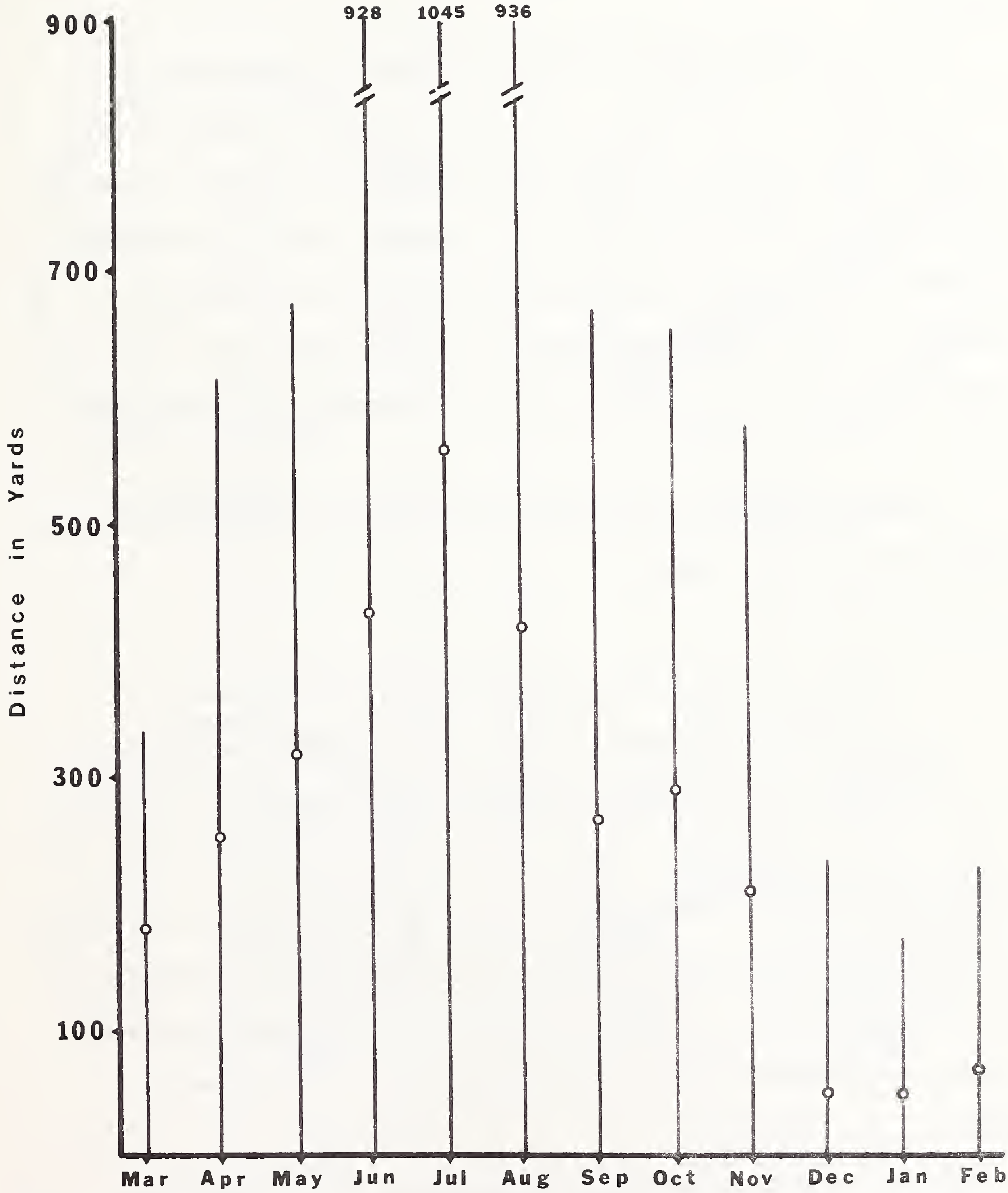


Figure 39. Mean distances (and standard deviations) between observed partridge and the nearest winter range, by month, 1969-72.

Diversity

Numbers of edge contacts between different land uses were also counted within a 100-yd radius of each of the 499 partridge groups. Seasonal mean numbers of contacts per observation were 10.4 in spring, 8.2 in summer, 8.9 in fall and 11.7 in winter. Monthly mean numbers of edge contacts were greatest in February (12.0) and lowest in September (7.6). The lowest numbers of field contacts for a partridge group was 1 (April 1971) while the highest was 23 (December 1971).

A land-use diversity index (DI) was determined for each partridge group's 6.5-a circle using:

$DI = F\ (EC + U)$,

where F = the number of different land uses/sub-uses;

EC = the number of edge contacts between two land uses

U = the number of land-use units involved in determining EC

F was considered the most constant of the three variables; it provided the escalating determinant as overall land-use diversity increased, and it appeared to more adequately describe the land-use complex surrounding the birds. Application of this formula is illustrated in Figure 40.

Land-use diversity indices were determined for 499 partridge groups between November 1970 and May 1972, inclusively (Table 55).

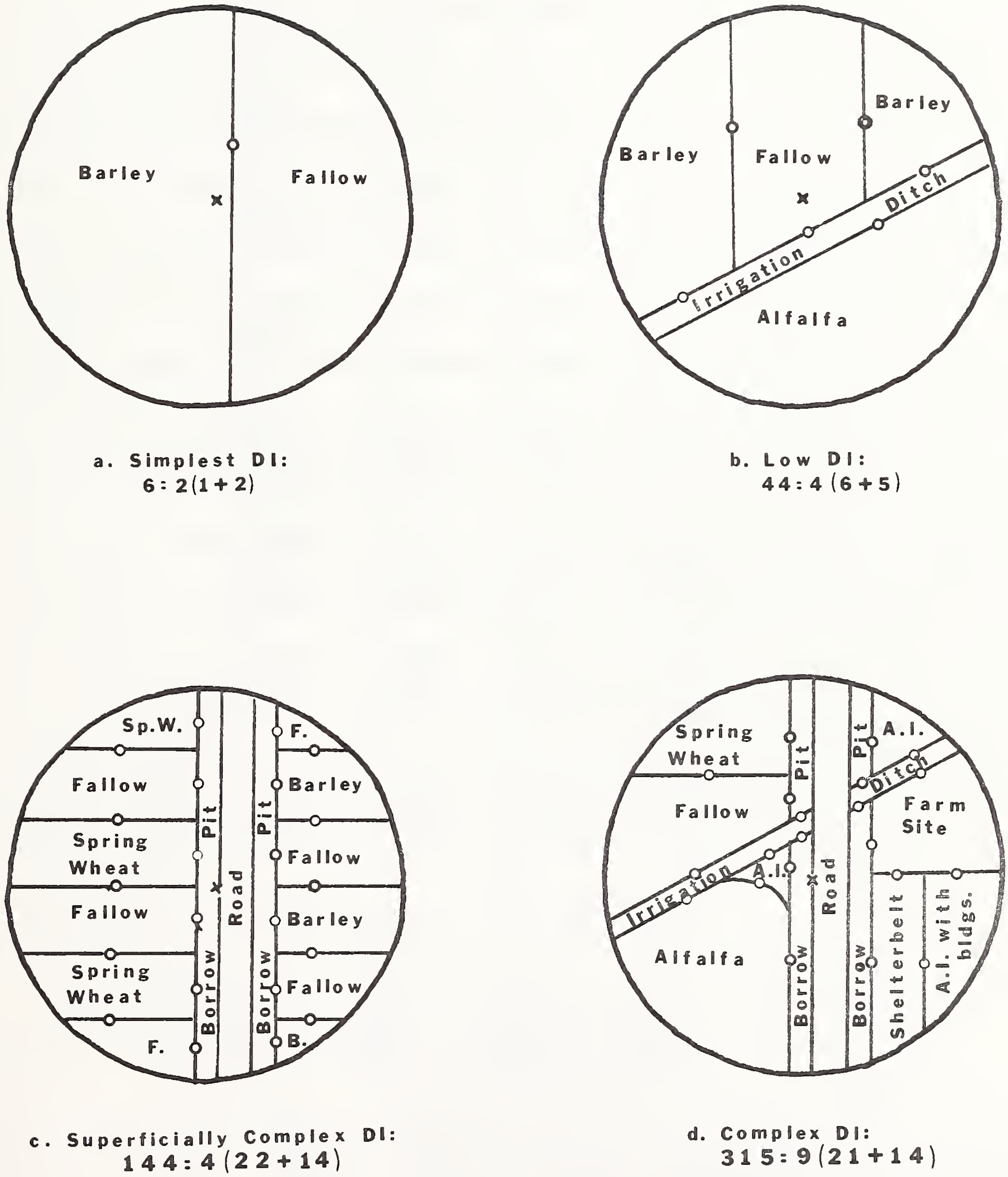


Figure 40. Four increasingly complex land-use diversity indices.

Table 55. Land use diversity indices determined for 499 partridge groups, by month and season, on the Agawam Study Area.

Season: Month		No. Groups	Diversity Index 1 - 50	51-100	101-150	151-200	201-250	251-300	301+	Mean
Spring:[1]										
March		75	5(6.7)[2]	12(16.0)	29(38.7)	19(25.3)	4(5.3)	6(8.0)	0(-)	139.6
April		31	8(25.8)	9(29.0)	9(29.0)	3(9.7)	0(-)	0(-)	2(6.5)	138.6
May		32	10(31.3)	11(34.4)	8(25.0)	2(6.2)	1(3.1)	0(-)	0(-)	85.5
	Totals	138	23(16.7)	32(23.2)	46(33.3)	24(17.4)	5(3.6)	6(4.3)	2(1.4)	126.8
Summer:										
June		15	7(46.7)	5(33.3)	1(6.7)	2(13.3)	0(-)	0(-)	0(-)	76.5
July		27	11(40.7)	8(29.6)	4(14.8)	3(11.1)	1(3.7)	0(-)	0(-)	79.8
August		80	27(33.7)	25(31.3)	14(17.5)	7(8.7)	6(7.5)	1(1.3)	0(-)	88.3
	Totals	122	45(36.9)	38(31.1)	19(15.6)	12(9.8)	7(5.7)	1(0.8)	0(-)	84.9
Fall:										
September		26	12(46.2)	4(15.4)	6(23.1)	3(11.5)	1(3.8)	0(-)	0(-)	80.0
October		21	5(23.8)	4(19.0)	5(23.8)	6(28.6)	1(4.8)	0(-)	0(-)	116.5
November[3]		15	2(13.3)	7(46.7)	2(13.3)	3(20.0)	0(-)	1(6.7)	0(-)	106.1
	Totals	62	19(30.6)	15(24.2)	13(21.0)	12(19.4)	2(3.2)	1(1.6)	0(-)	98.7
Winter:										
December		59	8(13.6)	11(18.6)	12(20.3)	20(33.9)	5(8.5)	3(5.1)	0(-)	138.2
January		43	4(9.3)	13(30.2)	8(18.6)	11(25.6)	4(9.3)	2(4.7)	1(2.3)	134.2
February		75	8(10.7)	12(16.0)	19(25.3)	22(29.3)	11(14.7)	2(2.7)	1(1.3)	145.9
	Totals	177	20(11.3)	36(20.3)	39(22.0)	53(29.9)	20(11.3)	7(4.0)	2(1.1)	140.6

[1]Monthly samples included data from 1971 and 1972.
[2]Percent.
[3]November sample included data from 1970 and 1971.

The greatest diversity was associated with partridge in winter and the least was in summer. The greater diversity in winter probably resulted from more numerous, smaller and different land uses (e.g. agriculturally idle areas; shelterbelts, farm/ranch sites) included within winter ranges. Although monthly sample sizes were small, partridge appeared to shift from less diverse summer ranges to more complex winter ranges in October and November, the movement being completed by December. The shift away from diverse winter ranges apparently occurred late April-early May. The apparent lesser diversity in summer and early fall suggested the mobility of adult groups and older broods permitted use of these areas with retreat to more diversified areas as needed. Ninety-five percent of observed partridge were in 6.5-a areas with DI's of 54 - 183 in spring, 26 - 144 in summer, 36 - 162 in fall, and 75 - 206 in winter. The lowest land-use diversity index (6=2(1+2)) was recorded for two groups in April 1971 while the highest index (351 = 9 (20+19)) occurred in February 1972.

Nest Sites

Four of the ten partridge nests located were in hay fields (3 in alfalfa, 1 in grass), two were grass-dominated agriculturally idle areas without buildings, two in grass-dominated lowland ranges, one in homogenous smooth brome in a borrow pit and one in spring wheat stubble. Vegetation concealing nests was grass plants at five sites and forbs at the remaining sites. Nearest different land uses were upland ranges (3), spring grain (3), hay (2), a fenceline and an irrigation ditch. The second nearest, different land uses were grain fields (4), upland ranges and borrow pits (2 each), an irrigation ditch and an idle area; each area was grass-dominated. Mean distance to NLU's and 2NLU's were 31 yd (range 7-95 yd; 28 m, and 6-87 m) and 72 yd (range, 10-157 yd; 66 m, 18-144 m), respectively. Nearest winter ranges averaged 493 yd (range, 0-1,400 yd; 451 m, 0-1,280 m) from nest sites. The mean distance to a grain-fallow field was 94 yd (86 m); one bird nested in grain stubble and the furthest distance was 360 yd (329 m).

In Michigan and Wisconsin, hayfields contained the largest proportions of partridge nests while roadsides, fences and grain fields were of secondary importance (Yeatter 1934:27; McCabe and Hawkins 1946:18; and Gates 1973:4). While hayfields also contained the most nests in eastern Washington, rangelands were the second most important nesting areas and wheat stubble was third (Knott et al. 1943:285). In Michigan, Yeatter (1934:30) also reported 89 percent of located nests were in grass-dominated units whereas brush piles (8%) and forb-dominated growth (3%) comprised the remaining sites. McCabe and Hawkins (1946:18), in Wisconsin, found grasses dominated the vegetation surrounding 49 percent of located nests and forbs dominated remaining sites. Gates (1973:4), also in Wisconsin, noted 23 of 28 nests in non-hay vegetation depended on bluegrass and/or quackgrass for concealment. Ordal (1952: 29) in Minnesota, observed nesting cover usually consisted of grasses; while there appeared to be a preference for natural grass areas, many nests were in domestic hayfields.

Habitat

Partridge habitat was defined by clustering and discriminant analyses of land uses/sub-uses of sixteen 40 a (16 ha) compartments centered about each partridge observation, 1969-72. A basic assumption of these analyses was that the habitat cluster with the greatest number of partridge observations was *in fact* the best partridge habitat (Class I). That cluster containing the second-largest number of partridge observations then included fair or intermediate habitat (Class II) and the cluster with fewest observations was poor or marginal habitat (Class III).

This assumption is obviously invalid *if* the highly favored habitats are in very limited supply. If the assumption is invalid, clusters with fewest partridge observations were in Class I habitats, Class II continued to be intermediate and Class III contained the most partridge observations. However, it seemed illogical that highest partridge observations would occur year round in the poorest habitat since security levels would be low and most of the population would probably be eliminated. This might explain the drastic population declines in spring but would contradict mortality rates indicated for other seasons. The cluster-analysis assumption was therefore accepted as valid.

Habitat Descriptions

Class I

Annual home ranges of partridge in these habitats apparently contained optimal land use/sub-use components and juxtaposition. Changes in shape of seasonal habitats (Fig. 41) suggested that even birds in primary habitat moved about to fulfill their nutritional and cover needs.

The amount of grain-fallow remained relatively constant during winter-summer but then increased noticeably in fall. Proportionately more of the total land uses/sub-uses were in grain all year in Class I habitat than in the other classes. Increases in grain-fallow were primarily at the expense of rangeland and secondarily of hayland.

Hayland showed a decrease in land-use composition from spring to winter. In fall and winter, Class I habitat contained less hayland than the other classes but was intermediate during the other seasons. Of the three habitat classes, this class contained the least proportion in each of the four main hay types in all seasons except that alfalfa-dominated hay was of intermediate ranking in spring and summer.

Rangeland composition remained fairly stable during winter-summer and was lowest in fall. Upland range comprised the greatest proportion of rangeland types in summer-winter and the least in spring. Seeded ranges were highest in composition in summer and winter. Corrals and

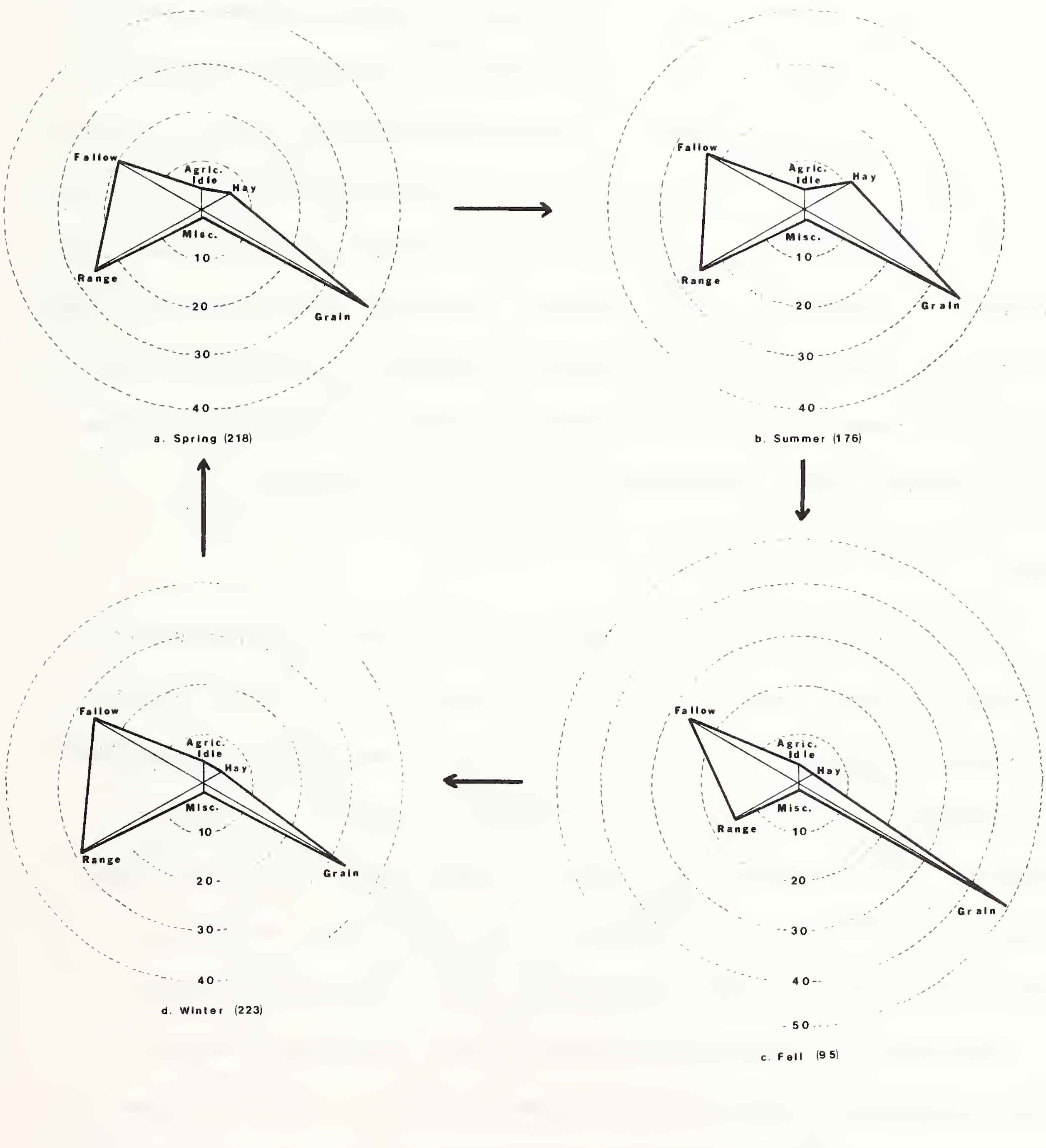


Figure 41. Class I habitat composition by season. Sample size in (); numbered rings are percents.

feedlots were most limited in Class I. Wooded rangelands did not appear in any habitat class during any season.

Agriculturally idle areas were most prevalent in summer and winter and the least in fall. Class I habitats had the highest composition of farm/ranch sites (spring-fall), fencelines (summer-winter), shelterbelts/trees (all year), idle areas without buildings (summer and winter) and oil facilities (fall-winter). These sub-uses ranked not less than intermediate between the other habitat classes in other seasons. Railroad rights-of-way occurred in greatest composition in spring, intermediate in summer and winter, and least in fall. Irrigation ditches were in their lowest proportion in this class all year.

Class II

Composition of major land uses in this habitat class remained relatively stable throughout the year (Fig. 42). Grain and fallow collectively represented about one-third of all land uses. It contained more hayland than the other classes except in winter. Alfalfa-dominated hay occurred at its maximum composition, among the habitat classes, year round in this class. Grass-alfalfa hay was proportionately higher here in summer and winter than in the other classes.

There was a slightly increasing trend in rangeland composition during spring-fall with the annual low in winter. Lowland ranges and corrals/feedlots attained highest proportional composition of all habitat classes in spring-fall and were intermediate only in winter.

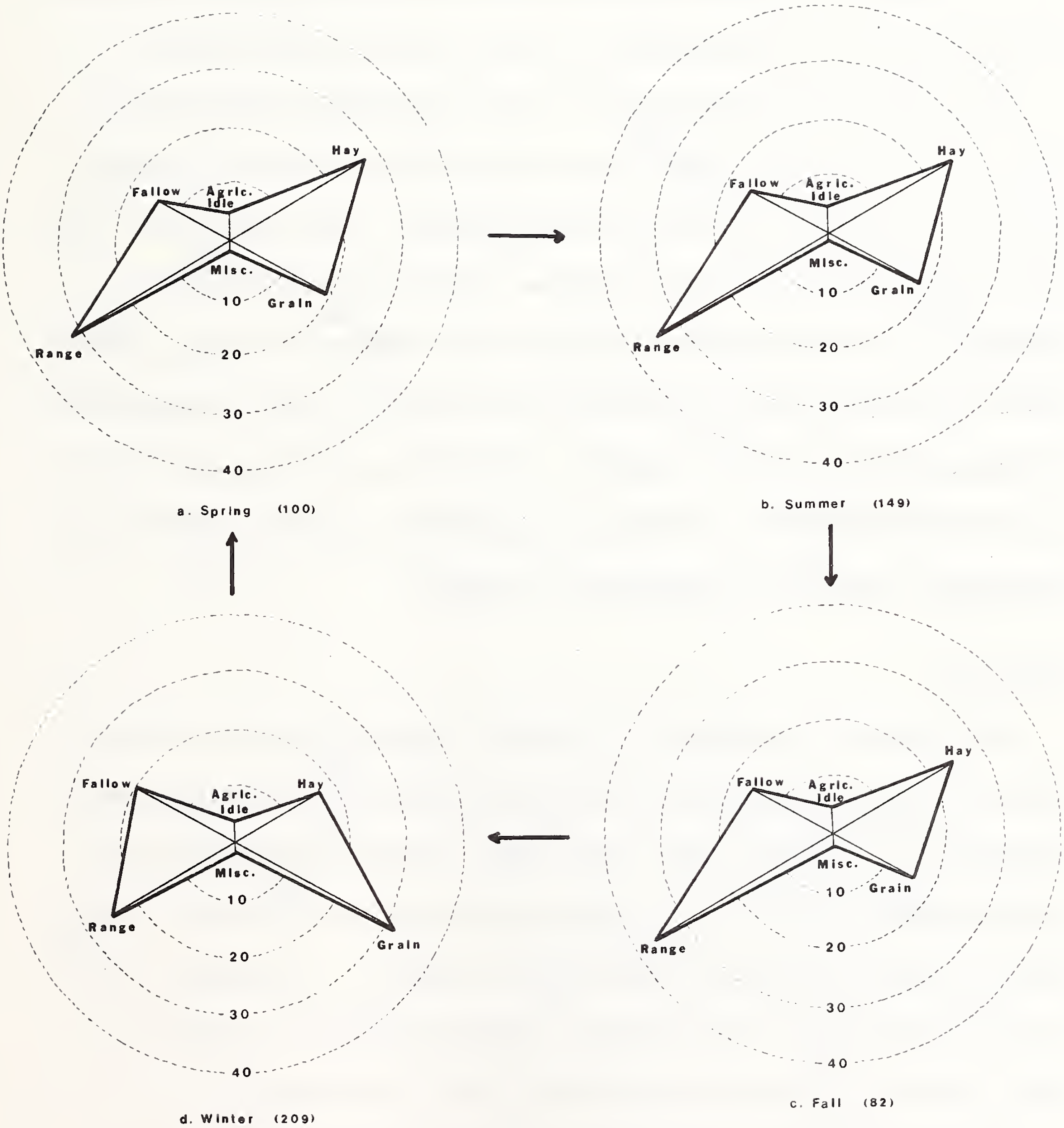


Figure 42. Class II habitat composition by season. Sample size in (); numbered rings are percents.

Seeded ranges were highest in winter-spring, intermediate in fall, and lowest in summer. Upland ranges occurred in proportionately intermediate composition in spring-summer and were lowest in fall-winter.

The highest agriculturally-idle area composition, spring-fall, occurred in Class II habitats; the highest value occurred in spring, gradually declining to an annual low in winter. Idle areas with buildings (summer-fall), irrigation ditches (spring-fall) and railroad rights-of-way (summer-winter) attained their highest seasonal, proportionate rankings in Class II habitat; they were at least intermediate in ranking during the other seasons. Fencelines, shelterbelts/trees, and oil facilities were of lowest proportionate, seasonal rank during spring-fall; they were intermediate in winter.

Class III

The greatest fluctuation in land-use composition of all habitat classes occurred in this class, probably reflecting the wide seasonal variability in security levels (Fig. 43). Seasonal habitat polygons resembled those of Class I in spring and Class II in fall and winter while a unique configuration was noted in summer. The highest proportion of grain-fallow was recorded in Class II habitats in spring and summer while it was intermediate during the other seasons.

Hayland composition was lowest in summer and highest in winter. This class contained less hayland than the other classes in spring and

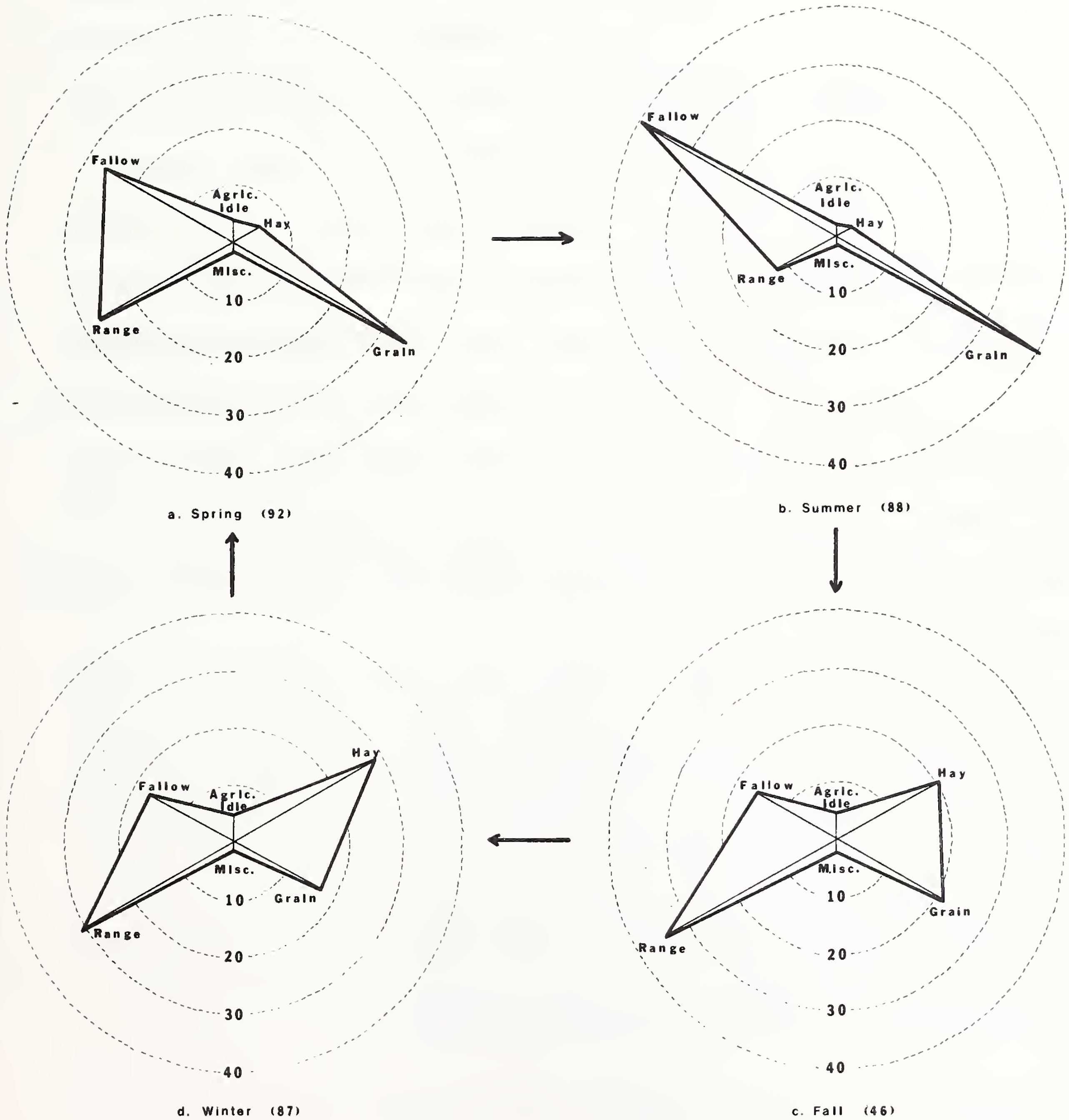


Figure 43. Class III habitat composition by season. Sample sizes in (); numbered rings are percents.

summer, was intermediate in fall and was greatest in winter. Grass hay was in its greatest proportionate composition, of all habitat classes, during fall-spring. Grass-alfalfa hay was highest in the habitat class rankings in spring and fall. Alfalfa dominated hay showed its lowest seasonal habitat compositions except in winter when it was highest.

Rangeland composition varied widely with a low in summer and high in fall. No distinct seasonal range sub-use composition pattern was noted; upland ranges ranked highest of the habitat classes in spring, upland and seeded were highest in fall, and lowland and corrals/feedlots were highest in winter. Conversely, upland ranges were lowest in summer, seeded were lowest in winter and spring, and corrals/feedlots were lowest spring through fall. Lowland ranges ranked lowest during spring and summer.

Agriculturally idle area composition of all habitat classes was lowest spring and summer, intermediate in fall and highest in winter. Highest composition occurred in idle areas with buildings in winter-spring, fencelines in spring, irrigation ditches in winter and oil facilities in spring-summer. Idle areas with the lowest proportionate seasonal rankings included those without buildings (spring-summer), those with buildings (summer-fall), farm/ranch sites (summer-winter), and shelterbelts/trees and railroad rights-of-way (summer-winter).

Habitat Cluster Determinants

Step-wise discriminant analysis indicated which of the 48 land use/

sub-use variables were most significant in determining spatial relationships segregating the three habitat clusters. The 5 most important uses/sub-uses and their variables are presented in Table 56. Partridge associations for percent composition of individual uses/sub-uses showed both close association and avoidance were involved in cluster determinations. Seasonally and annually, agriculturally idle areas represented 2 or 3 of the characterizing sub-uses while grain and fallow occurred once or twice. The 5 most important annual variables were approximated from rank-occurrence in the top 10 variables.

Habitat Dynamics

Seasonal composition differences of land uses/sub-uses of each habitat class suggested habitat descriptions were not rigid. The habitat of each partridge group may be compared to an amoeba, with the group forming the mobile "nucleus." Extensions and indentations of its periphery (i.e. "cell membrane") represent the mean composition of individual land uses/sub-uses. The inner habitat (i.e. "cytoplasm") represents the actual composition and juxtaposition of land sub-uses. Habitat composition changes with respect to quality, time and space, as the social status, composition and food and cover requirements of partridge groups change.

Inclusion or exclusion of a given habitat component in one habitat class resulted from interactions among other components within and between classes. To illustrate, assume the best habitat forms the

Table 56. The five most important seasonal land use/sub-use variables determining spatial relationships among the three clusters of partridge observations.

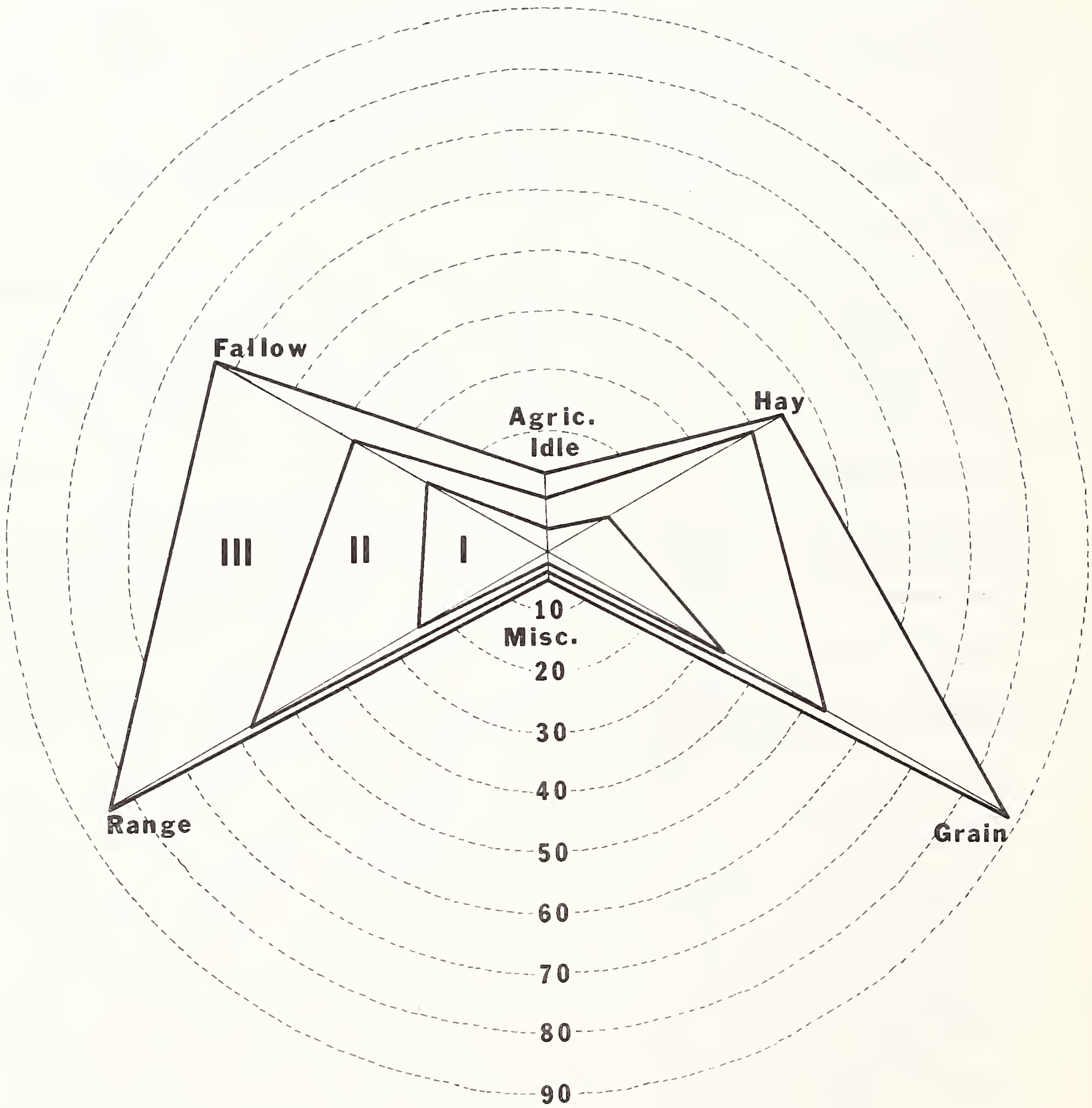
Season	Rank	Land use/sub-use	Variable[1]	Partridge Association[2]
Spring	1	Irrigation Ditch	Number	-
	2	Corral/Feedlot	Percent	Close (N.S.)
	3	Trail	Percent	-
	4	Borrow Pit	Number	-
	5	Shelterbelt/Trees (Idle w/)	Percent	Close (0.01)
Summer	1	Fallow	Percent	Avoid (N.S.)
	2	Grain	Percent	Avoid (N.S.)
	3	Idle w/Bldgs.	Percent	Close (0.01)
	4	Shelterbelt/Trees	Percent	Close (N.S.)
	5	Idle w.o./Bldgs.	Number	-
Fall	1	Grain	Percent	Avoid (N.S.)
	2	Oil Facilities	Number	-
	3	Corral/Feedlot	Number	-
	4	Idle w/Bldgs.	Percent	Close (0.01)
	5	Road/Highway	Percent	-
Winter	1	Alfalfa Hay	Number	-
	2	Alfalfa-Grass Hay	Number	-
	3	Idle w/Bldgs.	Percent	Close (0.01)
	4	Grain	Number	-
	5	Shelterbelt/Trees	Number	-
Annual (Est.)	1	Grain	Percent	-
	2	Irrigation Ditch	Number	-
	3	Idle w/Bldgs.	Percent	-
	4	Fallow	Percent	-
	5	Shelterbelt/Trees	Percent	-

[1]Mean number of use/sub-use units per 40 a compartment. Mean percent composition of use/sub-use per 40 a compartment.

[2]($P \leq$). As determined from Figure 34.

inner core of a 3-dimensional habitat mass. (Two-dimensional seasonal models, using land uses only, are presented in Fig. 44). This habitat is then surrounded by intermediate habitat which is, in turn, surrounded by poor habitat. The outer peripheries of the outer habitat classes may either accommodate or exaggerate those of the inner habitat class(es).

Peripheries of the inner habitat classes tend to be more flexible since, at least theoretically, they contain the best habitat. The Class III periphery tends to be more rigid since it defines the border between habitat and non-habitat. As the composition of Class I habitat changes between seasons, its periphery changes, excluding parts of some land uses and including parts of others. These changes are simultaneously reflected in composition changes in Class II and III habitats. However, effected changes in composition of the outer habitat classes are not necessarily proportional to land use/sub-use changes in Class I because juxtaposition of land uses/sub-uses also influences whether or not they are actually available. Perspective of habitat components by partridge also changes with vegetation phenology. Thus occupancy of components, vacated by Class I-habitat partridge, may occur by unsettled Class II-partridge or simply by non-inclusion in Class I habitat. Similar habitat component exchanges may occur between Classes II and III.



a. Spring

Figure 44. Cumulative land-use composition of three concentric habitat classes by season. Numbered rings are percents.

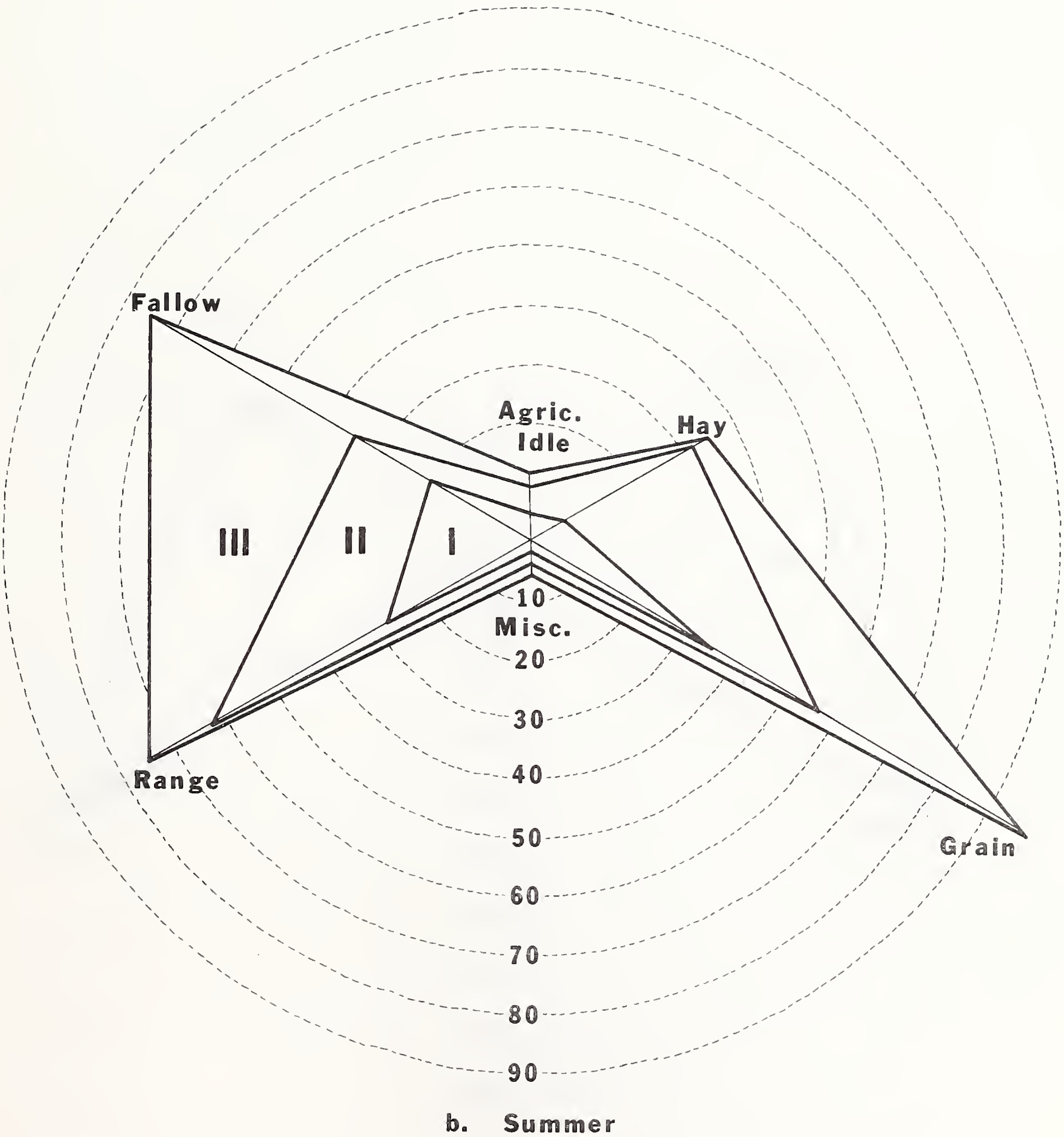


Figure 44. Continued.

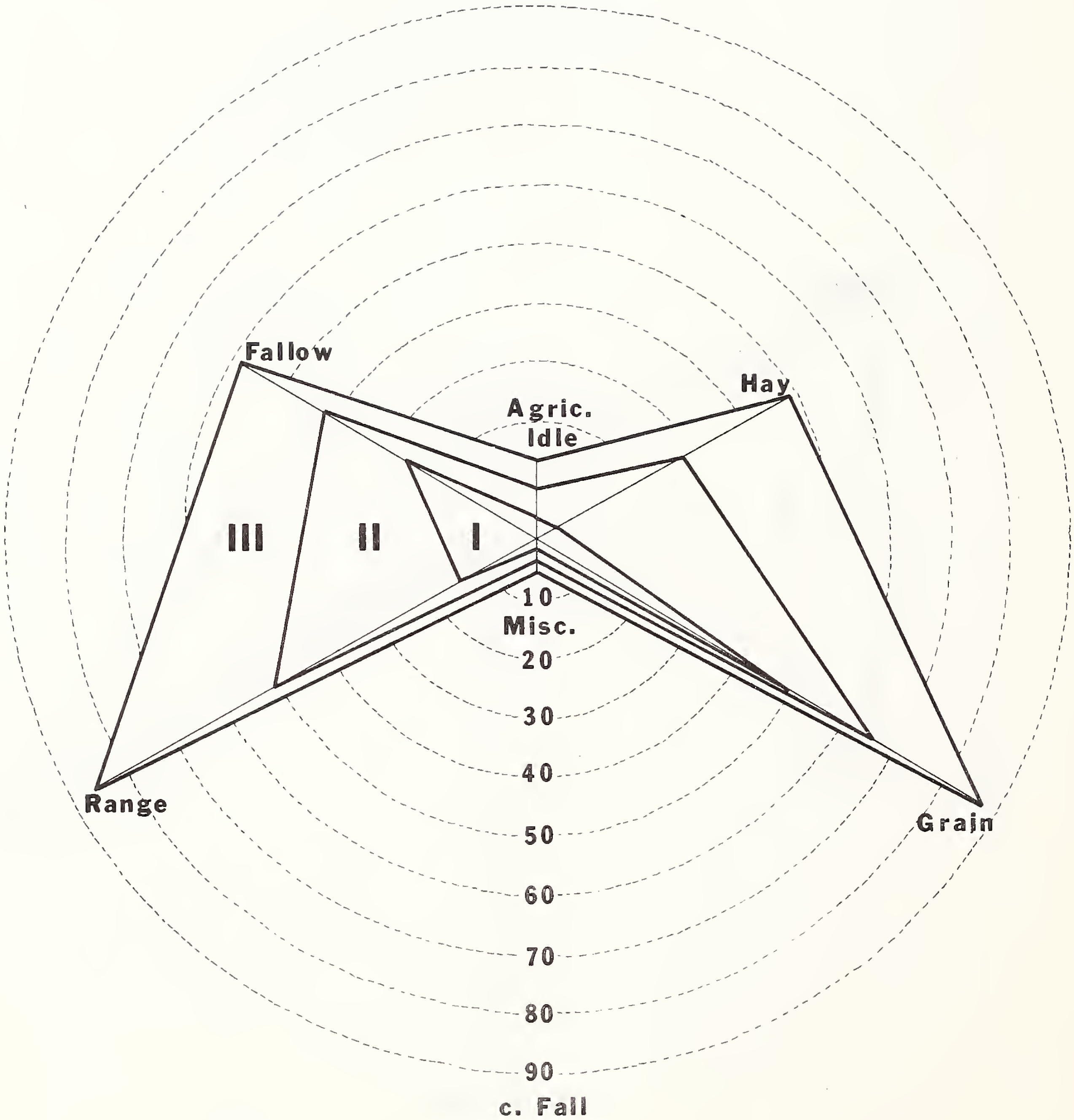


Figure 44. Continued.

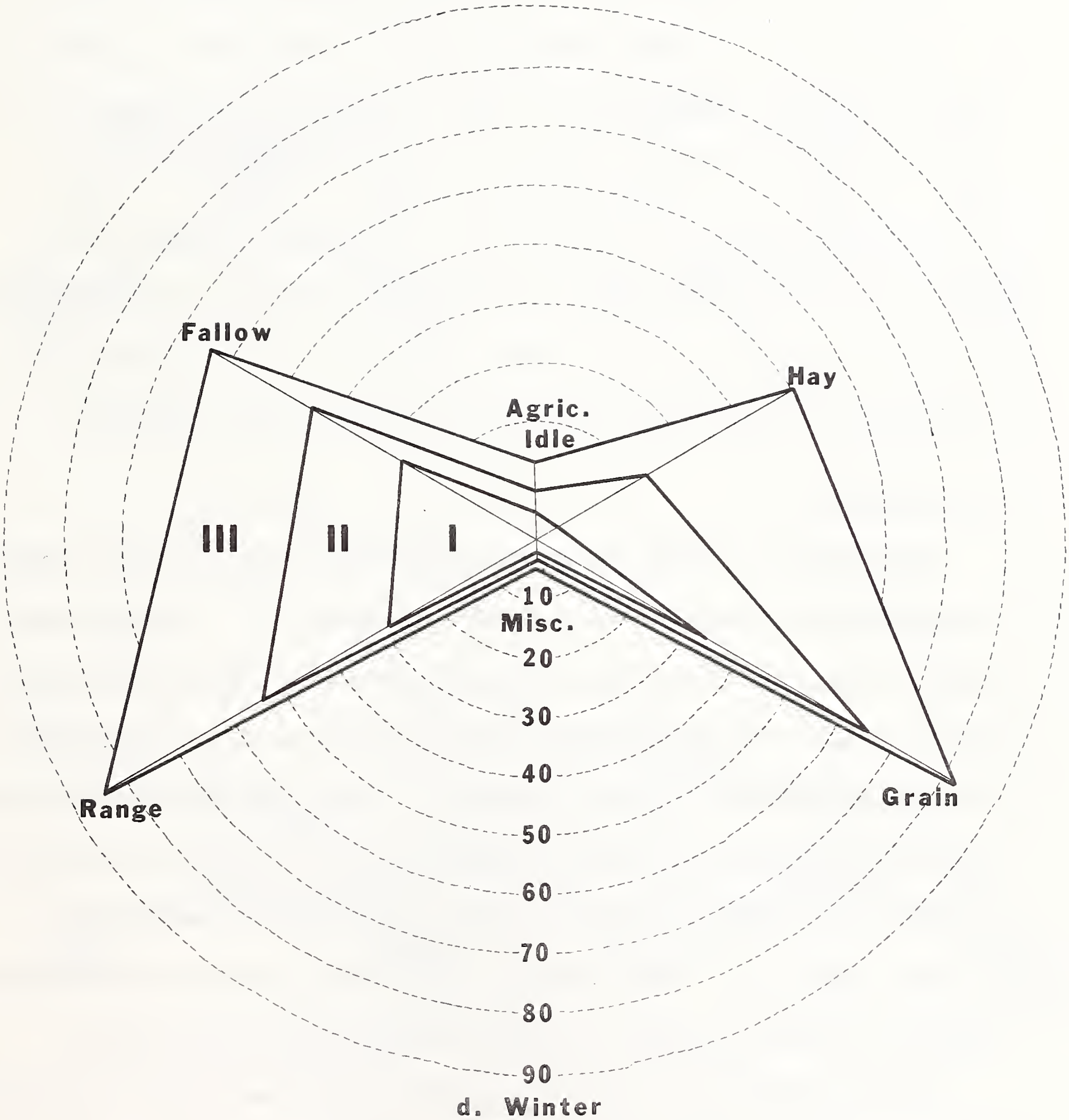


Figure 44. Continued.

Habitats of Selected Social Groups

Multivariate analyses of differences between habitat components of partridge social groups (within 160 a or 65 ha areas) in spring and summer tested the null hypotheses that the numbers and composition of land uses/sub-uses between social groups and months were the same. Since a limit of 20 land uses/sub-uses was imposed by the program, wooded rangelands, reservoirs and creeks were deleted; preliminary data scanning showed these did not occur within the defined habitat-size. Farm/ranch sites and shelterbelt/tree categories were combined.

Pair Habitat

Pair-habitat polygons revealed continuous month-to-month changes in proportions of the six major land uses (Fig. 45). Greater proportions of range and hay lands in early spring were replaced by grain and fallow by early summer. Maximum proportions of agriculturally idle and miscellaneous areas were noted in April. Only the April-June and May-June habitat comparisons met the conditions of the null hypothesis at $P \leq 0.04$ and habitat differences between other months were highly probable (Table 57). Pair habitat in March was consistently different from that occupied by pairs in other months during this period.

Habitat differences and similarities may be explained by partridge activities during this period. Pairs are searching for nesting areas in March. Those comprised of subadults, which form the largest age-segment of the population, have no previous nesting experience. The

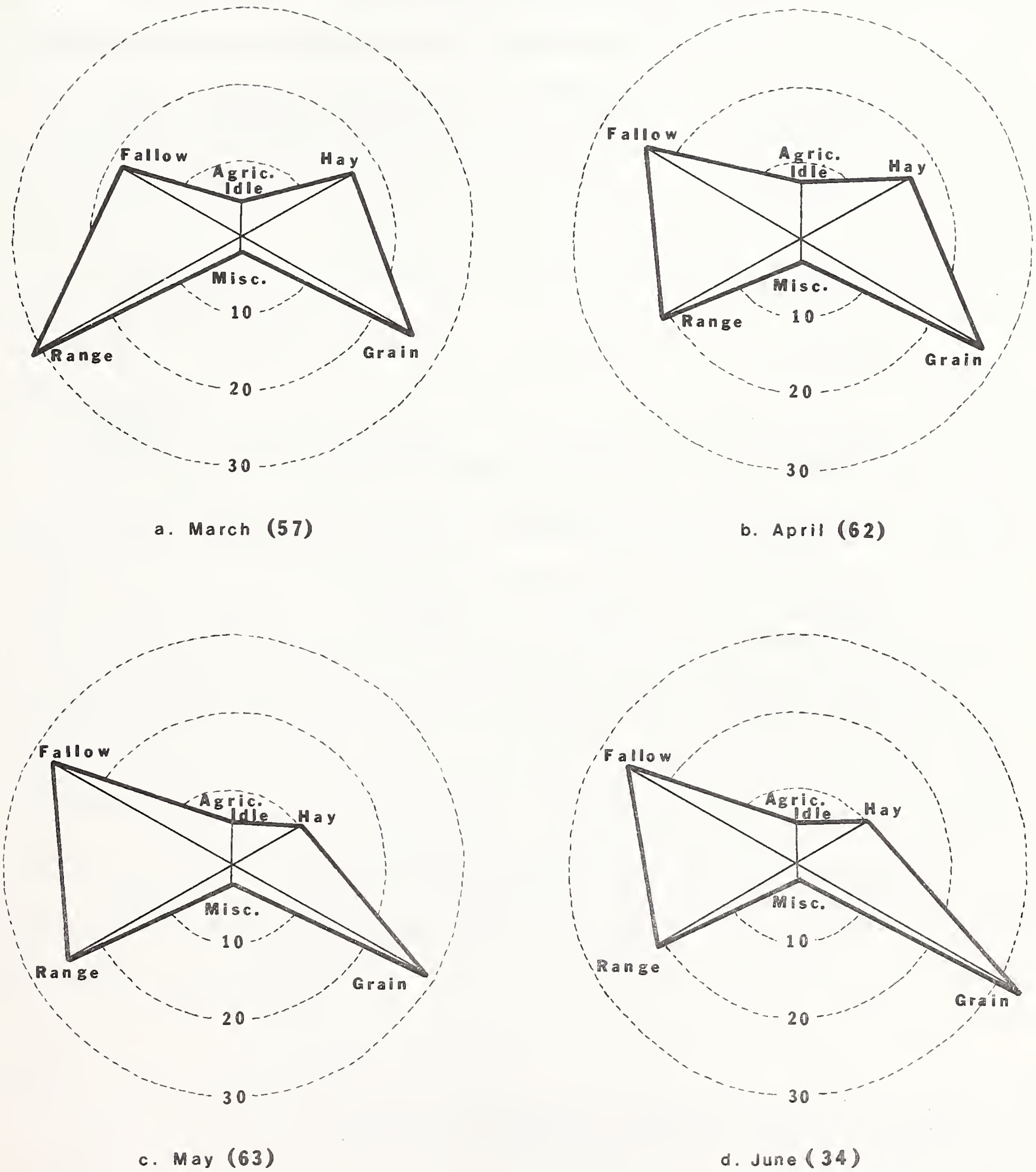


Figure 45. Partridge pair habitat composition by month during spring-early summer. Sample size in (); numbered rings are percents.

Table 57. Results of multivariate testing among habitat components of partridge pairs by month.

Months Compared	Hotelling t^2	F df	F value	P
March vs. April	47.78	20, 98	2.00	.01
March vs. May	71.00	20, 99	2.98	.00
March vs. June	78.14	20, 70	3.07	.00
April vs. May	41.38	20, 104	1.75	.04
April vs. June	21.16	20, 75	0.84	.65
May vs. June	28.75	20, 76	1.15	.32

mobility of subadults and adults, plus partridge which have lost initial mates and are seeking new ones, continues through April. Nesting, egg-laying and incubation occurs during May-early June; this localizes pair activities and no significant differences in pair habitats would be expected between these months. Furthermore, a majority of broods hatching by the end of June are less than 3 or 4 weeks-old, which restricts movements from nesting habitats.

Brood Habitat

Brood-habitat polygons changed noticeably, July to September, primarily due to the substitution of rangeland by grain (Fig. 46). Proportions of other land uses changed negligibly during this period. Comparison of monthly land-use changes revealed the greatest differences occurred between July and September (Table 58). Although changes between the other months were not statistically significant, they were considered ecologically significant. Insects, important in young chick diets in July, may have been more available on rangelands whereas vegetational-nutritional requirements of older chicks were met by grain in August and September.

Adults-only Summer Habitat

The only major land uses experiencing minimal changes in adults-only habitats, July-September, were agriculturally idle and miscellaneous areas (Fig. 47). As grain and fallow components decreased, range

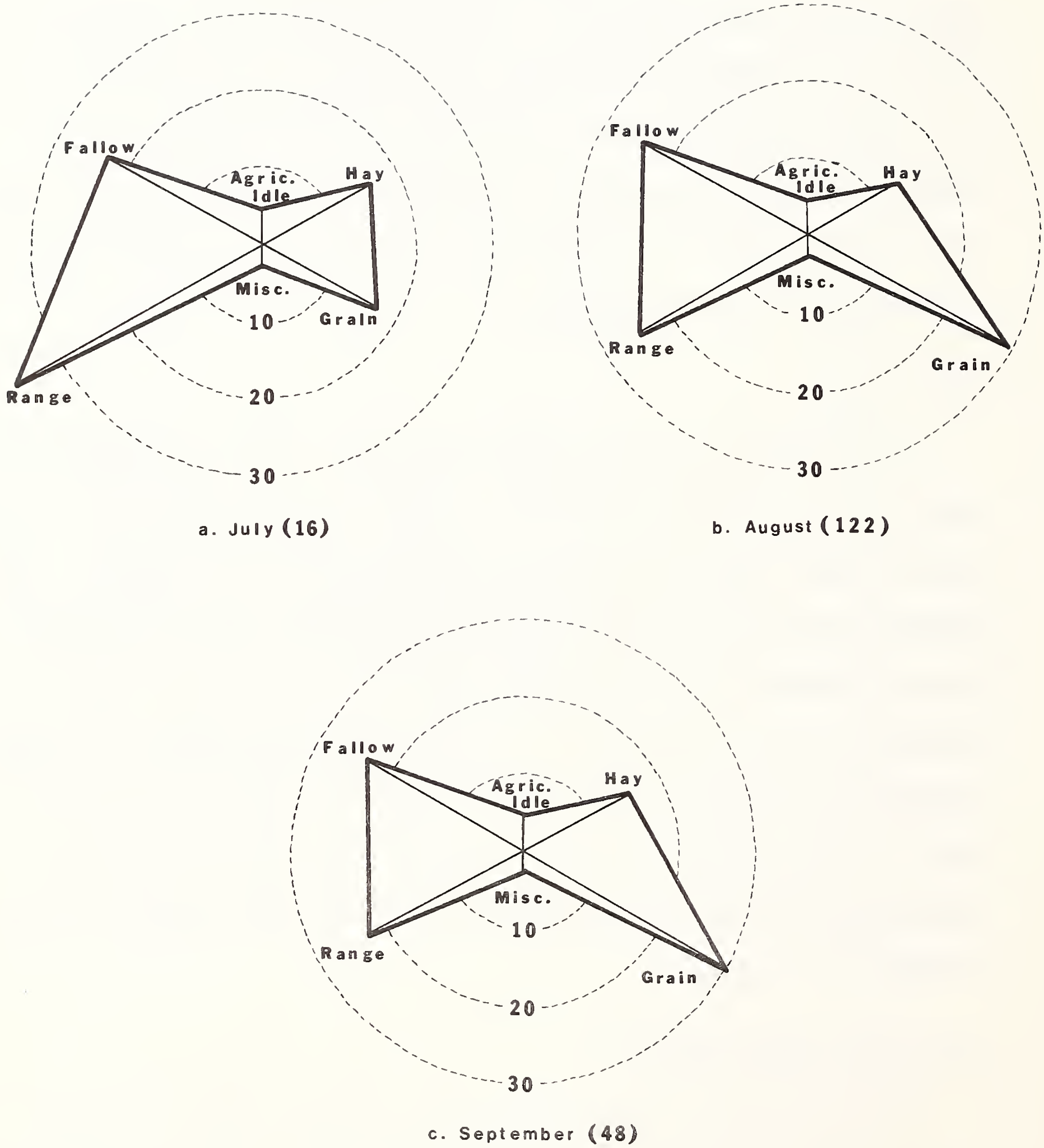


Figure 46. Partridge brood habitat composition by month. Sample size in (); numbered rings are percents.

Table 58. Results of multivariate testing among habitat components of partridge broods by month.

Months Compared	Hotelling t^2	F df	F value	P
July vs August	31.35	20, 117	1.35	.16
July vs. September	66.39	19[1], 44	2.48	.01
August vs. September	28.19	20, 149	1.25	.22

[1]Railroad rights-of-way were an excluded land-sub-use due to non-occurrence in the 160 a areas tested.

and hay lands increased. Although none of the month-to-month changes were significantly different within reasonable probabilities, the greatest differences were noted between July and September (Table 59). Adult-only groups in July could have included renesting and recently unsuccessfully-nesting pairs while those in September comprised autonomous coveys of birds unsuccessful in pairing and breeding.

Comparison of brood and adults-only summer habitats indicated nearly opposite trends in land-use composition (Figs. 46 and 47). Greatest differences occurred in July and September while habitats appeared similar in August. This suggested interactions between these groups may have resulted in occupancy of preferred habitats by the

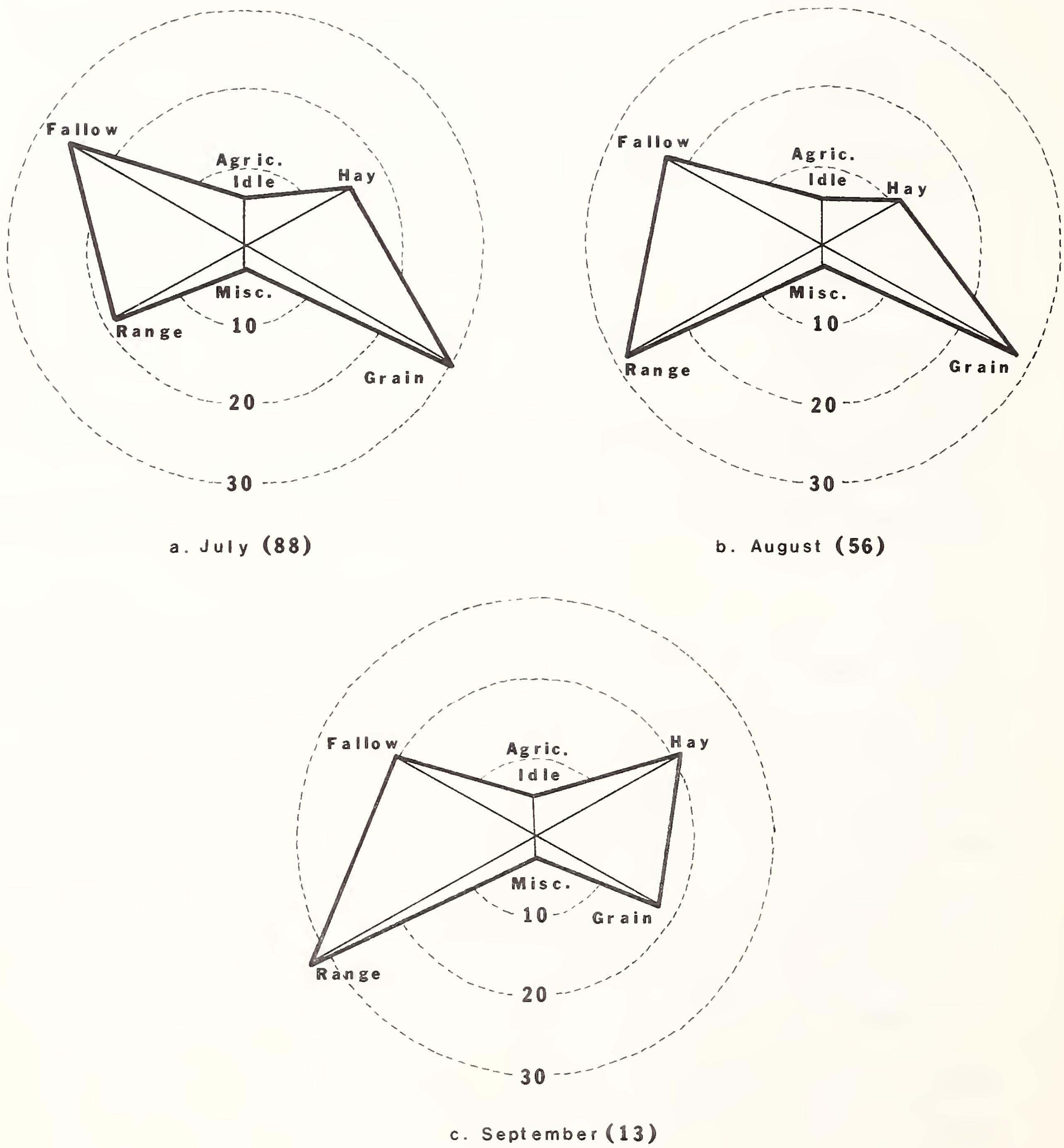


Figure 47. Partridge adults-only habitat composition by month during late summer - early fall. Sample size in (); numbered rings are percents.

Table 59. Results of multivariate testing among habitat components of adults-only partridge groups by month.

Months Compared	Hotelling t^2	F df	F value	P
July vs. August	25.56	20, 123	1.11	.35
July vs. September	31.92	20, 80	1.29	.21
August vs. September	20.77	20, 48	0.74	.76

socially dominant group. Since annual production is essential to perpetuation of the species, broods (and their associated adults) would probably be dominant.

Multivariate testing revealed the greatest and significant habitat differences between broods and adults-only groups occurred in August with the least differences in September (Table 60). Since these tests included accountability for sample sizes of compared groups, the small brood sample in July and small adults-only sample in September were apparently irrelevant. Furthermore, the largest samples in both groups were in August. The disparity may be resolved if the proposed social group-dominance occurred within the different habitat classes (i.e. I, II and III). The habitat class analysis within these social groups

Table 60. Results of multivariate testing among habitat components of brood vs. adults-only partridge groups by month.

Month	Hotelling t^2	F df	F value	P
July	29.94	20,83	1.22	.26
August	42.95	20,16	1.92	.01
September	26.80	19,41	0.98	.50

was not undertaken due to the small samples in each month.

Comparison of brood- vs. adults-only habitats by month also suggested most differences occurred in August and the most similarities were in September (Table 60). In August, brood-habitat must contain nutrient requisites for growing chicks, even though they are becoming increasingly mobile as coveys, while adults-only groups apparently have more freedom of mobility all month. In September, young are becoming adult-size and all coveys possess approximately equal mobility. The statistical lack of significance between brood and adults-only habitat may be due to inclusion of renesting adults in the latter category plus the limited movements of young broods from nesting habitat.

Management Practices

Documentation of management practices was limited to those employed on agricultural lands with emphasis on those applied to crop lands. Chronologies of grain field treatments were obtained during growing seasons, 1970-74. Surveys during these periods also yielded data on hay harvesting. Livestock utilization of grain and hay fields were obtained year round while forage utilization by livestock on rangelands was collected the summer of 1971.

Grain Crops

Spring Activities

1970. Spring seeding began during the last half of April, was interrupted by intermittent rainfall 7-15 May and was completed by 15 June. Spring seeding comprised 70 percent of 1969-summer fallow; none of this fallow remained unseeded in 1970.

Cultivation of 1969-grain stubble (Figs. 48 and 49) was 50 percent complete about 1 June and complete by 25 June. Upland stubbles were fallowed more rapidly than lowland stubbles; by 4 June, 81 percent of upland and 53 percent of lowland stubbles were plowed.

1971. Earliest cultivation, stubble fallowing, was observed 13 April. The first spring survey (3 May) revealed 35 percent of barley, 43 percent of spring wheat and 28 percent of winter wheat stubbles had been fallowed. Stubble cultivation was about half complete by 27 May

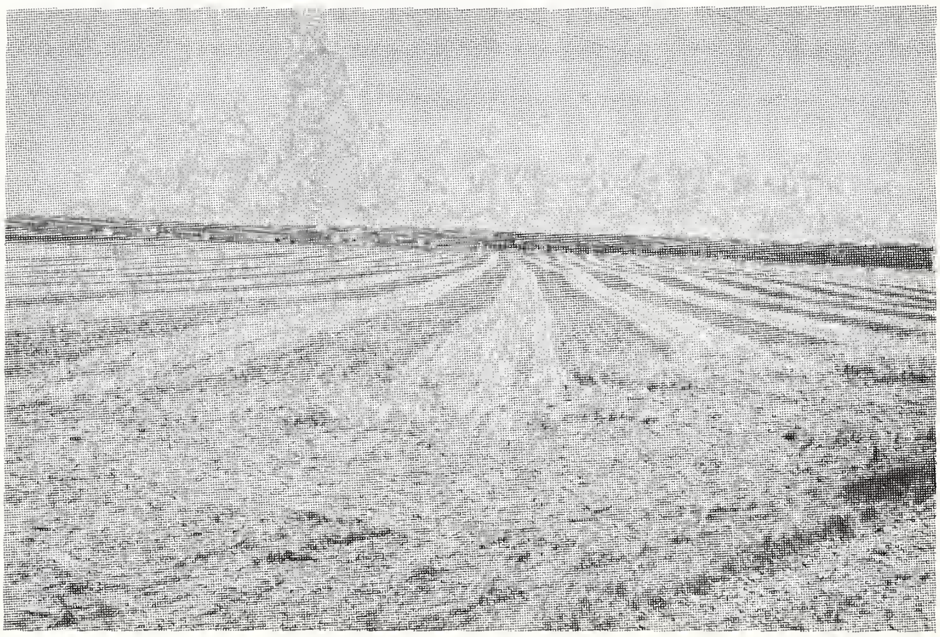


Figure 48. Grain stubble, cultivated once, presents a striped appearance. Waste grain is turned under or falls beneath soil clumps and is unavailable to feeding partridge.

Figure 49. Grain stubble is usually cultivated three or more times prior to successive grain seeding.

and 98 percent complete by 24 June (Fig. 50). Upland stubbles were cultivated more rapidly in 1971 than were those on lowlands.

The 3 May-survey also showed 3 percent of 1970-summer fallowed fields had been planted to spring grain. Spring seeding was complete by 3 June with 53 percent of 1970-fallow planted to spring grain. Only 4 percent of 1970-fallow remained fallow during the 1971 growing season.

1972. Fallowing and spring seeding started about 26 April, the latest date for these activities during the study; it followed the severest winter conditions recorded. By 3 May, 51 percent of barley, 50 percent of oats, 26 percent of spring wheat and 75 percent of winter wheat stubbles had been plowed. Stubble plowing was about 90 percent complete by mid-June. Lowland stubbles were fallowed at a faster rate than upland stubbles in 1972. Ninety-eight percent of all 1971-fallow was planted to winter wheat and spring grain by 14 June.

By 3 May, spring grain had been seeded on 32 percent of 1971-fallow and 3 percent of 1971-stubbles. Spring seeding was completed about mid-June with 96 percent of 1971-fallow, 23 percent of barley, 5 percent of spring wheat and 5 percent of winter wheat stubbles seeded. This was the first spring that notable proportions of previous summers' stubbles were seeded in spring.

1973. Spring cultivating was underway by 15 April following the mildest winter of the study. Fallowing was 65 percent complete in barley, 79 percent in spring wheat and 95 percent in winter

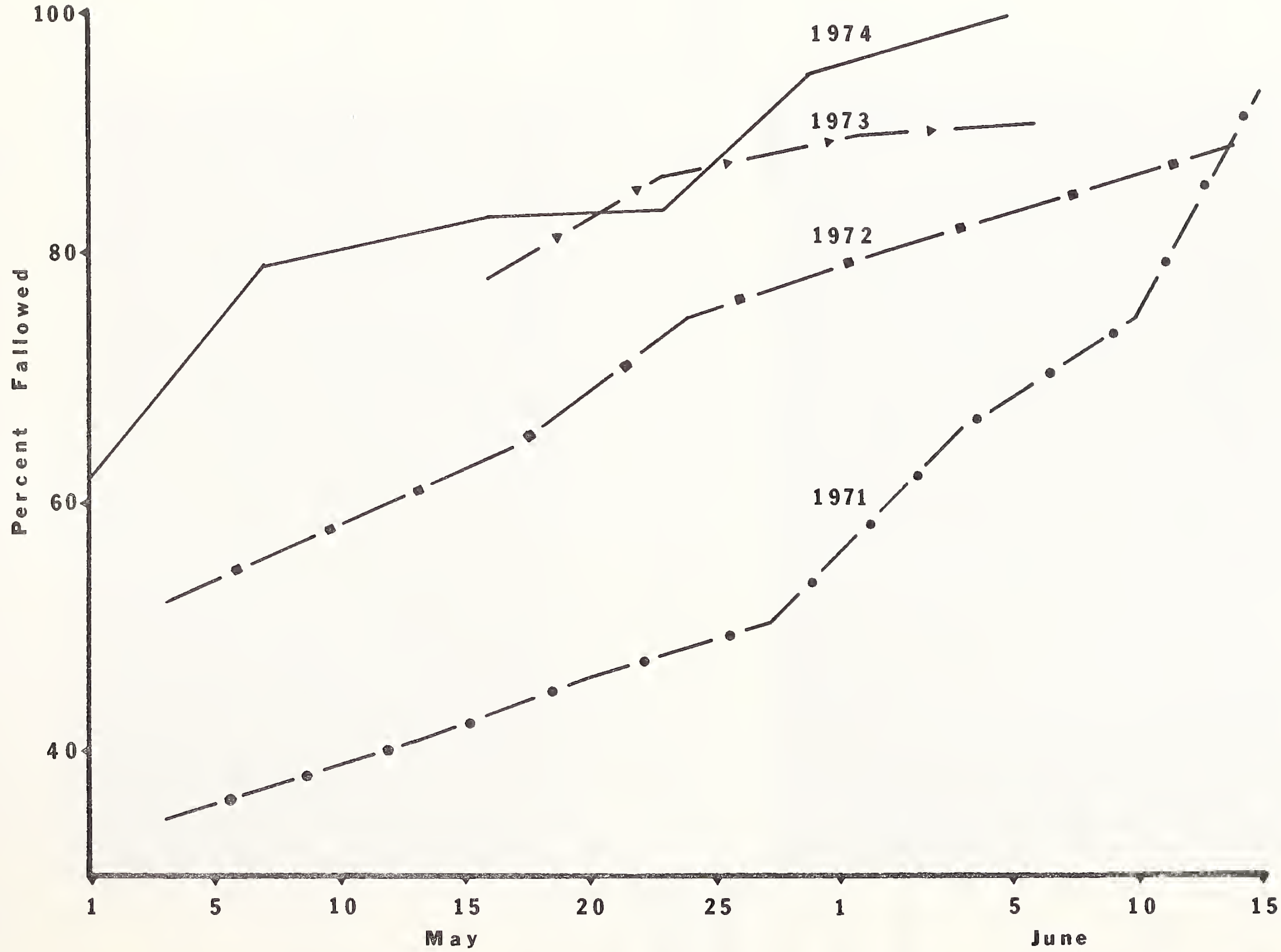


Figure 50. Grain stubble spring chronology on the Agawam Study Area, 1971-74.

wheat stubbles by 16 May. Ninety percent of all grain stubble was fallowed by the last spring survey (6 June). Upland and lowland stubbles were fallowed at approximately equal rates.

By 6 June, 99 percent of 1972-fallow had been spring seeded. Ten percent of barley, 50 percent of oats, 4 percent of spring wheat and 7 percent of all 1972-grain stubbles were seeded to spring grain in 1973. No winter wheat stubble was seeded this year.

1974. Although a specific cultivation-starting date was not noted this year, advanced spring activities recorded during the first surveys (1-2 May) indicated cultivation was underway by mid-April. This survey revealed 60 percent of barley, 69 percent of spring wheat, and 62 percent of winter wheat stubbles had been fallowed. Fallowing of all grain stubbles was 99 percent complete on 5 June. Lowland stubbles were fallowed more rapidly in early spring than upland stubbles.

Twenty-one percent of 1973-fallow was spring seeded by 1-2 May whereas 59 percent was seeded by the final survey (5 June). Only 3 percent of 1973-fallow remained in fallow during the 1974 growing season. Seventeen percent of barley, 7 percent of spring wheat, 3 percent of winter wheat and 12 percent of all 1973-grain stubbles were seeded to spring grain this year.

Grain Harvests

Winter wheat harvesting began the first week in August 1970 and was 90 percent complete by 27 August. Cutting of spring grains also began the first week of August but progressed slowly; only 42 percent was harvested by the end of August. Ninety-eight percent of all grain was harvested by 24 September (Fig. 51); one oats and two spring wheat fields remained unharvested on 1 October, presumably to provide field forage for livestock in winter.

Winter wheat harvests began 1 August in 1971, and were completely harvested by 25 August. Harvesting spring grains began 11 August and was 50 percent complete by 25 August. All grain was harvested by 17 September.

Grain harvesting began 7 August in 1972 but was delayed 9-25 August due to rainfall. Nonetheless, 40 percent of winter wheat and 50 percent of spring grains were harvested by the end of August. All winter wheat was harvested by 15 September and 98 percent of all grains were cut by 29 September.

Harvesting of grain began the last week in July in 1973. Fifty percent of winter wheat was cut by 9 August and it was completely harvested by 22 August. Spring grain harvests were 50 percent complete by 25 August and all grain was cut by 17 September.

Winter wheat harvesting in 1974 also began the last week of July. These harvests were 50 percent complete by 3 August but were not finished until 15 September. Spring grain harvesting started about 10 August and was 50 percent complete by 27 August. Eighty-nine percent of all grain had been harvested when surveys terminated 15 September.

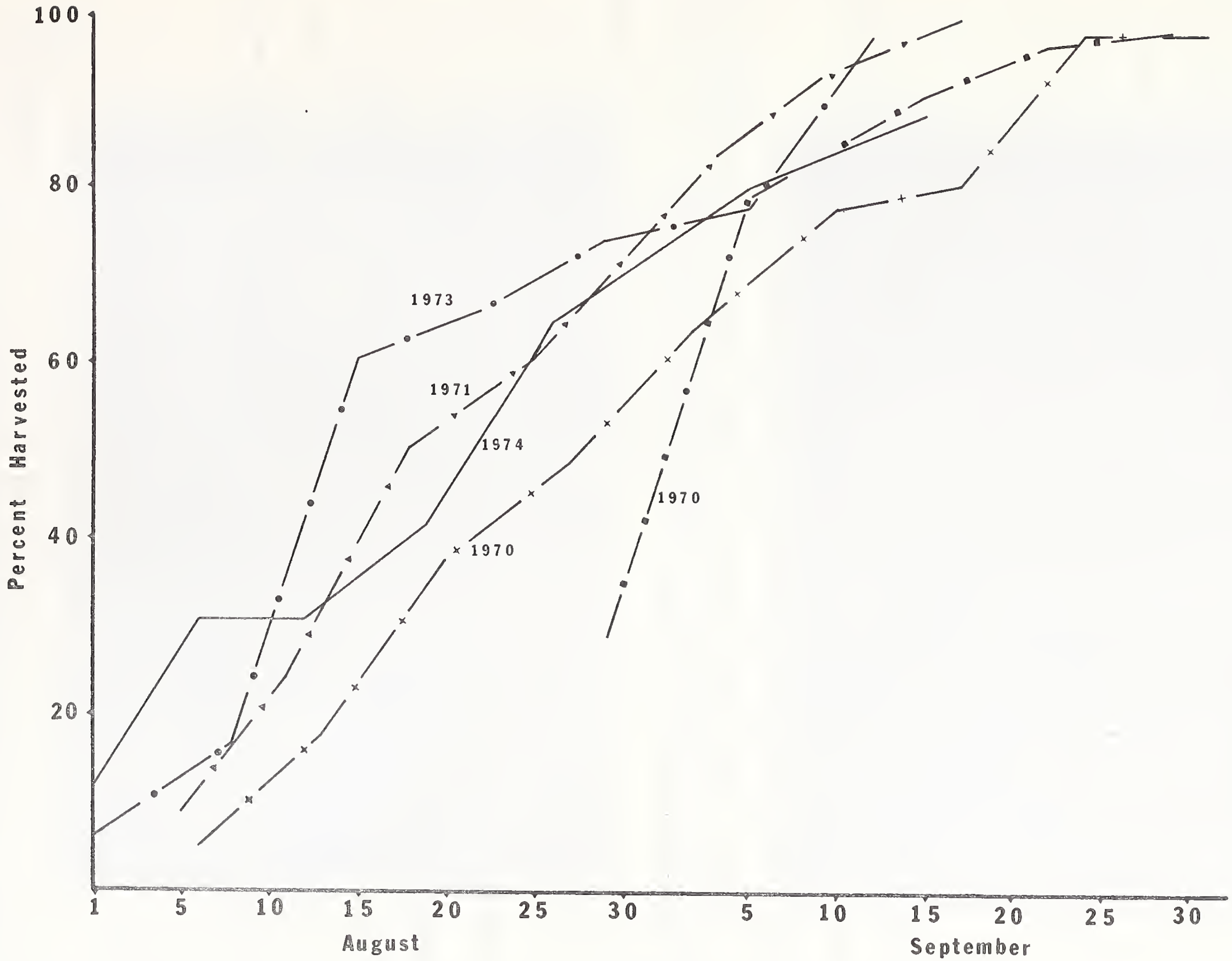


Figure 51. Grain harvest chronology on the Agawam Study Area, 1970-74.

Swathing

While a majority of cereal grain was harvested by straight combining (Fig. 52) on the study area each year, a portion was swathed prior to combining. Swathing (Figs. 53 and 54), a preliminary harvesting method, usually occurred for one of two reasons: (1) the grain was ripe but contained too much moisture for marketing or storage so was cut on the stem and allowed to dry while lying in windrows; or (2) ripened grain was vulnerable to shattering in strong winds or hailstorms and lying in windrows minimized major grain losses under these conditions.

Barley fields were swathed at annual rates of 8-31 percent, 1970-74, compared to 50-54 percent for oats, 7-24 percent for spring wheat and 6-23 percent for winter wheat. Swathing of spring grains occurred proportionately less during summers when harvests began early and extended over prolonged periods while later harvest dates resulted in higher proportions of fields swathed. The late, long 1970-harvest period had the highest proportion of swathed grain. The highest percentage of winter wheat swathing (1970) occurred during a prolonged harvest period while shorter harvest periods resulted in less swathing, regardless of the harvest-starting date.

Straw Baling

Farmers baled and removed straw from a certain portion of harvested grain fields each fall (Fig. 55). Straw was baled annually in

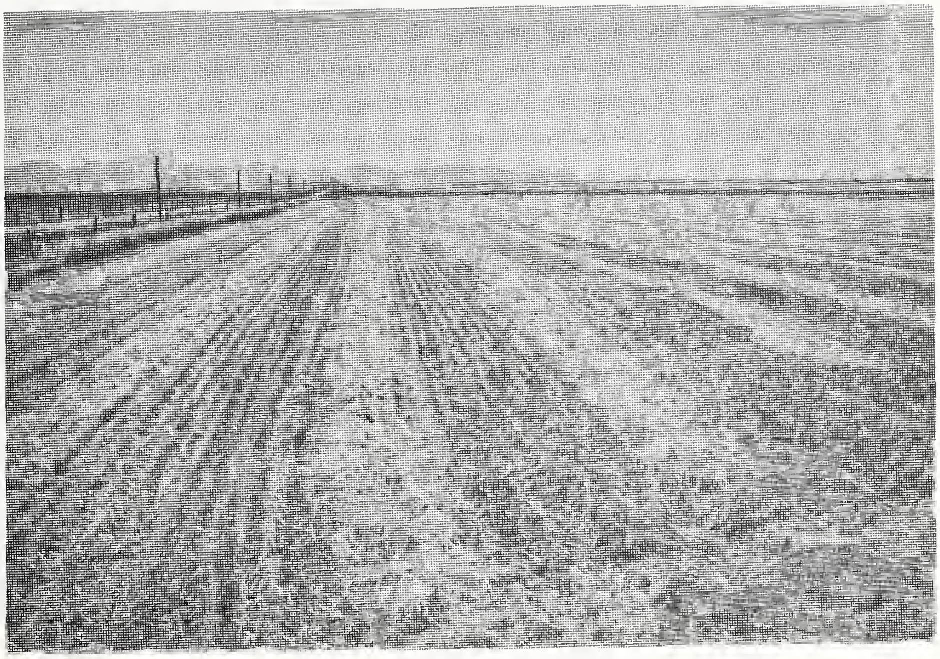


Figure 52. In straight-combined grain fields, residual stubble and waste grain provide partridge with cover and food through the following spring.

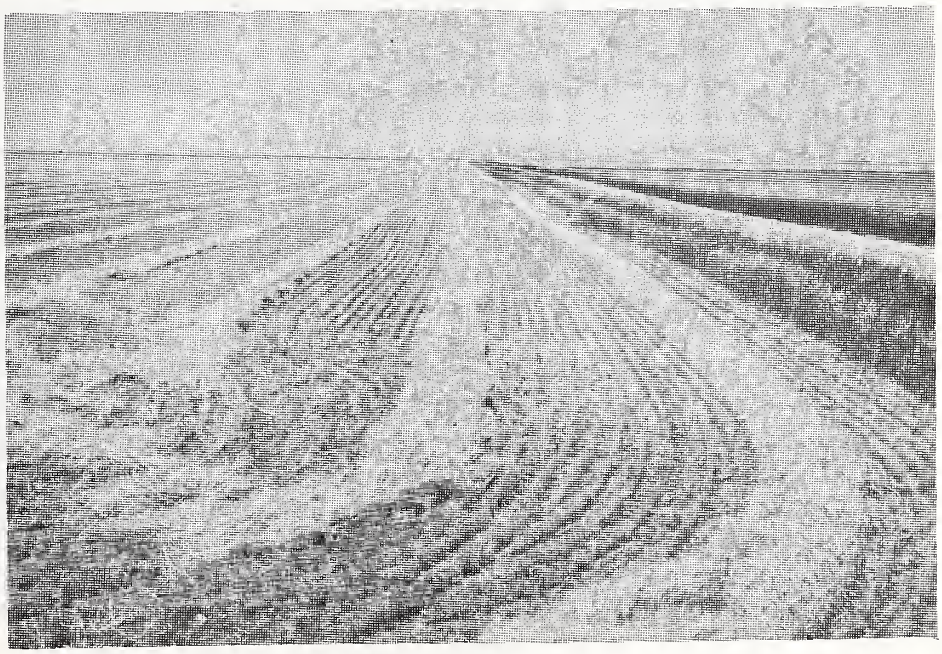


Figure 53. Swathing of grain permits additional drying and minimizes losses during wind and hail storms.

Figure 54. Grain windrows from swathing provide short-term feeding and cover sites for partridge.

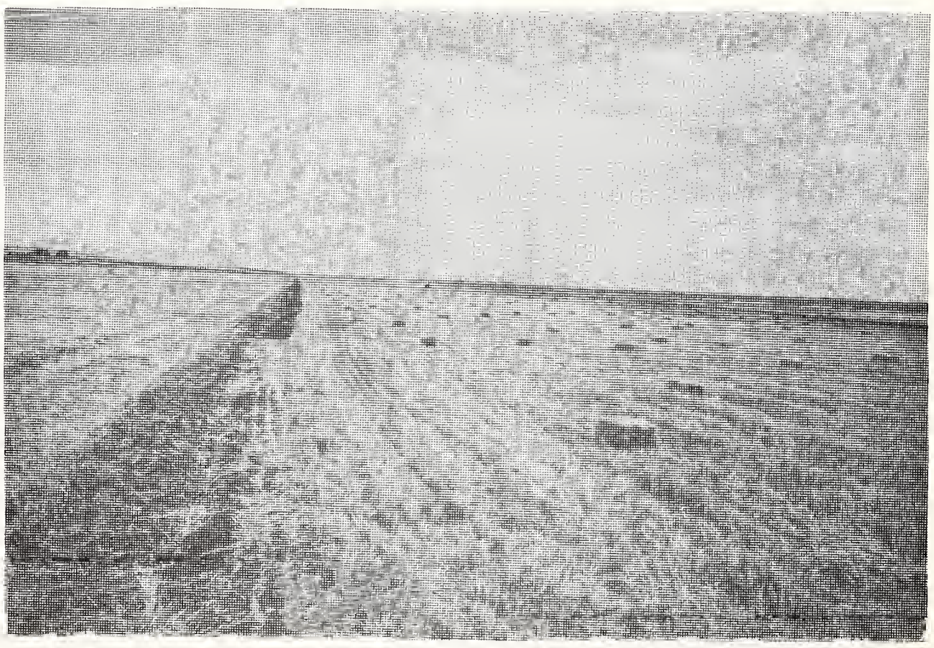


Figure 55. Baling straw after grain harvesting reduces the amount of waste grain for food for partridge.

16-65 percent of barley fields, 31-50 percent of oats, 10-67 percent of spring wheat and 2-56 percent of winter wheat. A maximum 61 percent of all surveyed grain fields contained baled straw in 1972. This followed the severe winter, 1971-72, which depleted hay and straw reserves of many ranchers in the region. Straw from upland grain was harvested from about 60 to 100 percent more fields than in lowland areas.

Fall Activities

Seeding the next year's winter wheat crop began about 1 September each year and was completed by the first 2 weeks in October. Percentages of summer-fallow seeded to winter wheat in fall ranged from 30 to 48 percent during 1969-73.

No relationship was detected between overall grain or winter wheat harvest rates and timing of seeding of winter wheat. This suggested the approximate 1 September-date for beginning winter wheat seeding was necessary for proper pre-winter germination and maximum utilization of fall precipitation received prior to ground-freezing.

Fallowing grain stubble in fall was not extensively practiced on the study area and appeared to be secondary to winter wheat seeding in fall cultivating. First fall-fallowing began as early as 26 August during 1970-74 and most occurred during September. Final fall surveys revealed 8-15 percent of barley, 0-13 percent of spring wheat and 2-37 percent of winter wheat stubble fields were fallowed in fall.

Hay Crops

Hay crops were harvested by swathing and then permitted to dry in windrows. Most harvested hay was mechanically packed into rectangular bales and the bales were stacked in one corner of the field or adjacent to winter livestock feeding areas.

First hay cutting (Fig. 56), in alfalfa, was observed 20-30 June each year, 1970-74; it began later in dry years (e.g. 1972-74). Harvesting began and was completed earlier on lowland than upland fields and 75-99 percent of all fields yielded first cuttings. Most fields yielded first cuttings in every year when normal or above-normal precipitation was received while only alfalfa-dominated hay produced first cuttings on most fields in dry years. Alfalfa-dominated hay harvests were about 50 percent completed by 2-16 July and completed by 14-29 July. Harvests of grass-dominated hay began within 1-2 weeks of those for alfalfa, 50 percent levels of cutting were attained through 29 July and, except for 1969, was not harvested on 17-57 percent of the fields annually.

Second hay cuttings (Fig. 57) began 9-18 August. Fifty percent levels of harvest were recorded in alfalfa-dominated hay by late August-early September. Most second cuttings were completed by late September. Seventy-eight to 97 percent of alfalfa fields produced second cuttings compared to 42-92 percent for alfalfa-grass, 23-50 percent for grass-alfalfa and 5-50 percent for grass. Lowland and upland hay was cut at

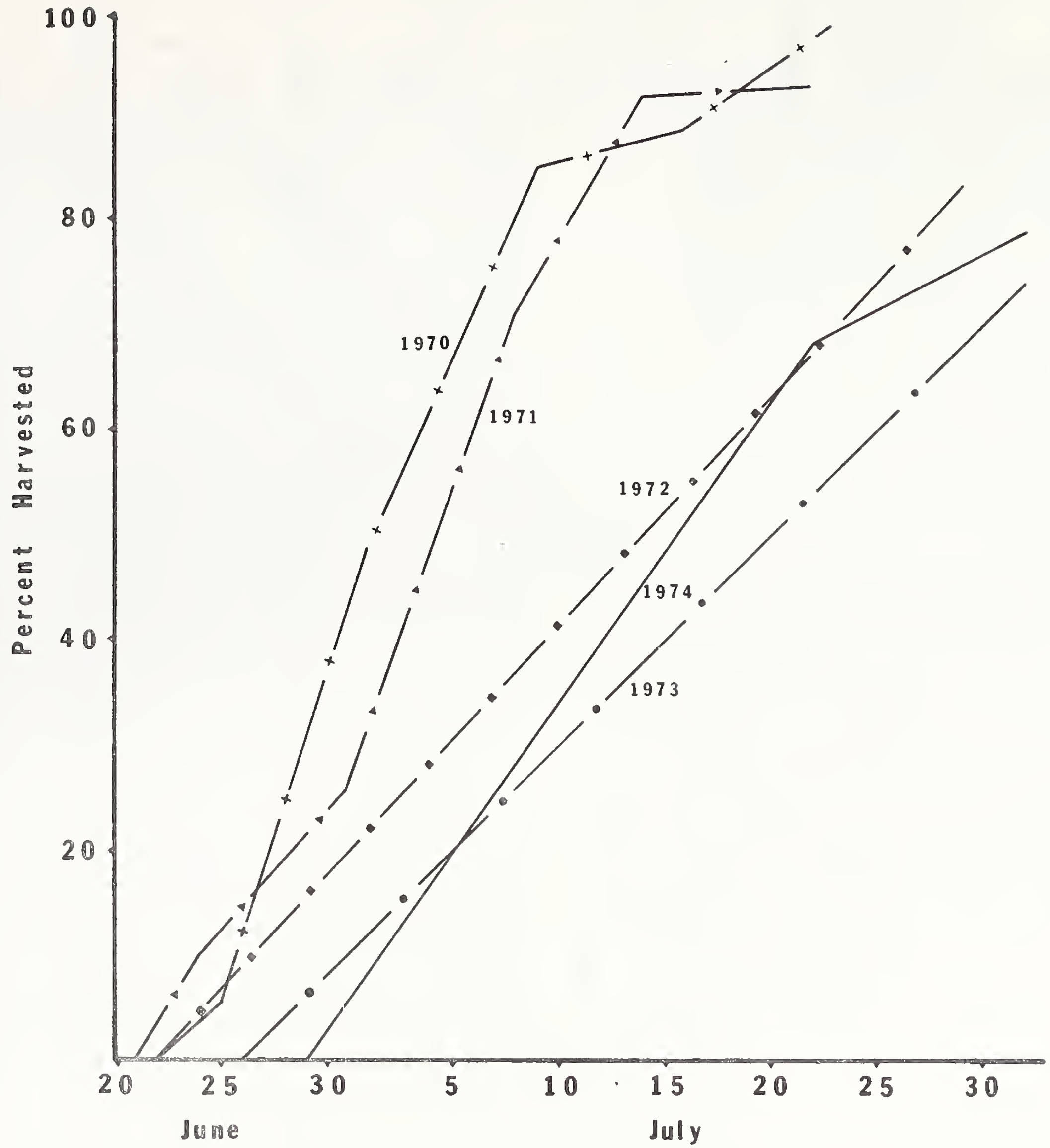


Figure 56. Chronology of first-cutting hay harvest on the Agawam Study Area by year, 1970-74.

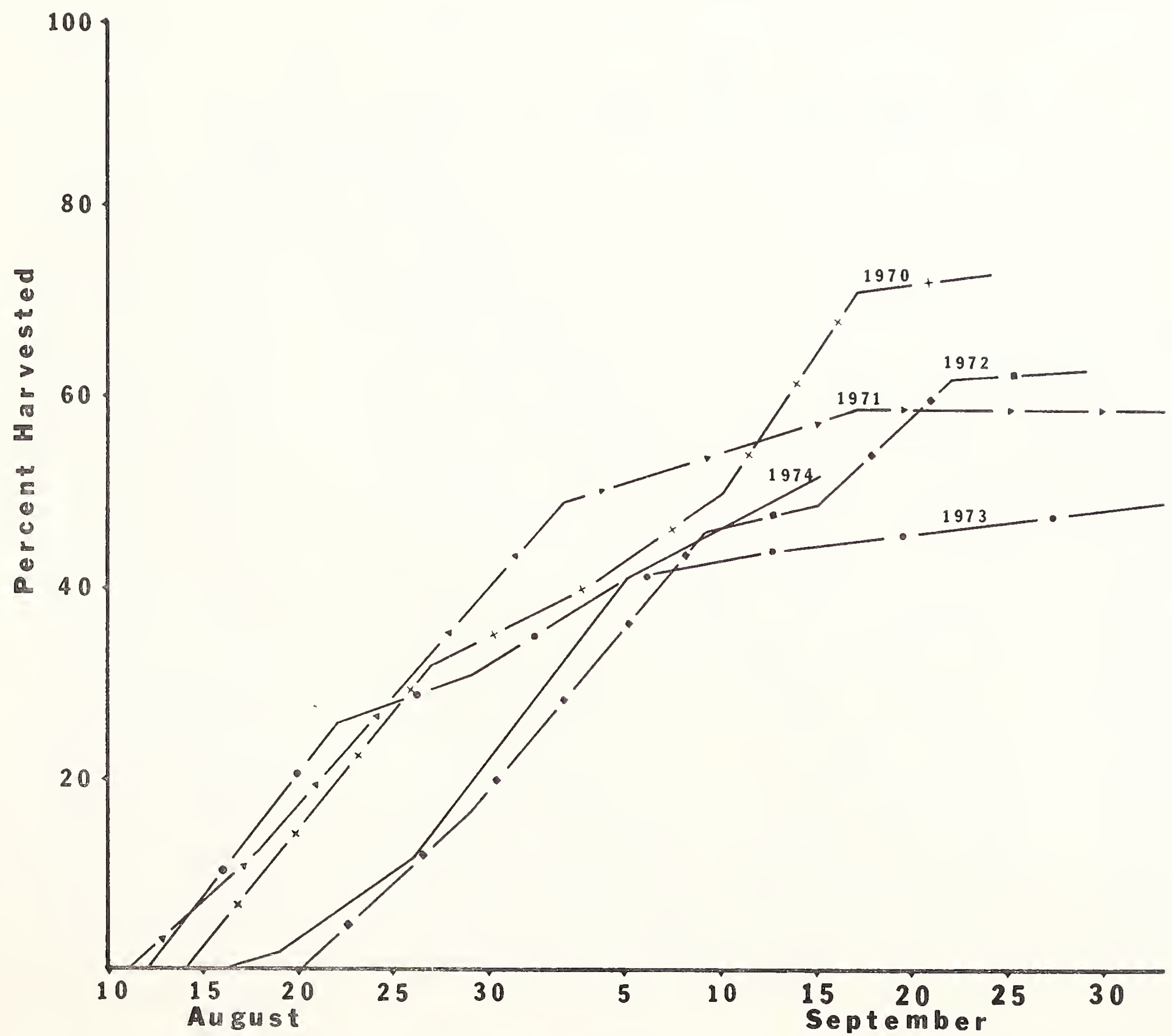


Figure 57. Chronology of second-cutting hay harvests on the Agawam Study Area by year, 1970-74.

about equal rates with 43-73 percent of all hay cut a second time. Lowest proportion of second cuttings (43-52%) occurred during the dry summers of 1973 and 1974.

Livestock Grazing

Forage utilization by livestock during the summer, 1971, was measured using plant weights and heights at eight sites on five disjunct rangeland units. Precipitation prior to grazing was above normal but was below normal in June and July. Forage production, determined from plant weights, on five lowland sites (three range units) was 470-3,420 lbs (213-1,553 kg) of grass/grasslike plants and 1,140-3,150 lbs (518-1,430 kg) of forbs per acre. Foraging cattle removed 21-61 percent of grass/grasslike plants and 25-93 percent of the forbs produced (Figs. 58 and 59). Two other lowland sites, both ungrazed this summer, produced 3,067 and 4,570 lbs (1,392 and 2,075 kg) of grass/grasslike plants and 308 and 140 lbs (140 and 64 kg) of forbs per acre, respectively.

Forage production, determined from weights, on two upland sites (two ranges) was 240 and 250 lbs (109 and 114 kg) of grass/grasslike plants and 300 and 455 lbs (136 and 207 kg) of forbs per acre. Cattle utilized 20-45 percent of the grass/grasslike plants and 73 percent of the forbs (one site only) (Figs. 60 and 61). An ungrazed upland range produced 333 lbs (151 kg) of grass/grasslike plants and 239 lbs (109 kg) of forbs per acre.

Figure 58. Agronomy cage on lowland range at the beginning of the 1971 summer-grazing season.

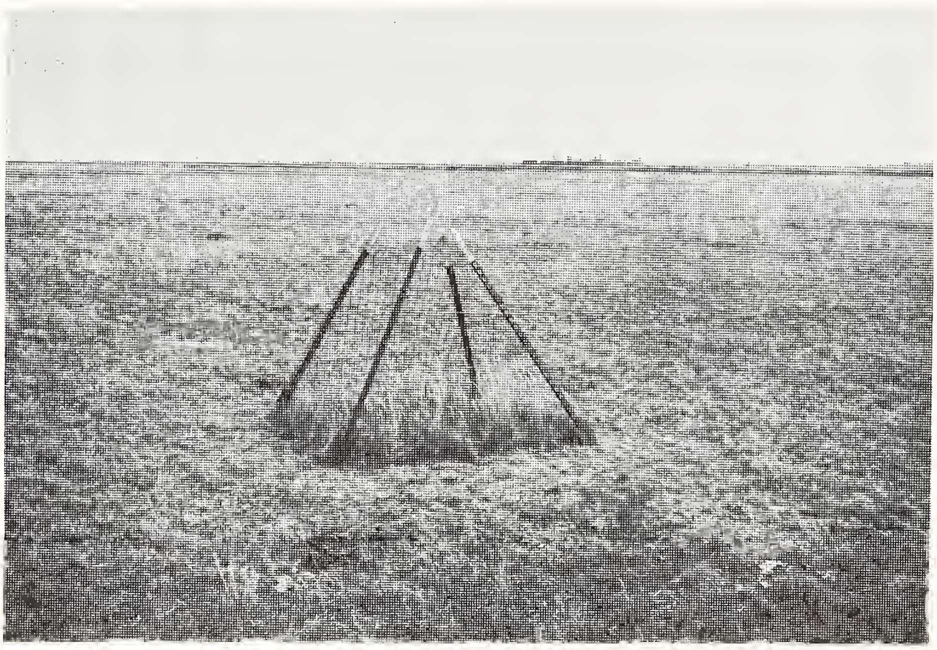


Figure 59. The same lowland site after grazing; cattle consumed 60 percent of the grass and 93 percent of the forbs produced this growing season.

Figure 60. Agronomy cage on upland range prior to summer grazing by cattle in 1971.

Figure 61. Upland range after grazing; cattle consumed 45 percent of the grass and 73 percent of the forbs produced this growing season.

The only seeded range sampled (seeded in 1965) was irrigated at irregular intervals and was grazed lightly or not at all prior to 1971. Forage production was 10,163 lbs (4,614 kg) of grass/grasslike plants and 119 lbs (54 kg) of forbs per acre in 1971. Cattle utilized 92 percent of the first plant group and 87 percent of the second (Figs. 62 and 63). Much of the residual vegetation was eaten or trampled by cattle during this grazing season.

Grass utilization, determined by comparing mean grazed and ungrazed plant heights, was 25-63 percent on lowland ranges, 61-64 percent on upland ranges and 82 percent on the seeded range.

Winter-use of ranges by livestock was recorded on the study area. A 3 May 1972 survey revealed 48 percent of upland and 58 percent of lowland ranges were subjected to winter grazing. A 1 May 1974 survey showed these respective percentages were 87 and 93 percent.

Grain

Increasing proportions of grain stubble fields grazed during late fall and winter were noted 1970-73 (Fig. 64). Comparison of results between the 3 November 1970 and 3 May 1971 surveys suggested some of the grazing indicators did not over-winter. Spring survey results probably reflected one-half of the true winter grazed-field proportions.

Hay

Permitting livestock to graze haylands was a common practice by landowners. Farmers specializing only in grain cultivation generally

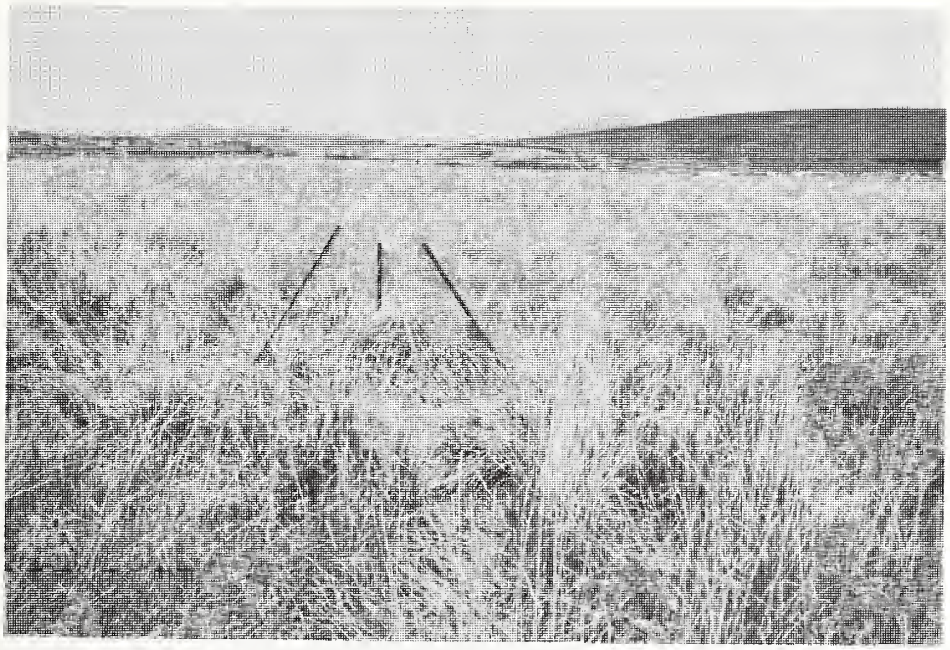


Figure 62. Six years of light grazing preceded placing the agronomy cage on this seeded range.

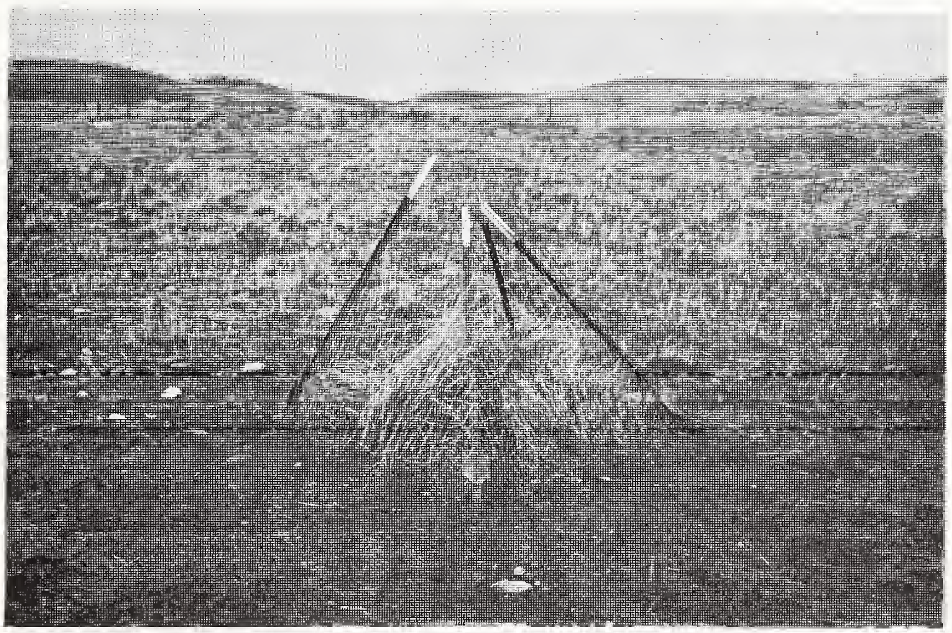


Figure 63. Seeded range after grazing; cattle consumed or trampled 90 percent of the vegetation during the summer, 1971.

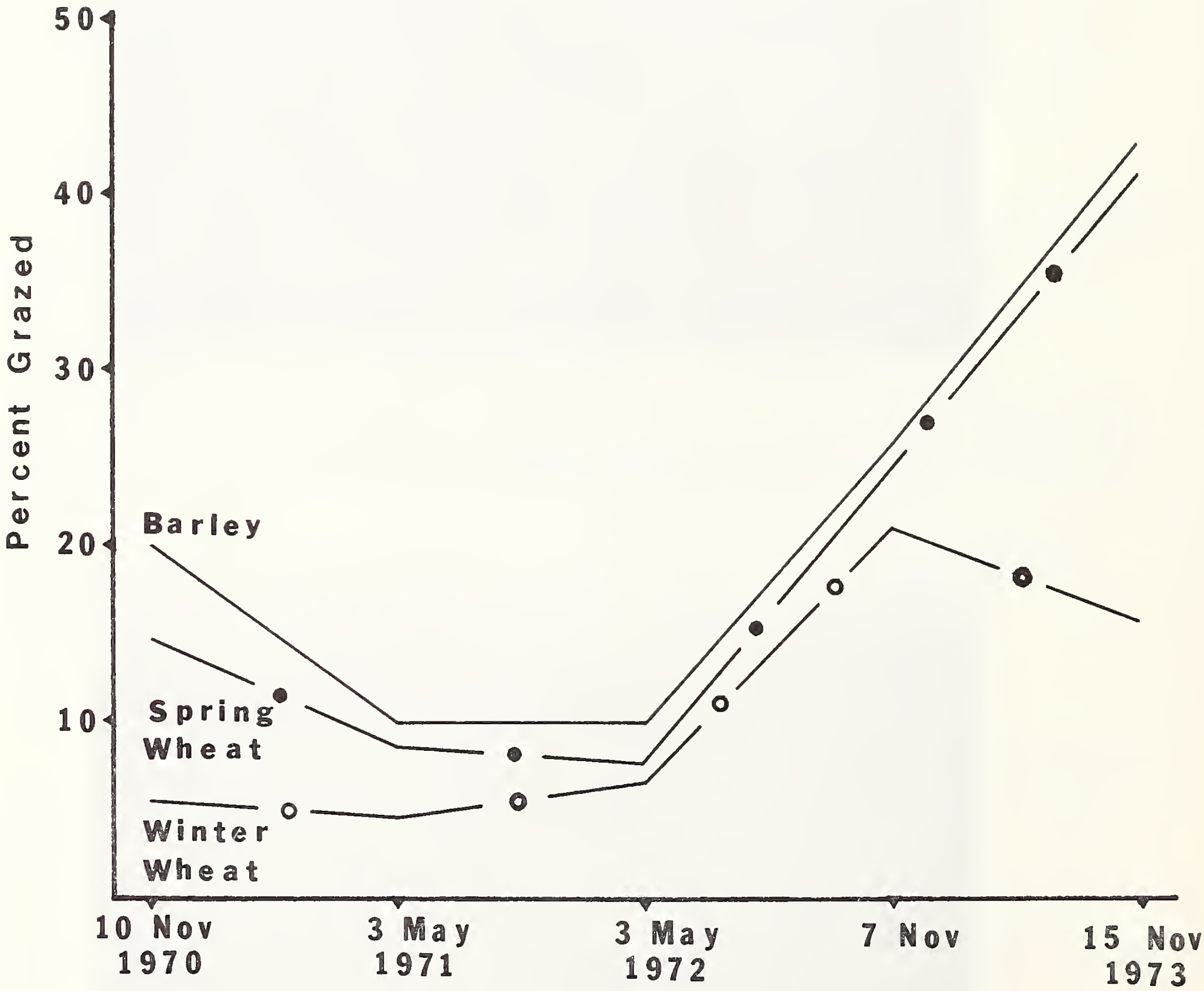


Figure 64. Proportions of stubbles of three grain species grazed by livestock in late fall-winter on the Agawam Study Area, 1970-73.

did not fence around fields, precluding any grazing by livestock. One exception was a farmer in the northcentral part of the study area who allowed part of his pig herd to range over all land uses included on three farms from the time of grain harvests until spring seeding.

Surveys during early spring revealed proportions of hay fields grazed by livestock, primarily by beef cattle. An increasing trend in proportions of the four major hay types grazed in winter was noted during 1970-74 (Figs. 65 and 66). Trends of the two alfalfa- and the two

Figure 65. Residual vegetation in this grass hay field was eliminated, by grazing, as a source of late summer-early spring cover for partridge.

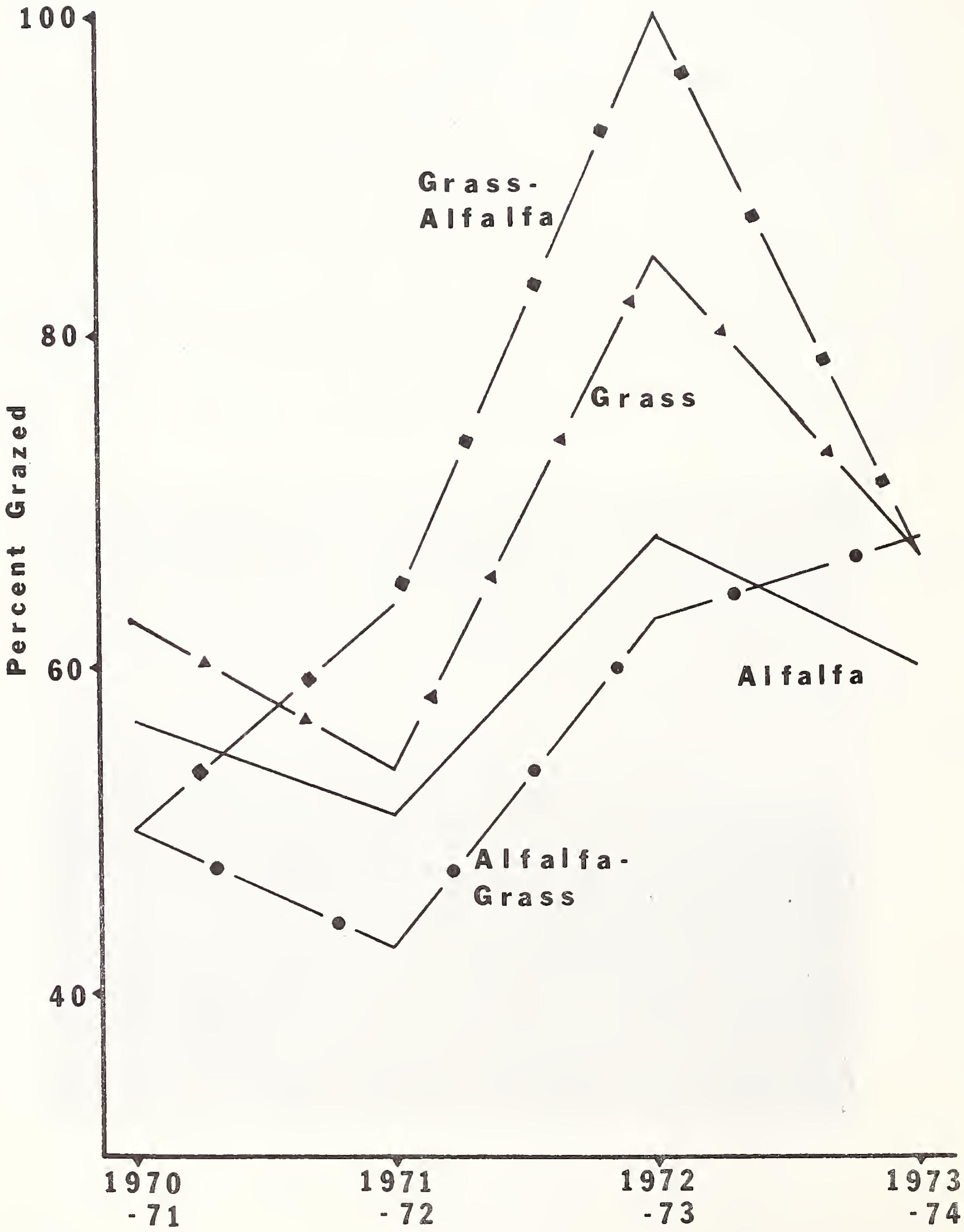


Figure 66. Trends in percent of hay fields grazed by livestock in winter on the Agawam Study Area, 1970-74.

grass-dominated types paralleled each other in 3 of the four years. In only one winter, on one type, did proportion of the fields grazed occur below 50 percent (i.e. alfalfa-grass in 1971-72). Proportions of hay fields grazed were greater on lowlands (48-80%) than on uplands (33-62%).

Agriculturally Idle Areas

A decreasing trend in the grazing of agriculturally idle areas was noted along the four observation routes, 1972-74. During the winter, 1972-73, 78 percent of such areas were grazed, 50 percent had been grazed by livestock during the summer and fall of 1973 and 41 percent were grazed the winter of 1973-74. Proportionately more lowland than upland sites were grazed. Irrigation ditches were grazed in greater proportion than the other two idle areas monitored; idle without buildings were second and those with buildings were third. Irrigation ditches were grazed proportionately less in alfalfa, ranges, grain fields, other hayfields and other idle areas.

Effects of Land Management on Partridge

Land Uses

Responses of partridge populations to land use changes were documented in three areas in the southeast quarter of the study area. In each case, extensive areas which were idle from agricultural production were transformed into intensively grazed or cultivated areas with deleterious affects on local partridge populations.

Conversion to Grazed Rangeland

A partially irrigated, 72 a (29.1 ha) upland range was seeded with an intermediate wheatgrass-yellow sweetclover mixture in 1965. From the time of seeding through March, 1970, few or no livestock grazed this range. Thirty adult herefords grazed the area in April, 1970 and then no further grazing occurred until late May, 1971. During most of 6 years this area represented an agriculturally idle area. Partridge production about two sides of the area's periphery included 3 broods with 25 birds in 1969 and 6 with 54 in 1970. Additional broods within the dense vegetation could have escaped observation. A nearby winter range contained 5 coveys with 33 birds the winter of 1968-69, 1 with 10 in 1969-70 and 1 with 7 in 1970-71.

In early 1971, ownership of this property changed and on 22 May 56 cows and 30 calves were turned into the range; they consumed 92 percent of the grass/grasslike plants and 87 percent of the forbs by November. Residual and current growth was eaten and an irrigation ditch passing through the range was almost denuded of vegetation. A fire in mid-July removed most of the vegetation on the eastern one-half of the range. Only two partridge broods (27 birds) were recorded in the area this summer and two coveys (20 birds) were noted on the nearby winter range the succeeding winter.

Grazing of this range continued during spring-fall each of the remaining years of study. One brood (17 birds) was recorded the summer of 1972 and seven broods (66 birds) occurred here the following summer. No further winter covey data were recorded.

These data indicated the grass-dominated range was a primary partridge production area until cattle and the fire removed the dense, residual vegetation. Increased production in 1973 was attributed to nesting and brood cover on the adjacent idle areas and only lightly grazed lowland range. Since the nearby winter range supported a maximum of 2 coveys and 20 birds in winter, most partridge produced on the seeded range apparently wintered elsewhere. The high population on the winter range, 1968-69, was probably due to the residual high population from 1968, the severeity of that winter, and less human activity on the area that winter.

A second parcel of land, 172 a (69.6 ha) containing 99 a (40.1 ha) of crested wheatgrass hay with the remainder being rangeland, changed ownership in late April 1970. No cattle grazed the rangeland and the hay was harvested once each summer from the beginning of the study until the sale. During much of this period the area was considered idle from agricultural production. Four partridge broods with 44 birds frequented the entire area the summer of 1969. Coveys on an adjacent primary winter range were three (29 birds) in 1968-69 and two (18 birds) in 1969-70.

The hay was harvested in June 1970 and 13 adult cattle grazed the range beginning in July. The cattle were moved to the hayland in October but were removed from the entire area in early winter. Five partridge broods (38+ birds) were on the area this summer and two coveys (19 birds) inhabited the winter range.

Cattle grazed the rangeland through the 1971 growing season and were turned into the unharvested hay in mid-October. Three broods (26 birds) were noted on the area that summer and three coveys (26 birds) were on the winter range.

Grazing by 13-30 head of cattle continued on both land uses year round after the winter 1971-72. No broods were seen on the area during the summer, 1972, although four broods (32 birds) were present in 1973. Winter-covey observations showed only one covey (6 birds) present the winter of 1973-74.

The grass-hay field was a primary partridge production area and hay harvesting apparently did not adversely affect this seasonal activity. Residual rangeland vegetation each spring through 1970 probably provided nesting and brood cover as well. Except in 1973, cattle grazing of both areas seemingly deterred partridge production.

Conversion to Grain Fields

A primary winter range contained seven coveys totaling 47 partridge during the winter of 1968-69. Grain and fallow fields bordered three sides of the range while rangeland occupied the remaining side.

An irrigation ditch lay 740 yd (677 m) east, and ran perpendicular to, this range. The ditch was 25-30 yd (23-27 m) wide, had not carried irrigation water for at least 21 years and was considered agriculturally idle for most of this period. Its inside slopes and bottom were heavily vegetated with grasses and cattail (*Typha* sp.). Tops and outside slopes of the ditchbanks were densely covered with grasses and rose clumps. During the fall, 1969, the local irrigation project designated the ditch unnecessary and returned it to the adjacent landowners. In November, the 1.5-mi (2.4-km) segment closest to the winter range was filled in, with the vegetated spoilbanks used as filler. Grain crops were grown on this new soil beginning in 1970.

Although no accurate census of partridge wintering on the winter range was obtained in 1969-70, there was one covey (7 birds) present in 1970-71 and two coveys were there in 1971-72 and 1973-74 (10 and 14 birds, respectively). This information suggested the irrigation ditch had been a primary partridge production area for the winter range. Since management practices on the winter range had not changed, the data also indicated wintering partridge numbers were below the seasonal carrying capacity of this unit.

Management Practices

Farming and ranching activities exerted varying affects on study area partridge populations. Spring fallowing of grain stubble began about the same time as partridge nesting (Fig. 67). Fallowing stubble

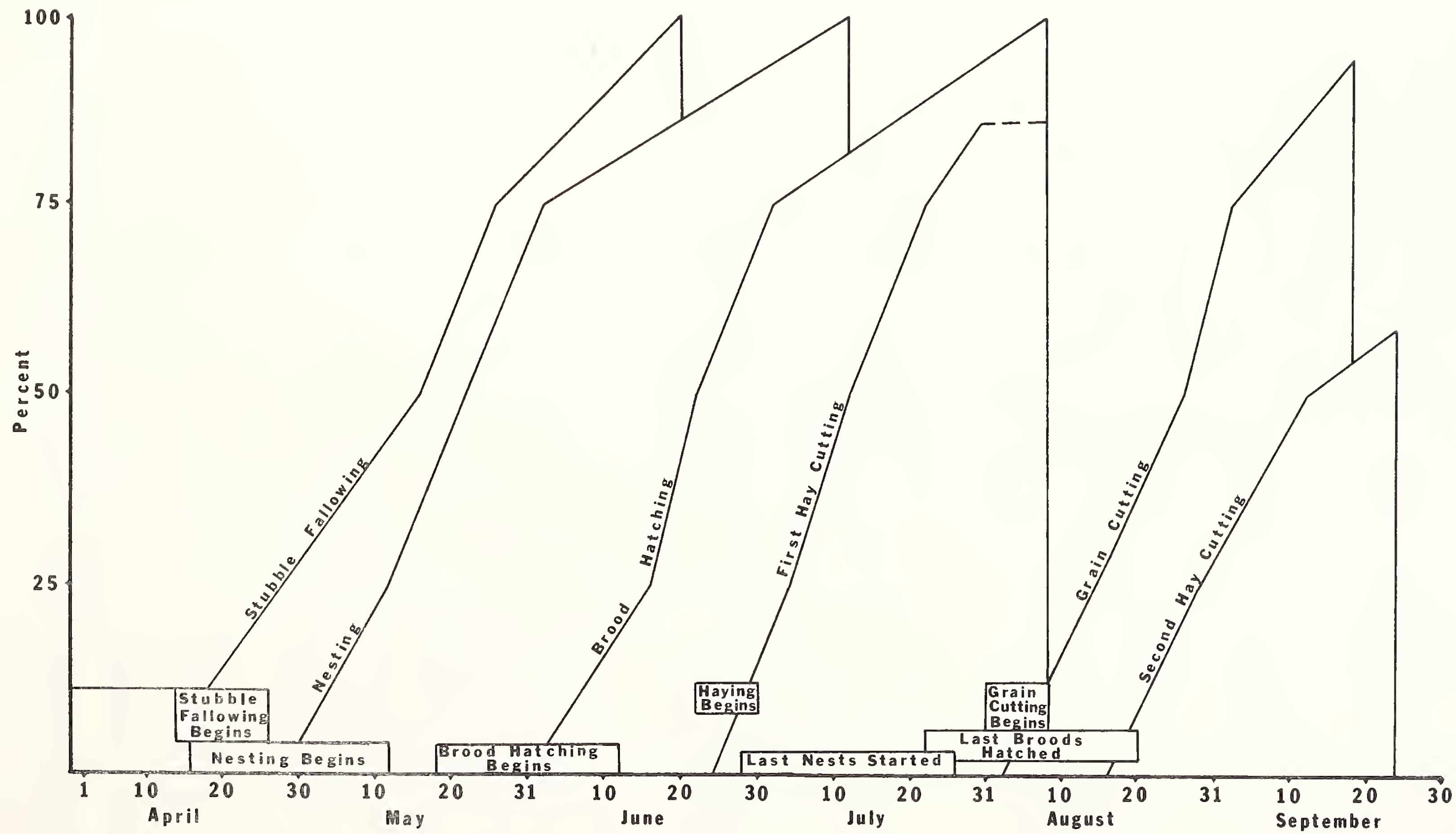


Figure 67. Chronology of average agricultural management and partridge reproductive activities.

was completed about mid-June while partridge nesting continued through late July. First nesting attempts in stubble were subject to destruction or desertion resulting from disturbance by cultivation; one hen deserted her nest following cultivation of stubble 16 June 1972. Spring plowing accounted for 15 percent of the nest desertions in eastern Washington (Knott et al. 1943:285) and 1 percent of nest failures in southern Wisconsin (McCabe and Hawkins 1946:28).

Spring fallowing of the previous year's stubbles may have also been responsible for the decline of cereal grain volumes in partridge crops between March (93%) and June (40%). An average of only 5 percent of all grain stubble, 1970-74, remained unfallowed by mid-June.

In an average year, the earliest partridge broods hatched the last few days in May and 50 percent were hatched before first hay cuttings began. Two successful nests were in newly harvested alfalfa and alfalfa-grass hay while a third nest, deserted due to observer activities, was in unharvested grass hay. A fourth nest, in first-year, harvested alfalfa, was deserted after the incubating hen was flushed from the nest by a swather. First cuttings of grass-hay were 1-2 weeks later than those of alfalfa and may have permitted higher hatching success of nests. Although one-half of partridge broods hatched prior to hay cutting, only the earliest hatching broods (3-4 weeks-old) attained flight characteristics sufficient to enable them to escape the self-propelled swathers. Three-fourths of nests and young broods in hay, particularly in alfalfa-dominated fields, may have been adversely affected by hay cutting. All broods had hatched and 75 percent were ≥ 6 weeks-old before second hay cuttings began. Thus little conflict existed between these harvests and partridge productivity.

The main factor neutralizing partridge productivity in the United States has been farming operations, and particularly hay harvesting. In southern Michigan, Yeatter (1934:59) noted 68 percent of all nests failed to hatch, 46 percent of these were due to farming operations, 70 percent of which were hay mowing. Similarly, McCabe and Hawkins (1946:28) found an average 68 percent of all nests failed with 53 percent of these failures attributable to hay cutting. Sixty-three percent nesting failure in eastern Washington was also partly (37%) due to hay mowing (Knott et al. 1943:285). Haying in Washington extended from the last week of May through mid-June and coincided with the main partridge hatching period.

Nests and broods in grain probably survived grain harvesting on the study area. Less than 5 percent of the broods hatched after commencement of harvests and 75 percent of the broods were ≥ 6 weeks-old when these harvests began. The change from a predominantly animal-matter diet to a predominantly vegetation-diet by a majority of young partridge began within 2 weeks of the first grain harvests.

Swathing of grain and of hay (except for timing) was considered beneficial to partridge in summer. Windrows provided protective cover, particularly to younger chicks, when broods foraged into harvested fields. Several chicks and the adults of a brood less than 1-week-old were sighted on an alfalfa windrow but the observed and other possible chicks could not be located under the windrow.

Fallowing grain stubble in fall, primarily a moisture-conserving practice, effectively buried waste grain and reduced protective cover. Cover values were not totally eliminated since partridge blended well into the broken ground surface. Fall-fallowed fields removed any value for nest sites for the succeeding spring. Middleton and Chitty (1937) thought fall plowing of grain stubble removed a large part of partridge winter-feeding range in Great Britain; little food remained other than on unplowed stubble and grassland or meadows.

Abundant residual vegetation characterized nine of the ten partridge nest sites in this study. Two of the alfalfa fields containing nests were cut only once the previous summer and a third alfalfa field, with one nest, provided barley stubble in early spring. The one exception was a nest in a heavily winter-grazed lowland range; the nest had been built in a dense stand of current, bristle thistle. Yeatter (1934:27) stated nests were begun when "stubble fields, fencerows, woodlots and roadsides, especially where dead herbaceous growths and grasses remain from last year, provide the only cover for nests." The presence of residual vegetation may similarly explain moderate use of these sites by nesting partridge in Wisconsin (McCabe and Hawkins 1946;

Gates 1973). Removal of residual vegetation on any of the five agricultural land uses in the current study reduced available nesting cover for partridge.

Since partridge preferred grass-dominated vegetation for nesting sites, production success was vulnerable to grazing activities of livestock. Proportions of second-harvests of grass-dominated hay apparently fluctuated with amounts of rainfall received. In a wet year (1970), two cuttings of hay on most fields were followed with a short livestock grazing season; much of the vegetation missed by the swathers was removed by cattle. In dry years (1973 and 1974), fewer fields yielded second cuttings and ranchers permitted cattle to forage in fields longer to conserve available hay reserves. Although incidence of grazing of agriculturally idle areas by livestock appeared to decline during the last three years of the study, 50 percent or more were nonetheless grazed.

Interrelationships among weather, partridge productivity, and farming practices were examined, in chronological order. In a cool, wet spring (1970), late nesting, average partridge production and late, prolonged spring cultivation were characteristic. Highest proportions of hay harvests of first (99%) and second crops (73%) were also noted. During the second-driest, warm spring (1971), earlier than normal nesting occurred but overall partridge productivity was about average. The low proportion of residual hay, the earliest spring cultivation, 93 percent of stubble fallowed by mid-June, earliest first hay cuttings, and 93 percent of first hay crops harvested apparently moderated a potentially above-average partridge production year. Only 58 percent of second hay crops were harvested in 1971. Although the spring of 1972 followed the severest winter, the combination of a high residual hay crop, below normal April-June precipitation, about normal temperatures, the latest start for spring cultivation with 12 percent of 1971 stubble undisturbed until mid-June, and normal first hay cutting dates with 17 percent remaining uncut, produced the earliest first nesting and best overall partridge production recorded. Thirty-seven percent of second hay crops were unharvested in 1972. Spring, 1973 followed the mildest winter, April-July was the driest such period recorded and temperatures were above normal. However, spring cultivation began early, stubble fallowing was 90 percent complete by 6 June, first hay cuttings began late and 26 percent of first crops went uncut. Partridge production was characterized by the earliest and second-latest hatching broods of about average size, suggesting considerable renesting. Peak proportions of hay fields and agriculturally idle areas grazed by livestock the winter of 1972-73 could have resulted in only sparse residual nesting cover in spring. Partridge resorting to grain stubble for nesting sites would have subsequently been disturbed by early fallowing, necessitating renesting in current vegetation growth among several land uses.

CONCLUSIONS

Population Characteristics

Hungarian partridge on the Agawam Study Area represented a low density population during 1969-74. An orderly social structure, especially within coveys, was maintained by reproduction and/or behavioral mechanisms.

Spring populations were composed of three social units: the pair, the pair plus an accessory male; and, the bachelor-male flock. The pair was the basic population unit. Once formed in late winter, the pair-bond sustained this unit throughout the summer and probably through the succeeding winter. Pairing data suggested lifetime pair-bonding. Virtually every female in spring was paired. Since more males than females existed in winter and spring, individual unmated males became attached as accessory males to a pair, or several males formed autonomous bachelor-male flocks.

Composition of summer partridge groups was: a pair and its brood, with or without an accessory male; a pair and its brood, with or without a single-parent brood; a pair and its brood, with or without one or more unsuccessful pairs; and unsuccessful pair, with or without an accessory male; a group of two or more unsuccessful pairs, with or without accessory males; and bachelor-male flocks. Successful breeding and incubation resulted in pair-broods or family units. Accessory males attached to pairs apparently were accepted as fully-integrated family members. Pairs unsuccessful in brood-hatching either joined other unsuccessful pairs or were accepted into family units. There was no evidence that exchange of members occurred between coveys in summer. Two family units feeding through the same area simultaneously may have mixed briefly but soon separated into, what seemed to be, their original units. Two exceptions to this pattern were noted when a single male and his chicks were accepted into family units; one such acceptance was only temporary.

Intercovey behavior in summer and winter suggested maintenance of social units was continuous between these periods. Single parent-broods and adultless-broods may have been incorporated into family units during fall.

While a few partridge occupied winter ranges year round, most of the population moved away from and returned toward these ranges with the progression of seasons. Partridge mortality averaged 8 percent per month in winter which may have been greater than that incurred during mild-weather months; it was greater than average monthly mortality of 6 percent (utilizing 73 percent annual mortality). Most partridge paired on their winter ranges, promoting gene-pool mixing on a local basis, while those which moved to other winter ranges for pairing provided mixing over more extensive areas. Winter ranges thus served as nucleii for partridge populations.

The apparent low proportion of partridge remaining on winter ranges for breeding, nesting and brood-rearing seemed to reflect residency by the smallest, producing sex-age class, adult females. If adult male-mates more successfully defended spring territories than subadult male-mates, adult females had an added advantage since all of their known-age mates were adults compared to 38 percent adult male-mates for subadult females. Maximum longevity favored adult females. However, lifetime movements data indicated subadult females were less mobile than adult females. Furthermore, all subadult females returned to initial winter ranges the following winter while only 50 percent of adult females returned.

Two possible interpretations may apply to the apparent differences in affinity for winter ranges displayed by the female age groups: (1) sample size for adult females was too small to accurately depict tendencies to home to winter ranges and *they* were the female segment to reside on or near winter ranges year round, or (2) adult females selected production areas away from winter ranges and provided a mechanism for range expansion by the population. Middleton (1949) reported gamekeepers felt the partridge's worst enemy was older birds which tended to hold territories, forcing young birds to move from one area to another. Jenkins (1961) found limited evidence suggesting young female partridge tended to have larger clutches than adult females. If adult birds were more successful in defending spring territories, in occupying winter ranges as favored production areas, and their smaller clutches led to a declining population, the first of the above interpretations was acceptable. Winter-trapping data revealed an increasing female component, 1969-74, with subadult females increasing at a more rapid rate than adult females; these phenomena suggested a decreasing partridge population which was verified by winter observations, 1968-72.

Upland game birds, native to Montana, possess courtship displays which may attract subadults to courting areas. Communal displays by male sharp-tailed and sage grouse and non-communal displays by male blue grouse and ruffed grouse may function positively in this regard. Crowing by male pheasants, an introduced species, attracts females and probably other males to spring territories. Courtship displays by male Hungarian partridge occurs on winter ranges. Solitary pairs disperse to spring ranges and further courtship is not generally observed. Paired males continue calling until nesting begins but it seems to be more functional in territorial defense than in attracting other partridge. It would not be advantageous to the resident pair to attract additional pairs to this site as it would promote conflict.

The polygamous/promiscuous nature of pheasants and grouse apparently permits high nesting densities. Females of communal displaying grouse species tend to nest in close proximity to display grounds and territorial defense by males decreases as females begin incubation.

Hens of solitary-displaying grouse species and of the pheasant nest in the vicinity of territorial males; any spacing of nests would be contingent upon female tolerances for crowding. More than one female, however, may nest in one male's territory.

Hungarian partridge are monogamous and territorial defense in spring by the male occurs about the female's location. Each territory is therefore limited to a male and a female, and male tolerance for other partridge appears to be very low. These tolerance levels probably fluctuate with habitat quality and partridge density. It seems, therefore, that monogamy is not as conducive as polygamy/promiscuity to high nesting densities.

The factor limiting partridge populations during the study appeared to be the quantity and quality of protective cover in spring. That mean life expectancies and maximum longevity concluded between mid-April and late June indicated spring was a period of major mortality, at least for adult-size birds. Partridge density indices between winter and spring decreased 79 percent in 1971 and 77 percent in 1972. Middleton (1949) noted extraordinary losses, which averaged up to 40 percent, of spring populations at pairing time. Protective vegetative cover, other than woody cover, was minimal from winter-snow melt, about 1 March, through late April. Winter-grazing by livestock on residual hay, agriculturally idle areas and grain stubble reduced the amount of residual vegetation on a significant portion of the study area.

Cultivation of previous-summer grain stubble reduced available protection even further. April and May were months of greatest annual ingress of raptors onto the study area as a result of spring migrations. Large numbers of raptors were hunting over minimal vegetative cover in which partridge were active. With hunters and accidents claiming less than 15 percent of annual partridge populations, the major mortality factor appeared to be predators and much of the loss of adult-size birds could have occurred in spring. Losses would be expected to decrease about 1 June ($\pm$ 2 weeks) when annual and perennial herbaceous vegetation attained sufficient height and density to conceal partridge.

Juvenile and adult partridge were harvested at similar rates (3%) by hunters. Ninety percent of annual partridge harvests occurred during the first 6 weeks of 10-week hunting seasons in northcentral Montana. The sixth week of the partridge season coincided with the first week of pheasant season and the 10-week season permitted pheasant hunters to bag a "bonus" species. It appeared that either few hunters took advantage of this opportunity or partridge became increasingly difficult to bag as seasons progressed. If the proportion of the partridge population harvested is directly related to hunting pressure, study area data project 30 percent of the population would be harvested by 5-hunters-per-square-mile-pressure on opening day. Neither is considered an excessive parameter. The data further suggest there is no justification for reducing season length, except with regard to landowner tolerances for hunters; if a reduction is desirable under this circumstance, partridge daily bag limits could be increased at least proportionately to the season reduction. In view of the current level of harvested partridge, doubling of the present daily bag limit seems biologically permissible.

Habitats

Loamy soils supported a major portion of the grain economy on the study area while alluvial soils supported varying proportions of hay, range and grain. Hungarian partridge distribution coincided with that of cereal grain fields except where winter ranges were absent.

Grain was the dominant food of partridges and wheat seemed preferred to barley. Unfortunately for partridge, the amount of wheat grown on the study area decreased while barley increased proportionately. Winter wheat, the second-most abundant grain, provided food for partridge over a greater part of the year than either spring wheat or barley. Germination in September provided green plant material for partridge during most of the fall, the entire winter (snow depths and texture permitting), spring, and early summer. There were approximately 4-8 weeks when green grain materials were unavailable. Waste grain was available from 1 August through 1 June each year with 1-4 week extensions on either end of this period in wet years. Availability of forbs was apparently influenced by various management practices on all land uses. Insects were available from April through October.

Winter ranges were areas of the most concentrated seasonal use by partridge, a fact attributable to the inclusion of: (1) the only major sources of protective woody cover during the season of most adverse weather conditions; (2) readily available sources of food in the form of waste grain and green plant material; (3) the greatest land-use diversity; and (4) land uses of more permanent status, less disturbance by management activities and more agriculturally idle areas. Agriculturally idle areas were critical components of all seasonal partridge ranges.

Behavior of individual partridge as well as the composite population may influence habitat selection and movements among seasonal ranges. Imprinting of habitat features (geographic, physiographic and vegetative) on young partridge results from close association with adult birds. Any innate tendency to "select" habitat in the future would be reinforced during this period. Assuming family and family-surplus adult associations are maintained through fall and winter, and except for basic survival instincts, subadults in such associations would not be confronted with significant degrees of decision-making with regard to choice of fall or winter ranges.

Vegetations aspects of habitat imprinting during juvenile and subadult periods would include plant physiognomy, particularly heights and density, in various degrees of magnification as perceived by the young birds. Vegetative height, density and protective value at this time would be maximal for that given year and would be maintained until dessication and vernalization. Vegetation characteristics perceived by chicks prior to attainment of flight would be of greatest magnification because of the chick's small size. Increase in chick size and ability to view habitat while in flight reduces height and density magnification. Once the young are adult-sized, magnification of summer habitat features are reduced to the lowest possible level for that season. Magnified perception of habitat by partridge decreases progressively through fall and winter and reaches the lowest annual level during winter.

The period between late winter snowmelt and vegetative growth in spring is accompanied by winter-covery dissolution and pair-bonding. This also represents the first period of "decision-making" by subadult birds. Assuming that females are responsible for selecting the spring and summer ranges, selections could vary with age composition of the pairs. Adult male-adult female pairs should have a decided advantage from previous experience and would presumably choose the most secure habitats. Subadult male-adult female pairs would possess a similar degree of experience. Adult male-subadult female pairs possess prior experience from the male aspect but this is limited to defense of a territory including the residence of the nesting-incubating female. Although the female is inexperienced in selecting the necessary habitat, the area chosen might be more successfully defended by her adult mate than if she were paired to a subadult. It follows that subadult male-subadult female pairs represent no previous spring habitat-selecting experience and any selection would be based on innate ability plus her habitat perception as a chick. Habitats with the requisite perception magnification are much less extensive in early spring than in late spring or summer. Desirable habitats available for selection would probably include a portion of the winter range.

Partridge selected grass-dominated nesting sites in this study and in Michigan (Yeatter 1934) while no preference for grass- or forb-domination was found at nest sites in Wisconsin (McCabe and Hawkins 1946) or in eastern Washington (Knott et al. 1943). In the current study plant canopies over nests were provided equally by grasses and forbs while grass formed most canopies over nests in Michigan. Montana data and those from a later, eastern Washington study (Swanson and Yocom 1958) showed annual partridge ranges were dominated by grasses. The Washington study also suggested high partridge populations were maintained because the birds utilized wheat stubble in place of bunch-grass. These collective studies plus the most successful establishment of Hungarian partridge in North America occurring in the Great Plains suggested partridge preferred grass-dominated, prairie-type habitats. Forbs within these communities and in farmed areas provided concealment of nests in spring and sources of food throughout the year. Forb-dominated communities, such as alfalfa fields, are not preferred nesting or dwelling areas but offer some of the earliest spring vegetative cover when residual grass cover is absent.

In summer, 46 percent of the chicks and an unknown proportion of adults were lost from the study area population. Mowing of hay was a probable mortality factor in early summer and toxic insecticides could have been another. Application of insecticides was not an annual management practice; when they were applied, it was only on vulnerable crops (grain or hay) on individual farms. Herbicides (mostly 2,4-D amine) were commonly applied for control of broad-leaved plants in grain fields; other herbicides were frequently used for wild oats-control in grain fields. Herbicides and their application rates were not considered acutely or chronically toxic to partridge. Their main effect was initially believed to be changes in vegetation components on treated areas. However, Potts (1970a, 1970b) has reported evidence suggesting a subtle, but effective, relationship between farm management practices (including use of herbicides) and partridge population trends.

Partridge populations in Great Britain began a long-term decline about 1960 (Potts 1969). Primary foods of very young chicks are insects, especially ants which thrive on grazed rangelands (Potts 1970a). A decreased rabbit *(Oryctolagus cuniculus)* population and decreasing numbers of domestic sheep have resulted in increased acreages of ungrazed ranges. Larger mean brood sizes found on a grazed range (9.3 young vs. 2.9 young on an ungrazed range) were attributable to an abundance of ants and their pupae.

During the 1960's, increasing numbers of rangeland were converted to cultivated grain; a grain monoculture presently exists (Potts 1970a). Cultivation of rangeland destroyed ant habitat. Other arthropod species, harbored by knotweeds in grain fields, were apparently substituted for ants in partridge chick diets. Treatment of grain fields with herbicides has resulted in relatively weed-free fields. Arthropod biomass in an herbicide-treated field was one-third that of an untreated field (Southwood and Cross 1969). Insect species found in treated grain fields apparently were insufficient to provide nutrients requisite for chicks; six small chicks from four broods found dead had empty crops; 95 percent of gizzard contents was grass seeds. Potts (1970a:152) stated "the absence of arthropods was the cause of death."

In the second study phase Potts (1970b) reported 88 percent (by dry weight) of the dicotyledonous weed seeds in adult partridge crops were knotweeds during 1932-36. In October 1968 these species comprised only 44 percent. Knotweeds were richer than barley in calcium, magnesium and nitrogen but poorer in sodium, potassium and phosphorus. It appeared the dicotylegonous weed seeds were being selected for nutrients deficient in grain. Thus, herbicide-use may be holding partrdige populations at levels lower than would be realized without their use.

In fall, partridge on the Agawam Area remained in low diversity habitats with reduced quantities of protective vegetation. They began returning to winter ranges in late fall, the rate of return apparently being influenced by weather conditions. Mild weather in the fall and winter, 1973-74, allowed them to remain dispersed while winter weather in November-December of other years prompted rapid return.

Soils, topography and climate collectively suggested which agricultural uses were best suited and economically feasible to study area land managers. Actual land uses were dictated by current agricultural economics and land owner preferences. The choice of and intensity with which management practices peculiar to given land uses were employed were probably influenced by cost-profit margins and familial traditions in crop production. Hungarian partridge, ring-necked pheasants and sharp-tailed grouse were, and continue to be, viewed by land managers as aesthetically desirable by-products of farming and ranching operations. While pheasants were preferred to partridge, declines in populations of any species resulted in considerable, often dissonant vocal, concern by landowners.

The majority of hunters pursuing upland game birds on the study area obviously preferred pheasants and sharptails to partridge. Hunting occurred on privately-owned land and no temporary land-use fee was assessed to hunters by landowners nor were hunting rights leased on entire farms or ranches. Hunting activities were viewed positively by hunters and as neutral values by most land managers. Property destruction and careless shooting practices by hunters and others represented negative values of upland game birds to land managers. Although of low incidence, these adverse events tended to be cumulative over many years.

Recommendations to maintain or improve habitat for any upland game bird, resulting in higher bird populations and thereby attracting additional hunters, may be accepted by some land managers but also rejected by others. The present economic cost-beneit ratio of upland game birds is probably negative, i.e. they provide token or no monetary return for their production and their presence may incur direct property losses to land managers. Two methods which could, individually, generate positive cost-benefit ratios are: (1) temporary land-use fees assessed hunters by land managers, or (2) government subsidization of hunting activities on privately-owned lands. However, Montana hunters traditionally expect "free" access to private lands for their activities and previous government subsidy programs in Montana have not been successful (Weigand and Janson 1976). Restructuring of hunter attitudes toward fee-hunting or designing government subsidy programs which provide adequate payments and induce more extensive participation by landowners precludes successful attainment of either program. As long as satisfactory compensation for producing upland game birds is not realized by land managers, they will probably continue present land uses and apply whatever management practices are profitable. If those land uses and management practices are detrimental to upland game bird populations, land managers will also have to accept less than aesthetically desirable numbers of these species, including the Hungarian partridge.

RECOMMENDATIONS

Land Management

Results of this study relate land uses and associated management practices which enhance or deter populations of Hungarian partridge in northcentral Montana. The guidelines presented suggest procedures for maintenance and improvement of partridge habitat, successful implementation of which may provide additional benefits by simultaneously enhancing habitats for pheasants and sharp-tailed grouse.

Partridge populations are optimal in this region in diversified agricultural economics. A mixture of 34-52 percent grain, 20-26 fallow, 15-29 rangeland, 4-12 hayland, 4-5 agriculturally idle areas, and 2 roads, trails and borrow pits define the broad seasonal limits of this diversification.

Partridge will subsist in agricultural monocultures in summer *if* grain and fallow fields are strip-cropped and a secure winter range is available within about 1 mi. Such areas possess moderate diversity resulting principally from the numerous cropland edges and will contain low but persistent partridge populations. Block-field monocultures are not considered partridge habitat, although a winter range in such areas may intermittently harbor a covey or two of partridge.

Fallowing of grain stubble should be delayed until spring; fall cultivation buries waste grain and stubble which serve as food and cover for partridge. Turning under of stubble in spring should be delayed until 25 June in early, dry springs, 1 July in normal springs and 15 July in wet, late springs. This timetable seems especially important in intensively cultivated areas since stubble fields may contain the only available nesting cover. These dates should also be observed in initiating hay harvests.

Grain-cropping methods currently viewed as remedial in alleviating saline-seep problems in northcentral Montana should recognize:

(1) the value of grain stubble to partridge in annual cropping plans;

(2) the moisture-use and partridge-protection values of shrubs and trees among crop strips and in wet areas; and

(3) the moisture-use and partridge-production values of permanent grass strips among grain crops; these strips could be mowed for hay after the above specified dates.

Agriculturally idle areas are critical year round components of partridge habitat. These areas include active and inactive farm/ranch sites, shelterbelts, irrigation ditchbanks, wet areas in grain fields, naturally-vegetated fencelines (> 10 ft or 3.0 m in width), and borrow pits. Such areas should not be burned, grazed by livestock or treated with insecticides or herbicides. Natural succession of these undisturbed areas should progress to stable grass-dominated communities favored by partridge.

Shrubs or trees are requisite daytime winter cover for high partridge densities in this region. Clumps of taller shrubs (e.g. caragana, Russian olive, chokecherry) or shorter trees (e.g. willow, Siberian elm) 0.1 a (0.04 ha) or more in size protect one or more coveys in winter. Primary winter ranges should include at least 1 a (2.5 ha) of this woody cover. Single-or double-row shelterbelts bordering every two or three grain-fallow strips are recommended to increase partridge range in spring, summer and early fall. They do not, however, provide adequate cover during normal to severe winters in this region. Maximum value of these shelterbelts would be realized when they radiate from secure partridge winter ranges. Crop-fallow rotations should include a grain field on at least one side of each shelterbelt every year to provide a source of food in close proximity to protective cover. These shelterbelts could also benefit land managers and hunters by dispersing hunting activities away from dwellings and providing additional partridge for viewing and hunting.

Hunter Harvests

The Hungarian partridge is currently Montana's most prolific, and perhaps most adaptable, upland game bird. Although considered a species to be harvested incidentally to pheasants, prairie grouse and some mountain grouse, the partridge has persisted in areas under increasingly intensified agricultural management. It may become Montana's most popular farmland and farmland-rangeland transition upland game bird by default. It could become a more desirable game bird through hunter education and liberalization of harvest regulations.

Partridge populations, after hunter harvests, in habitats similar to those on the current study area are considerably greater than are necessary to maintain breeding stocks. Only 3 of the 73 percent annual average mortality of partridge populations is taken by hunters. Much of this mortality apparently occurs in spring due to limited nesting cover. Twenty-five to 40 percent of the females do not produce broods and are considered surplus to succeeding breeding populations.

Mean covey size in September was about ten birds. European game managers and researchers recommend individual coveys should not be harvested below six birds. Adherence to this minimum indicates 40 percent of individual fall coveys could be harvested in northcentral Montana. Although the present study showed winter survival of coveys containing at least 3 birds, the 6-bird limitation increases the probability of female occurrence in a covey.

Young partridge attain approximate adult-size at 10-12 weeks of age. In a year with normal spring conditions, these week classes occur during the first 2 weeks in September. It is therefore recommended that opening of partridge hunting seasons be adjusted with regard to annual spring conditions to meet the juvenile 10-12-week classification utilizing 1-15 September as the base.

A 6-week hunting season is adequate to obtain 90 percent of 10-week harvest levels. The 6th week, however, has included the 1st week of the pheasant season and partridge seasons should include this period of pheasant hunting. The additional 4 weeks provides recreational opportunities to a very limited number of avid hunters.

A continuous hunting season seems preferred to a split season in increasing the partridge harvest. The continuous partridge season may increase accidental harvests of pheasants and sharptails in areas where seasons on these species are closed.

Increased bag limits may be the most important incentives in attracting hunters to partridge. Daily bag and possession limits could be doubled without adverse affects on northcentral Montana populations. Increasing daily limits beyond this recommendation may result in decreased hunter interest since hunters may be unable to frequently fill the daily limit.

Research

The current study revealed population and habitat descriptions of a low-density partridge population, characteristic of much of north-central Montana's agricultural economy. This baseline information would be of additional value if used in future studies which included the following specific problems:

(1) refinement of habitat descriptions on a year-to-year basis;

(2) evaluation of land management changes designed to effect maximum partridge productivity and survival;

(3) relationships between insect associations in different vegetation communities and insect species utilized by partridge chicks, with emphasis on chicks up to 6 weeks of age;

(4) nutritional values of individual plant parts of various species of grain, plants supplying green materials and seeds to detect which species and which parts comprise balanced partridge diets;

(5) relationships among specific predator species, partridge and buffer species; and

(6) relationships of sympatric partridge, pheasant and sharptail populations.

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APPENDIX

Appendix I. Hungarian partridge hunting seasons in Teton County, Montana, 1929-74.

Year	Dates	Season Length (days)	Daily Bag Limit	Possession Limit
1929	Nov. 24-28	5	3[1]	6[1]
1930	Nov. 23-27	5	3[1]	6[1]
1931	Nov. 8-12	5	5[2]	10[2]
1932	Oct. 30-Nov. 3	5	5[2]	10[2]
1933	Oct. 29-Nov. 5	8	5[2]	10[2]
1934	Oct. 21-30	10	5	10
1935	Nov. 3-17	15	5	10
1936	Nov. 8-17	10	5	10
1937	Closed	-	-	-
1938	Closed	-	-	-
1939	Closed	-	-	-
1940	Nov. 10-14[3]	5	3	6
1941	Oct. 26-Nov. 16[3]	22	3	6
1942	Oct. 25-Nov. 15	22	5	10
1943	Oct. 31-Nov. 30	31	5	10
1944	Oct. 29-Nov. 19	22	3	6
1945	Oct. 28-Nov. 18	22	3	6
1946	Closed	-	-	-
1947	Closed	-	-	-
1948	Closed	-	-	-
1949	Oct. 30-Nov. 3	5	3	3
1950	Closed	-	-	-
1951	Oct. 28-30[4]	2.5	3	3
1952	Oct. 27-Nov. 11	15.5	3	3
1953	Nov. 8-12	4.5	2	2
1954	Nov. 7-21	14.5	3	3
1955	Nov. 6-20	14.5	3	3
1956	Oct. 28-Nov. 11	14.5	3	3
1957	Oct. 27-Nov. 17	21.5	5	5
1958	Sept. 21-28	7	3[5]	3[5]
	Oct. 26-Nov. 16	21.5	5[6]	10[6]
1959	Sept. 13-27	15	6	12
	Oct. 25-Nov. 22	28.5	6	12
1960	Sept. 11-18	8	6	12

Appendix I. Continued

Year	Dates	Season Length (days)	Daily Bag Limit	Possession Limit
1961	Sept. 17-24	8	6	12
	Oct. 22-Nov. 19	28.5	6	12
1962	Sept. 16-23	8	6	12
	Oct. 14-Nov. 11	28.5	6	12
1963	Sept. 29-Oct. 12	14	6	12
	Oct. 13-Nov. 3	21.5	6	12
1964	Sept. 20-Oct. 4	15	6	12
	Oct. 25-Nov. 29	35.5	6	12
1965	Sept. 19-Oct. 3	15	6	12
	Oct. 31-Nov. 28	28.5	6	12
1966	Sept. 18-Oct. 2	15	6	12
	Oct. 30-Nov. 27	28.5	6	12
1967	Sept. 17-Oct. 1	15	6	12
	Oct. 29-Nov. 26	28.5	6	12
1968	Sept. 15-29	15	6	12
	Nov. 2-24	22.5	6	12
1969	Sept. 13-28	16	6	12
	Oct. 25-Nov. 30	36.5	6	12
1970	Sept. 12-27	16	6	12
	Oct. 24-Nov. 29	36.5	6	12
1971	Sept. 11-Oct. 17	37	6	12
	Oct. 23-Nov. 28	36.5	6	12
1972	Sept. 9-Oct. 8	3o	6	12
	Oct. 22-Nov. 26	35.5	6	12
1973	Sept. 8-Oct. 7	30	6	12
	Oct. 21-Nov. 25	35.5	6	12
1974	Sept. 7-Nov. 24	79	6	12

[1]Singly or in aggregate with ring-necked pheasant cocks.
[2]No more than 3 pheasant cocks daily nor more than 6 pheasant cocks in possession.
[3]Shooting allowed all day on weekends and holidays but from 1200 hours until dark on weekdays.
[4]Start of pheasant/partridge seasons opening at 1200 hours opening day.
[5]Singly or in aggregate with sharp-tailed grouse.
[6]Singly or in aggregate with chukar partridge, 1958-74.

Appendix II. Nomenclature and descriptions of soils on the Agawam Study Area.

Name	Description
Asheulot[1]	
Cheyenne loam[2]:	Medium deep (20 to 40 inches), dark colored loamy soil over loose sand and gravel. It has a clay loam subsoil with good water intake, but water storage for plant use is low.
Cheyenne gravelly loam:	Dark colored, 20 to 40 inches deep, loamy over loose sands and gravel. There is 15 to 35 percent gravel in the surface. It has a clay loam subsoil with good water intake, but water storage for plant use is low.
Judith loam:	Moderately dark colored with a loam or clay-loam surface and occurs on high gravel benches. Little or no development in the subsoil. Is limey at or near surface. Gravels are filled with fine earths and are 12 to 14 inches from the surface.
Judith gravelly loam:	Over 40 inches deep, loamy and dark colored. High lime content in the subsoil; limey throughout. Gravelly in the surface and gravelly to very gravelly at 18 to 24 inches deep. Occurs on high bench areas.
Laurel silt loam:	Deep, wet, and saline. Light to dark colored. Clay to sandy soils. Non-drainable. Frequently found along saline stream bottoms. On gentle slopes.
Richey-Laurel complex:	(Not available at this time).
Morton	
Arengard loam:	Dark brown colored soils developed in local alluvium from soils on glacial drift and soils weathered soft sandstone. They have a thick,

Appendix II. Continued.

Name	Description
Arengard loam: (cont.)	dark surface, 10 to 20 inches deep and are over 40 inches to lime.
Belltower loam:	Deep (over 40 inches) dark colored soils that are limey throughout. They have a high percent of lime in the subsoil with some gravel on the surface with few to abundance of gravel in the subsoil.
Belltower cobbly loam:	Soils over 40 inches deep, dark colored and limey throughout with a high loam concentration in the subsoil. Has numerous cobblestones on the surface with a few throughout the profile.
Nihill gravelly loam:	Shallow loamy gravelly soils over very generally gravelly sandy loams at depths of 10 to 15 inches.
Other	
Fairfield clay loam:	Over 40 inches deep. Moderately dark colored with a clay loam surface. Occurs on high gravel benches on nearly level slopes. Subsoil is well developed silty clay-loam texture. Lime zone at 12 to 16 inches depth.
Fairfield gravelly loam:	Deep (over 40 inches) soil with a silty surface. May have 20 to 50 percent gravel by volume in the surface and in profile.
Straw silt loam:	Deep (40 inches or more) dark brown, developed on stream terraces.
Straw silt loam, seeped:	Deep (over 40 inches) loamy, dark brown soils developed in calcareous alluvium on stream terraces. Seeped areas.

Appendix II. Continued.

Name	Description
Other (cont.)	
Twin Lakes gravelly loam:	Shallow (10 to 20 inches) gravelly soil. Occupies areas of smooth topography of glacial alluvium outwash. A very droughty soil.

[1]Nomenclature by Giesecker et al. (1933).

[2]Nomenclature pending completion by Soils Division, Soil Conservation Service. Information provided by the U. S. Department of Agriculture, Soil Conservation Service, Teton County, Montana Office.

Appendix III. Winter sex ratios of 343 completely classified partridge groups, by 10-day period, month and winter, 1969-74.

Period		Year	No. Groups	Number Birds Males	Females	Total	No. Males Per 100 Females
December	1-10	1969	1	7	1	8	-
		1971	2	6	9	15	66.7
Subtotals			3	13	10	23	130.0
	11-20	1971	3	16	8	24	200.0
Subtotals			3	16	8	24	200.0
	21-31	1970	3	15	11	26	136.4
		1971	32	172	116	288	148.3
		1973	16	60	53	113	113.2
Subtotals			51	247	180	427	137.2
January	1-10	1970	3	24	7	31	342.9
		1971	15	59	47	106	125.5
		1974	30	113	149	262	75.8
Subtotals			48	196	203	399	96.6
	11-20	1969	1	3	2	5	-
		1970	5	34	14	48	242.9
		1971	1	7	3	10	-
		1972	14	71	56	127	126.8
		1974	11	32	28	60	114.3
Subtotals			32	147	103	250	142.7
	21-31	1969	4	17	13	30	130.8
		1970	9	50	35	85	142.9
		1971	20	79	48	127	164.6
		1972	11	38	29	67	131.0
		1974	1	3	4	7	-
Subtotals			45	187	129	316	145.0
February	1-10	1969	8	29	17	46	170.6
		1971	10	38	32	70	118.8
		1972	14	54	54	108	100.0
		1974	14	65	49	114	132.7
Subtotals			46	186	152	338	122.4

Appendix III. Continued

Period	Year	No. Groups	Number Birds Males	Number Birds Females	Number Birds Total	No. Males Per 100 Females
February 11-20	1972	10	41	23	64	178.3
(cont.)	1974	26	27	20	47	135.0
Subtotals		78	175	111	286	157.7
21-28	1970	24	31	23	54	134.8
	1972	10	36	24	60	150.0
	1974	3	3	3	6	-
Subtotals		37	70	50	120	140.0
Winter Totals and Means	1968-69	34	128	84	212	152.4
	1969-70	52	156	90	246	173.3
	1970-71	60	216	147	363	146.9
	1971-72	96	434	319	753	136.1
	1973-74	104	303	306	609	99.0
Five Winter Totals and Means		343	1,237	946	2,183	130.8

Appendix IV. Winter sex ratios of 73 incompletely classified partridge groups, 1969-74.

Period	Year	No. Groups	Number Birds Males	Females	Uncl.	Total	Percent Classified	No. Males Per 100 Females
December 21-31	1970	4	15	6	14	35	60.0	250.0
	1971	9	39	26	34	99	65.7	150.0
	1973	5	9	8	20	37	45.9	112.5
Subtotals		18	63	40	68	171	60.2	157.5
January 1-10	1970	1	2	2	2	6	-	-
	1971	2	5	6	5	16	68.8	83.3
	1974	6	14	9	21	44	52.3	155.6
Subtotals		9	21	17	28	66	57.6	123.5
11-20	1970	1	4	2	1	7	-	-
	1974	1	3	2	1	6	-	-
Subtotals		2	7	4	2	13	84.6	175.0
21-31	1969	1	4	4	2	10	80.0	100.0
	1970	3	14	5	12	31	61.3	280.0
	1974	2	5	8	4	17	76.5	62.5
Subtotals		6	23	17	18	58	69.0	135.3
February 1-10	1972	7	28	20	16	64	75.0	140.0
	1974	8	36	32	16	84	81.0	112.5
Subtotals		15	64	52	32	148	78.4	123.1
11-20	1969	9	29	18	22	69	68.1	161.1
	1970	2	8	7	4	19	78.9	114.3
	1971	1	3	0	1	4	-	-
	1972	3	11	10	10	31	67.7	110.0
Subtotals		15	51	35	37	123	69.9	145.7

Appendix IV. Continued.

Period	Year	No. Groups	Number Birds Males	Females	Uncl.	Total	Percent Classified	No. Males Per 100 Females
February 21-28/ (cont.) 29	1970	6	11	6	8	25	68.0	183.3
	1972	2	9	8	6	23	73.9	112.5
Subtotals		8	20	14	14	48	70.8	142.9
Winter Totals and Means	1968-69	10	33	22	24	79	69.6	150.0
	1969-70	13	39	22	27	88	69.3	177.3
	1970-71	7	23	12	20	55	63.6	191.7
	1971-72	21	87	64	66	217	69.6	135.9
	1973-74	22	67	59	62	188	67.0	113.6
Five-Year Totals and Means		73	249	179	199	627	68.3	139.1

Appendix V. Maximum and mean movements from trap-sites by partridge sex and age classes during the winter of initial capture, by year, 1969-74.

Trapping Period	Sex	Age	No. Birds	Movements Per Bird	Distance Per Movement[1] Maximum	Mean	±	Std. Dev.
January-March 1969	Male	Adult	6	3.5	172 (157)	58 (53)	±	55 (50)
		Subadult	31	2.1	475 (434)	63 (58)	±	91 (83)
	Female	Subadult	16	2.2	162 (148)	41 (37)	±	51 (47)
January-February 1970	Male	Adult	1	2.0	60 (55)	30 (27)	±	42 (39)
		Subadult	6	1.3	90 (82)	18 (16)	±	34 (31)
	Female	Adult	1	1.0	212 (194)	-		-
		Subadult	4	1.3	60 (55)	12 (11)	±	27 (25)
January-February 1971	Male	Adult	9	1.6	122 (112)	49 (45)	±	44 (40)
		Subadult	17	1.9	283 (259)	63 (58)	±	64 (58)
	Female	Adult	4	1.5	91 (83)	43 (39)	±	36 (33)
		Subadult	10	2.0	136 (124)	76 (69)	±	45 (41)
December 1971-March 1972	Male	Adult	34	2.2	905 (828)	136 (124)	±	212 (194)
		Subadult	63	3.0	3,709 (3,392)	222 (203)	±	422 (386)
	Female	Adult	17	2.5	2,095 (1,916)	177 (162)	±	447 (409)
		Subadult	58	2.6	2,110 (1,929)	185 169)	±	385 (352)
January-February 1974	Male	Adult	8	2.5	206 (188)	57 (52)	±	65 (59)
		Subadult	8	2.3	155 (142)	65 (59)	±	48 (44)
	Female	Adult	2	2.5	81 (74)	20 (19)	±	35 (32)
		Subadult	13	1.7	677 (619)	111 (102)	±	141 (129)

[1] In yards (meters).

Appendix VI. Maximum and mean spring movements from winter trap-sites by individual partridge sex-age class, by year, 1969-74.

Trapping Period	Sex	Age	No. Birds	Movements Per Bird	Distance Per Movement[1] Maximum	Mean	±	Std. Dev.
January-March 1969	Male	Adult	6	1.2	465 (425)	231 (211)	±	198 (181)
		Subadult	36	1.5	727 (665)	130 (119)	±	175 (160)
	Female	Subadult	17		293 (268)	66 (61)	±	90 (83)
January-February 1970	Male	Adult	1	1.0	130 (119)	-		-
		Subadult	2	1.0	110 (101)	100 (91)	±	14 (13)
January-February 1971	Male	Adult	3	1.7	258 (236)	196 (179)	±	66 (60)
		Subadult	6	1.3	2,212 (2,023)	439 (401)	±	724 (662)
	Female	Adult	3	2.0	556 (508)	280 (256)	±	149 (136)
		Subadult	3	2.0	258 (236)	156 (143)	±	66 (60)
December 1971-March 1972	Male	Adult	5	1.0	1,778 (1,626)	669 (612)	±	769 (703)
		Subadult	14	1.7	2,894 (2,646)	602 (550)	±	679 (621)
	Female	Adult	1	1.0	30 (27)	-		-
		Subadult	7	1.6	3,527 (3,225)	812 (742)	±	1,351 (1,235)
January-February 1974	Male	Adult	3	4.7	384 (351)	178 (162)	±	113 (104)
		Subadult	1	2.0	81 (74)	66 (60)	±	21 (19)
	Female	Adult	1	3.0	116 (106)	76 (70)	±	61 (56)
		Subadult	3	4.0	162 (148)	102 (93)	±	32 (29)

[1]In yards (meters).

Appendix VII. Maximum and mean movements to spring ranges from initial winter trap-sites by adult male and female partridge, by year, 1969-74.

Trapping Period	Sex	No. Birds	Movements Per Bird	Distance per Movement[2] Maximum	Mean ±	Std. Dev.
January-March 1969	Male	4	1.3	293 (268)	164 (150) ±	138 (122)
January-February 1970	Male	5	1.4	616 (563)	290 (265) ±	192 (176)
	Female	1	1.0	66 (60)	-	-
January-February 1971	Male	5	1.8	912 (834)	294 (269) ±	250 (229)
	Female	4	1.8	556 (508)	260 (238) ±	146 (133)
December 1971 - March 1972	Male	6	1.3	3,671 (3,357)	1,774 (1,622) ±	1,631 (1,492)
	Female	1	1.0	30 (27)	-	-
January-February 1974	Male	3	4.7	384 (351)	178 (162) ±	113 (104)
	Female	1	3.0	116 (106)	76 (70) ±	61 (56)

[1]Does not include first species SubAd, does include second species.
[2]In yards (meters).

Appendix VIII. Maximum and mean summer movements from winter trap-sites by individual partridge sex-age class, by year, 1969-72.

Trapping Period	Sex	Age	No. Birds	Movements Per Bird	Distance Per Movement[1]			
					Maximum	Mean	±	Std. Dev.
January-March 1969	Male	Adult	1	1.0	1,207 (1,104)	-		-
		Subadult	4	1.0	966 (883)	616 (564)	±	375 (318)
	Female	Subadult	1	1.0	323 (295)	-		-
January-February 1970	Male	Subadult	2	1.0	402 (368)	322 (294)	±	113 (103)
January-February 1971	Male	Adult	2	1.0	424 (388)	225 (205)	±	282 (258)
		Subadult	2	1.0	1,250 (1,143)	719 (657)	±	752 (687)
	Female	Subadult	2	1.5	237 (217)	93 (85)	±	125 (115)
December 1971-March 1972	Male	Adult	1	1.0	793 (725)	-		-
		Subadult	6	1.0	742 (679)	601 (549)	±	230 (211)
	Female	Subadult	5	1.2	586 (536)	276 (253)	±	157 (144)

[1]In yards (meters).

Appendix IX. Maximum and mean movements to summer ranges from winter trap-sites by adult[1] male and female partridge, by year, 1969-72.

Trapping Period	Sex	No. Birds	Movements Per Bird	Distance Per Movement[2] Maximum	Mean ± Std. Dev.
January-March 1969	Male	1	1.0	1,207(1,104)	- -
January-February 1970	Male	1	1.0	402(368)	-
January-February 1971	Male	6	1.0	3,651(3,339)	946(865)
	Female	2	1.5	237(217)	93(85)
December 1971 March 1972	Male	9	1.1	793(725)	475(434)
	Female	6	1.0	586(536)	276(253)

1

2In yards (meters).

Appendix X. Maximum and mean fall movements from winter trap-sites by individual partridge sex-age class, by year, 1969-72.

Trapping Period	Sex	Age	No. Birds	Movements Per Bird	Distance Per Movement[1] Maximum	Mean	± Std. Dev.
January-March 1969	Male	Subadult	1	1.0	50 (46)	-	-
	Female	Subadult	2	1.0	343 (314)	197 (180)	± 207 (190)
January-February 1970	Male	Subadult	1	1.0	939 (859)	-	-
January-February 1971	Male	Adult	1	1.0	505 (462)	-	-
		Subadult	1	1.0	2,075 (1,897)	-	-
	Female	Subadult	1	1.0	1,905 (1,742)	-	-
December 1971-March 1972	Male	Adult	2	2.0	222 (203)	120 (110)	± 68 (62)
		Subadult	3	1.7	2,435 (2,227)	987 (902)	± 1,001(916)
	Female	Subadult	5	1.8	2,872 (2,626)	434 (397)	± 916 (838)

[1]In yards (meters).

Appendix XI. Maximum and mean movements to fall ranges from initial winter trap-sites by adult[1] male and female partridge, by year, 1969-72.

Trapping Period	Sex	No. Birds	Movements Per Bird	Movements Distance Per Movement[2] Maximum	Mean
January-March 1969	Male	2	1.0	196(179)	115(105)
	Female	2	1.0	343(314)	197(180)
January-February 1970	Male	3	1.0	939(859)	745(681)
January-February 1971	Male	2	1.0	2,075(1,897)	1,290(1,180)
	Female	1	1.0	1,905(1,742)	-
December 1971 March 1972	Male	6	1.7	2,435(2,227)	550(503)
	Female	5	1.8	2,872(2,626)	434(397)

1

[2]In yards (meters).

Appendix XII. Maximum and mean movements to second-winter ranges from initial winter trap-sites by individual partridge sex-age class, by year, 1969-71.

Trapping Period	Sex	Age	No. Birds	Movements Per Bird	Distance Per Movement[1] Maximum	Mean	± Std. Dev.
January-March 1969	Male	Subadult	4	1.3	2,666 (2,438)	647 (591) ±	1,131 (1,034)
January-February 1970	Male	Adult	1	3.0	141 (129)	108 (919) ±	41 (38)
		Subadult	6	1.5	6,384 (5,838)	1,551 (1,418) ±	2,743 (2,508)
	Female	Subadult	1	4.0	141 (129)	94 (86) ±	44 (40)
January-February 1971	Male	Adult	3	4.3	2,135 (1,952)	505 (461) ±	727 (665)
		Subadult	5	2.8	4,572 (4,181)	2,039 (1,865) ±	1,545 (1,413)
	Female	Adult	3	1.7	2,815 (2,574)	2,094 (1,915) ±	789 (722)
		Subadult	2	5.0	253 (231)	115 (105) ±	85 (78)

[1]In yards (meters).

Appendix XIII. Maximum and mean movements to second-winter ranges from initial winter trap-sites of adult[1] male and female partridge, by year, 1969-72.

Trapping Period	Sex	No. Birds	Movements Per Bird	Distance Per movement[2] Maximum	Mean	±	Std. Dev.
January-March 1969	Male	4	1.8	2,580(2,359)	1,056(966)	±	1,181(1,080)
January-February 1970	Male	8	2.1	6,384(5,538)	875(800)	±	2,076(1,898)
	Female	2	4.0	192(176)	111(102)	±	59(54)
January-February 1971	Male	8	3.4	4,572(4,181)	1,300(1,189)	±	1,431(1,309)
	Female	4	3.5	2,815(2,574)	766(701)	±	1,096(1,002)
December 1971 March 1972	Male	3	1.7	3,590(3,283)	822(752)	±	1,548(1,416)
	Female	1	2.0	61(56)	31(28)	±	43(39)

[1]

[2]In yards (meters).

Appendix XIV. Partridge productivity by 10-day periods, by year, 1969-73.

Year	Time Period		Number Birds Observed: Males	Females	Unk.-Sex Adults	Young	Young Per 100 Adults	Adults with Young: No.	Percent	No. Broods	Young Per Brood	Hens[1] with Young: No.	Percent
1969	July	21-31	21	11	29	119	195	24	39.4	10	11.90	4	36.4
	August	1-10	26	12	25	111	176	29	46.0	12	9.25	8	66.7
		11-20	20	9	15	79	180	26	59.1	11	7.18	6	66.7
		21-31	18	11	11	93	232	30	75.0	10	9.30	9	81.8
		Totals	64	32	51	283	192	85	58.7	33	9.35	27	62.9
	September	1-10	22	11	6	56	144	30	76.9	9	6.22	6	54.5
		11-20	1	1	0	3	150	2	100.0	1	3.00	1	100.0
		Totals	23	12	6	59	144	32	78.0	10	5.90	7	58.3
1970	July	1-10	8	6	16	11	31	1	3.3	1[2]	11.00	1	16.7
		11-20	11	8	2	17	81	1	4.8	1[3]	17.00	1	12.5
		21-31	8	5	11	42	175	7	29.1	4	10.50	2	40.0
		Totals	27	19	29	70	93	9	8.3	6	11.67	4	21.0
	August	1-10	5	2	20	56	208	15	18.0	6	9.33	1	50.0
		11-20	22	15	28	171	264	45	69.2	20	8.55	12	80.0
		21-31	12	10	34	123	220	31	55.4	16	7.70	7	70.0
		Totals	39	27	82	350	236	91	61.5	42	8.34	20	74.2
	September	1-10	17	9	15	149	363	32	78.0	15	9.93	6	66.7
		11-20	20	15	12	109	232	30	63.8	12	9.08	8	53.3
		21-30	5	6	0	29	264	11	100.0	3	9.67	3	50.0
		Totals	42	30	27	287	289	73	73.7	30	9.57	17	56.7
1971	July	1-10	4	2	2	0	0	0	-	0	-	0	-
		11-20	7	3	8	27	150	4	22.2	2	13.50	1	33.3
		21-31	3	2	14	0	-	0	-	0	-	0	-
		Totals	14	7	24	27	60	4	8.9	2	13.50	1	14.3
	August	1-10	10	6	26	86	205	18	40.9	9	9.56	4	66.7
		11-20	13	7	22	173	412	31	73.8	14	12.36	6	85.7
		21-31	24	25	17	164	248	49	74.2	20	8.20	16	64.0
		Totals	47	38	65	423	282	98	65.3	43	9.84	26	68.4
	September	1-10	5	3	5	12	92	8	61.5	3	4.00	3	100.0
		11-20	5	4	0	23	256	9	100.0	2	11.50	2	50.0
		21-30	1	1	0	4	200	1	100.0	1	4.00	1	100.0
		Totals	11	8	5	39	163	18	75.0	6	6.50	6	75.0

Appendix XIV. Continued

Year	Time Period		Number Birds Observed				Young Per	Adults with Young		No.	Young Per	Hens[1] with Young	
			Males	Females	Unk.-Sex Adults	Unk.-Sex Young	100 Adults	No.	Percent	Broods	Brood	No.	Percent
1972	August	1-10	19	10	16	98	218	21	46.7	9	10.89	8	80.0
		11-21	25	6	4	52	149	11	31.4	4	13.00	4	66.7
		21-31	26	17	11	114	211	29	53.7	11	10.39	10	58.9
		Totals	70	33	31	264	197	61	45.5	24	11.00	22	66.7
	September	1-10	22	17	14	126	238	28	52.8	12	10.50	11	58.9
		11-21	1	1	0	16	800	2	100.0	1	12.00	1	100.0
		Totals	23	18	14	142	258	30	54.5	13	10.92	12	66.7
1973	July	17-20	0	0	15	26	173	4	26.6	2	13.00	0	-
		21-31	0	0	19	54	284	11	57.9	5	10.80	0	-
		Totals	0	0	34	80	235	15	44.2	7	11.43	0	-
	August	1-10	31	27	61	257	216	71	59.6	25	10.28	12	44.4
		11-20	45	36	14	185	195	67	70.6	21	8.81	20	55.6
		21-31	43	41	16	212	212	66	66.0	23	9.22	22	53.7
		Totals	119	104	91	654	208	204	65.0	69	9.48	54	51.9
	September	1-10	40	36	1	185	240	60	78.0	24	7.71	23	63.9
		11-20	12	17	8	71	192	23	62.2	9	7.89	7	41.2
		21-30	5	2	0	25	357	7	100.0	2	12.50	2	100.0
		Totals	57	55	9	281	232	90	80.4	35	8.03	32	58.2

[1]Productive status of hens determined at time of observation.
[2]One clutch of 11 hatched eggs.
[3]Includes one clutch of 17 hatched eggs.

Appendix XV. Land uses along four observation routes on the Agawam Study Area during the summer, 1969.

Land Use	Route A No. Fields	Route A Area[1]	Route B No. Fields	Route B Area	Route C No. Fields	Route C Area	Route D No. Fields	Route D Area	Totals No. Fields	Totals Area
Grain:										
Barley	16	2.475	16	3.575	19	6.900	9	2.175	60	15.125
Oats	0	-	0	-	1	.200	2	.750	3	.950
Spring Wheat	9	1.500	3	.275	5	1.075	3	.925	20	3.775
Winter Wheat	11	2.500	16	1.575	41	3.675	16	5.050	84	12.800
Subtotal	36	6.475	35	5.425	66	11.850	30	8.900	167	32.650
Fallow: (Subtotal)	36	6.825	29	2.300	70	16.325	21	5.750	156	31.200
Hay:										
Alfalfa	22	2.850	17	3.100	3	0.525	7	1.450	49	7.925
Alfalfa-Grass	2	.550	0	-	0	-	0	-	2	.550
Grass-Alfalfa	3	.625	2	-	1	.300	0	-	6	1.475
Grass	6	.825	8	2.175	3	.700	4	.425	21	4.125
Sweet Clover[2]	0	-	2	.750	0	-	0	-	2	.750
Subtotal	33	4.850	29	6,575	7	1.525	11	1.875	80	14.825
Range:										
Lowland	28	6.725	23	5.400	6	0.825	13	2.450	70	15.400
Upland	12	1.600	0	-	23	4.300	11	2.000	46	7.900
Seeded	1	.275	1	.500	0	-	1	.350	3	1.125
Feedlot	1	.025	5	.300	1	.050	2	.075	9	.450
Muddy Creek	0	-	2	.675	0	-	0	-	2	.675
Subtotal	42	8.625	31	6.875	30	5.175	27	4.875	130	25.550
Agriculturally Idle:										
With Buildings	5	0.225	6	.350	7	0.650	1	0.050	22	1.275
Without Buildings	17	1.800	10	.875	22	2.225	14	1.825	63	6.725
Farm/Ranch Site	9	.950	10	1.100	10	.725	3	.225	29	3.000
Gravel Pit	0	-	0	-	0	-	1	.100	1	.100
Irrigation Ditch	15	.500	9	.825	0	-	4	.625	28	1.950
Oil Facility	2	.050	0	-	0	-	4	.175	6	.225
Railroad R-O-W[3]	0	-	3	.325	0	-	0	-	3	.325
Soil Bank	1	.400	0	-	0	-	0	-	1	.400
Wetland	0	-	0	-	3	.325	0	-	3	.325
Subtotal	49	3.925	38	3.475	42	3.925	27	3.000	156	14.325
Totals	196	30.700	162	24.650	215	38.800	116	24.400	689	118.550

[1]Area refers to length along both sides of route measured to nearest 0.025-mi (0.04 m).
[2]Various combinations with alfalfa and/or grass.
[3]Railroad right-of-way.

Appendix XVI. Land uses along four observation routes on the Agawam Study Area during the summer, 1970.

Land Use	Route A		Route B		Route C		Route D		Totals	
	No. Fields	Area[1]	No. Fields	Area	No. Fields	Area	No. Fields	Area	No. Fields	Area
Grain:										
Barley	17	2.000	16	2.175	31	4.875	8	2.025	72	11.075
Oats	1	.275	0	-	5	1.150	2	.425	8	1.850
Spring Wheat	14	3.200	1	.050	25	5.000	5	1.550	45	9.800
Winter Wheat	11	2.175	16	1.250	16	3.550	8	3.475	51	10.450
Subtotal	43	7.650	33	3,475	77	14.575	23	7.475	176	33.175
Fallow: (Subtotal)	36	5.525	33	4.200	66	13.450	25	5.925	160	29.100
Hay:										
Alfalfa	25	3.500	12	2.225	1	0.225	3	0.525	41	6.475
Alfalfa-Grass	3	.400	5	1.400	1	.300	4	.925	13	3.025
Grass-Alfalfa	2	.375	2	.300	1	.225	0	-	5	.900
Grass	7	1.350	8	2.300	3	.625	5	.775	23	5.050
Sanfoin	1	.300	0	-	0	-	0	-	1	.300
Yellow Sweet Clover[2]	1	.100	4	.325	0	-	1	.250	6	.675
Subtotal	39	6.025	31	6.550	6	1.375	13	2.475	89	16.425
Range:										
Lowland	27	5,775	23	5.750	5	0.725	11	2.025	66	14.275
Upland	14	1.900	0	-	24	4.200	11	2.125	49	8.225
Seeded	0	-	1	.500	0	-	4	1.425	5	1.925
Feedlot	1	.025	5	.300	1	.050	2	.075	9	.450
Muddy Creek	0	-	2	.675	0	-	0	-	2	.675
Subtotal	42	7.700	31	7.225	30	4.975	28	5.650	131	25.550
Agriculturally Idle:										
With Buildings	4	0.200	5	0.225	5	0.275	1	.050	15	0.750
Without Buildings	17	1.775	9	.650	27	3.125	12	1.675	65	7.225
Farm/Ranch Site	9	.950	11	1.200	10	.725	3	.225	33	3.100
Gravel Pit	0	-	0	-	0	-	1	.100	1	.100
Irrigation Ditch	16	.525	7	.800	0	-	4	.625	27	1.950
Oil Facility	2	.050	0	-	0	-	4	.200	6	.250
Railroad R-O-W[3]	0	-	3	.325	0	-	0	-	3	.325
Soil Bank	1	.300	0	-	0	-	0	-	1	.300
Wetland	0	-	0	-	3	.300	0	-	3	.300
Subtotal	49	3.800	35	3.200	45	4.425	25	2.875	154	14.300
Totals	209	30.700	163	24.650	224	38.800	114	24.400	710	118.550

[1]Area refers to length along both sides of route measured to nearest 0.025-mi (0.04 km).
[2]Various combinations with alfalfa and/or grass.
[3]Railroad right-of-way.

Appendix XVII. Land uses along four observation routes on the Agawam Study Area during the summer, 1971.

Land Use	Route A No. Fields	Route A Area[1]	Route B No. Fields	Route B Area	Route C No. Fields	Route C Area	Route D No. Fields	Route D Area	Totals No. Fields	Totals Area
Grain:										
Barley	17	3.125	15	2.225	25	4.800	16	3.850	73	14.000
Oats	1	.250	0	-	1	.175	0	-	2	.425
Spring Wheat	14	2.925	6	.700	22	4.075	9	2.975	51	10.675
Winter Wheat	16	2.325	20	1.875	26	4.900	7	.950	69	10.050
Subtotal	48	8.625	41	4.800	74	13.950	32	7.775	195	35.150
Fallow: (Subtotal)	27	4.300	31	2.400	72	14.350	22	5.775	152	26.825
Hay:										
Alfalfa	23	3.125	9	2.225	1	0.100	3	0.600	36	6.050
Alfalfa-Grass	4	.850	6	1.675	0	-	4	.775	14	3.300
Grass-Alfalfa	6	.825	3	.525	3	.625	0	-	12	1.975
Grass	8	1.175	10	2.175	1	.350	5	.775	24	4.475
Sanfoin	1	.075	0	-	0	-	0	-	1	.075
Yellow Sweet Clover[2]	0	-	4	.350	1	.025	1	.400	5	.775
Subtotal	42	6.050	32	6.950	6	1.100	13	2.550	92	16.650
Range:										
Lowland	27	6.100	24	5.825	9	1.350	12	2.100	72	15.375
Upland	12	1.700	0	-	22	4.200	13	2.350	47	8.250
Seeded	2	.350	1	.500	0	-	3	1.225	6	2.075
Feedlot	1	.025	2	.175	1	.050	2	.075	6	.325
Muddy Creek	0	-	2	.675	0	-	0	-	2	.675
Subtotal	42	8.175	29	7.175	32	5.600	30	5.750	133	26.700
Agriculturally Idle:										
With Buildings	3	0.200	5	0.225	6	0.450	1	0.050	15	0.925
Without Buildings	19	1.850	10	.675	24	2.325	12	1.375	65	6.225
Farm/Ranch Site	9	.950	11	1.200	10	0.700	3	.225	33	3.075
Gravel Pit	0	-	0	-	0	-	1	.100	1	.100
Irrigation Ditch	15	.500	10	.900	0	-	3	.600	28	2.000
Oil Facility	2	.050	0	-	0	-	5	.200	7	.250
Railroad R-O-W[3]	0	-	3	.325	0	-	0	-	3	.325
Wetland	0	-	0	-	3	0.325	0	-	3	.325
Subtotal	48	3.550	39	3.325	43	3.800	25	2.550	155	13.225
Totals	207	30.700	172	24.650	227	38.800	122	24.400	728	118.550

[1] Area refers to length along both sides of route measured to nearest 0.025-mi (0.04 m).
[2] Various combinations with alfalfa and/or grass.
[3] Railroad right-of-way.

Appendix XVIII. Land uses along four observation routes on the Agawam Study Area during the summer, 1972.

Land Use	Route A		Route B		Route C		Route D		Totals	
	No. Fields	Area	No. Fields	Area	No. Fields	Area	No. Fields	Area	No. Fields	Area
Grain:										
Barley	14	2.975	15	1.475	38	7.000	15	3.800	82	15.250
Oats	1	.050	1	.050	0	-	0	-	2	.100
Spring Wheat	3	.525	1	.025	17	3.375	5	1.025	26	4.950
Winter Wheat	15	1.900	18	1.150	27	4.225	9	2.925	69	10.200
Subtotal	33	5.450	35	2.700	82	14.600	29	7.750	179	30.500
Fallow: (Subtotal)	38	7.425	34	4.725	64	13.325	21	6.150	157	31.625
Hay:										
Alfalfa	21	3.000	4	0.800	1	0.100	3	0.550	29	4.450
Alfalfa-Grass	4	.725	12	3.000	0	-	4	.925	20	4.650
Grass-Alfalfa	5	.700	3	.700	4	.825	3	.375	15	2.600
Grass	7	1.100	10	2.150	1	.350	3	.350	21	3.950
Sanfoin	1	.300	0	-	0	-	0	-	1	.300
Sweet Clover[2]	0	-	3	.150	0	-	0	-	3	.150
Subtotal	38	5.825	32	6.800	6	1.275	13	2.200	89	16.100
Range:										
Lowland	27	6.175	23	5.725	9	1.550	12	1.925	71	15.375
Upland	13	1.775	0	-	24	4.325	14	2.350	51	8.450
Seeded	1	.275	1	.500	1	.050	3	1.100	6	1.925
Feedlot	1	.025	5	.300	0	-	3	.425	9	.750
Muddy Creek	0	-	2	.675	0	-	0	-	2	.675
Subtotal	42	8.250	31	7.200	34	5.925	32	5.800	139	27.175
Agriculturally Idle:										
With Buildings	4	0.275	4	0.200	5	0.275	1	0.050	14	0.800
Without Buildings	18	1.900	10	.700	24	2.425	12	1.325	64	6.350
Farm/Ranch Site	9	.950	11	1.200	10	0.700	4	.250	34	3.100
Gravel Pit	0	-	0	-	0	-	1	.100	1	.100
Irrigation Ditch	16	.575	7	.800	0	-	4	.625	27	2.000
Oil Facility	2	.050	0	-	0	-	3	.150	5	.200
Railroad R-O-W[3]	0	-	3	.325	0	-	0	-	3	.325
Wetland	0	-	0	-	3	0.275	0	-	3	.275
Subtotal	49	3.750	35	3.225	42	3.675	25	2.500	151	13.150
Totals	200	30.700	167	24.650	228	38.800	120	24.400	715	118.550

[1] Area refers to length along both sides of route measured to nearest 0.025-mi (0.04 m).
[2] Various combinations with alfalfa and/or grass.
[3] Railroad right-of-way.

Appendix XIX. Land uses along four observation routes on the Agawam Study Area during the summer, 1973.

Land Use	Route A No. Fields	Route A Area[1]	Route B No. Fields	Route B Area	Route C No. Fields	Route C Area	Route D No. Fields	Route D Area	Totals No. Fields	Totals Area
Grain:										
Barley	19	4.125	29	2.900	41	9.600	18	4,575	107	21.200
Oats	1	.225	0	-	0	-	0	-	1	.225
Spring Wheat	8	1.750	1	.350	15	2.025	6	1.650	30	5.775
Winter Wheat	14	1.650	38	4.775	72	13.525	26	6.550	40	5.400
Subtotal	42	7.750	38	4.775	72	13.525	26	6.550	178	32.600
Fallow: (Subtotal)	29	5.075	32	2.750	76	15.300	25	6.400	162	29.525
Hay:										
Alfalfa	20	2.775	7	1.150	1	0.100	5	1.500	33	5.525
Alfalfa-Grass	7	1.575	10	2.825	0	-	2	.250	19	4.650
Grass-Alfalfa	5	.625	2	.725	2	.350	3	.750	12	2.450
Grass	4	.575	8	1.775	1	.300	6	.575	19	3.225
Subtotal	36	5.550	27	6.475	4	0.750	16	3.075	83	15.850
Range:										
Lowland	30	6.600	25	5.975	9	1.575	10	1.600	74	15.750
Upland	8	1.225	0	-	22	4.125	14	2.650	44	8.000
Seeded	3	.525	1	.500	1	.050	4	1.475	9	2.550
Feedlot	1	.025	5	.300	0	-	2	.075	8	.400
Muddy Creek	0	-	2	.675	0	-	0	-	2	.675
Subtotal	42	8.375	33	7.450	32	5.750	0	5.800	137	23.375
Agriculturally Idle:										
With Buildings	5	0.250	5	0.225	6	0.450	1	0.050	17	0.975
Without Buildings	20	2.200	9	.650	21	2.100	13	1.175	63	6.125
Farm/Ranch Site	19	.950	11	1.200	10	.700	3	.225	33	3.075
Gravel Pit	0	-	0	-	0	-	1	.100	1	.100
Irrigation Ditch	15	.500	7	.800	0	-	4	.825	26	2.125
Oil Facility	2	.050	0	-	0	-	4	.200	6	.250
Railroad R-O-W[2]	0	-	3	.325	0	-	0	-	3	.325
Wetland	0	-	0	-	3	0.225	0	-	3	.225
Subtotal	51	3.950	35	3.200	40	3.475	26	2.575	152	13.200
Totals	200	30.700	165	24.650	224	38.800	123	24.400	712	118.550

[1]Area refers to length along both sides of route measured to nearest 0.025-mi (0.04 m).
[2]Railroad right-of-way.

Appendix XX. Partridge densities and Z-values of associated land uses and sub-uses on the Agawam Study Area, 1969-72.

Land Use:	No.	Spring			Summer			Fall			Winter		
Sub-Use	Miles	Obs.	Obs./ Mi.	Z	Obs.	Obs./ Mi.	Z	Obs.	Obs./ Mi.	Z	Obs.	Miles	Fields
Grain:													
Barley	40.200	75	1.866	-1.440	82	2.040	-0.711	18	0.448	-2.230	54	1.343	- 4.263
Oats	3.225	11	3.411	-0.234	10	3.101	+0.032	4	1.240	-0.699	15	4.651	- 0.896
Spring Wheat	24.250	41	1.691	-1.640	64	2.639	-0.254	42	1.732	-0.217	56	2.309	- 2.753
Winter Wheat	33.300	124	3.724	-0.587	54	1.622	-1.121	48	1.441	-0.482	120	3.604	- 1.564
Subtotals[1]	100.975	256	2.535	-0.953	211	2.090	-0.461	112	1.109	-0.523	240	2.377	- 1.191
Fallow:													
Fallow	87.125	468	5.372	+0.681	185	2.123	-0.640	59	0.677	-1.592	115	1.320	- 4.313
Subtotals	87.125	468	5.372	+0.691	185	2.123	-0.433	59	0.677	-1.113	115	1.320	- 2.233
Hay:													
Alfalfa	20.450	37	1.809	-1.503	31	1.516	-1.242	14	0.685	-1.576	14	0.685	- 6.221
Alfalfa-Grass	6.875	9	1.309	-2.168	10	1.455	-1.316	5	0.727	-1.485	15	2.182	- 2.907
Grass-Alfalfa	4.350	15	3.448	-0.212	9	2.069	+0.686	8	1.839	-0.131	5	1.149	- 4.711
Grass	13.650	8	0.586	-3.904	19	1.392	-1.396	6	0.440	-2.259	11	0.806	- 5.744
Sanfoin	0.375	0	0	-9.792	1	2.667	-0.236	1	2.667	+0.411	4	10.667	+ 1.293
Sweet Clover	2.200	2	0.909	-2.941	3	1.364	-1.433	0	0	-7.094	0	0	-12.808
Subtotals	47.900	71	1.482	-1.928	73	1.524	-0.980	34	0.710	-1.061	49	1.023	- 2.613
Range:													
Lowland	45.050	85	1.887	-1.417	87	1.931	-0.808	47	1.043	-0.951	103	2.286	- 2.779
Upland	24.375	87	3.569	-0.144	59	2.421	-0.408	42	1.723	-0.225	102	4.185	- 1.721
Seeded	5.125	12	2.341	-0.984	5	0.976	-2.050	3	0.585	-1.814	3	0.585	- 6.677
Feedlot	1.225	6	4.898	+0.492	2	1.633	-1.108	0	0	-7.094	31	25.306	+ 3.863
Muddy Creek	2.025	0	0	-9.792	0	0	-8.725	0	0	-7.094	0	0	-12.808
Subtotals	77.800	190	2.442	-1.027	153	1.967	-0.564	92	1.183	-0.439	231	2.969	- 0.740
Agriculturally Idle													
W. Buildings	2 950	72	24.407	+4.327	46	15.593	+3.299	45	15.254	+3.525	161	54.576	+ 6.759
W/O Buildings	20.175	100	4.957	+0.517	104	5.155	+0.957	42	2.082	+0.049	96	4.758	- 0.837
Farm/Ranch Site[2]	9.175	116	12.643	+2.566	40	4.360	+0.647	67	7.303	+2.029	253	27.575	+ 4.151
Gravel Pit	0.300	0	0	-9.792	0	0	-8.725	0	0	-7.094	0	0	-12.808
Irrigation Ditch	5.900	42	7.119	+1.268	43	7.288	+1.624	29	4.915	+1.353	30	5.085	- 0.664
Oil Facility	0.725	2	2.759	-0.656	7	9.655	+2.203	4	5.517	+1.543	2	2.759	- 2.273
Railroad R-O-W[3]	0.975	7	7.179	+1.286	4	5.128	+0.947	0	0	-7.094	8	8.205	- 0.588
Soil Bank	0.700	0	0	-9.792	0	0	-8.725	0	0	-7.094	0	0	-12.808
Wetland	0.950	0	0	-9.792	0	0	-8.725	0	0	-7.094	0	0	-12.808
Subtotals	41.850	339	8.100	-9.792	244	5.830	+1.554	187	4.468	+1.637	550	13.142	
Totals	355.650	964	-	-	866	-	-	484	-	-	1,185	-	-
			LU:	SU:		LU:	SU:		LU:	SU:		LU:	SU:
k			5	25		5	25		5	25		5	25
$\bar{X}_{1,k}$			3.986	3.835		2.707	3.045		2.013	1.629		4.166	6.561

1 Land use subtotals computed from their data only, i.e. not from means of above sub-uses.
2 Includes shelterbelts.
3 Railroad right-of-way.