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Factors Affecting Mourning Dove Use of Water in Artificial Catchment Basins in a Dryland Farming Area of Utah

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FACTORS AFFECTING MOURNING DOVE USE OF WATER

IN ARTIFICIAL CATCHMENT BASINS IN A

DRYLAND FARMING AREA OF UTAH

BY

Norman A. Slade

A thesis submitted in partial fulfillment
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of

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Norman A. Slade

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ABSTRACT

Factors Affecting Mourning Dove Use of Water in Artificial Catchment Basins in a Dryland Farming Area of Utah

by

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The mourning dove population of the Howell-Blue Creek Watershed in northern Utah was studied in an effort to determine why many more doves frequented certain of the fiberglass catchment basins in the area.

More doves used basins on the west side of the valley, probably as a result of temperature differences. More doves used those basins surrounded by more land in summer fallow and with fewer basins nearby. Areas in sagebrush were used for nesting.

The number of doves drinking in a particular hour was affected by the presence of predators or antagonists but not by light rain, cloud cover, temperature, wind velocity, or amount of space available for drinking. Frequency of drinking was highest in the early morning and late evening, particularly in late summer.

(68 pages)

INTRODUCTION

The purpose of this study was to identify certain environmental factors which had an effect on the numbers of mourning doves (*Zenaidura macroura*) drinking from artificial water catchments. The study was conducted from July, 1965 to September, 1966 in a dryland farming area of northern Utah.

The mourning dove is one of the most popular game birds in the United States. It breeds in all of the contiguous 48 states and is hunted in 30 of these. The annual hunting kill of mourning doves in the United States exceeds that of any other game species. The western mourning dove (*Zenaidura macroura marginella*) is Utah's second most popular upland game bird. In 1966, an estimated 20,594 dove hunters bagged 212,696 doves. Only the pheasant (*Phasianus colchicus*) was more popular in Utah (Nish, 1967).

Because of its present popularity and ability to flourish in regions of intensive agriculture, the mourning dove should provide even more sport in the future for Utah's ever-increasing number of hunters. As the populations of sage (*Centrocercus urophasianus*) and sharp-tailed (*Pedioecetes phasianellus*) grouse dwindle, the mourning dove is the only native upland game bird to increase in north-central Utah since farming began. If the potential of the mourning dove is to be realized, more information regarding its ecology and management in the West is needed.

After Grinnell (1927) recognized water as a limiting factor for desert vertebrate populations, game managers in arid regions attempted to increase the supply of water available to desert wildlife. Glading (1947) made one significant contribution when he conceived the idea of "gallinaceous guzzlers." These were concrete tanks installed below ground, covered to reduce evaporation, and accompanied by an apron of impervious material to collect and channel rainwater into the basin. He reported that these devices not only were successful in collecting and holding water throughout the year, but also resulted in increased Gambel's (*Lophortyx gambelii*) and California (*L. californicus*) quail populations. Since then most of the states in the Southwest have installed similar devices in desert areas.

In 1960, the Northern Utah Soil Conservation District, in cooperation with the town of Howell, the Utah State Division of Fish and Game, and the Blue Creek Irrigation Company, submitted a proposed watershed development plan to the United States Department of Agriculture for federal aid under the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress, 68 Stat. 666). This law provided federal financial and technical assistance to areas wishing to initiate programs for more efficient use of water resources. The objectives of the Howell-Blue Creek Plan were as follows:

> to reduce erosion and maintain productivity on agricultural lands within the watershed, reduce sediment and floodwater damages to farm lands, roads, irrigation facilities, and other developments; increase the supply of irrigation water by improving irrigation efficiencies, reducing water losses in canals and ditches, and providing additional capacity for storage of irrigation water; and improve wildlife habitat conditions. (Northern Utah Soil Conservation District et al., 1965:1)

The wildlife habitat improvement phase of the program included planting of permanent woody cover along waterways and construction of artificial catchment basins. The cover plantings failed because of the destruction of young plants by agricultural sprays, and this portion of the program was abandoned. However, 20 fiberglass basins were installed between the fall of 1962 and the spring of 1965.

Large numbers of mourning doves inhabited the study area in the summer and early fall. Therefore, it was a popular dove hunting area, and the installation of basins provided an excellent opportunity to gain information regarding use of water in these basins by mourning doves.

LITERATURE REVIEW

Gallinaceous guzzlers have been tried in many states with varying success. Glading (1947) in California, Wright (1953) in Arizona, and Gullion (1958) in Nevada all reported that desert quail populations were increased by water development. However, Campbell (1960) found in New Mexico that basins did not increase quail populations. MacGregor (1953), in a California study, offered a mixed opinion as to the success of water development and stressed the importance of proper site selection. Nish (1965), working in Utah, stated that further investigations were necessary before firm conclusions as to the value of water development could be drawn. These studies concerned quail populations and were pertinent to this study only as evidence of the varied opinions concerning the success of water development and the importance of proper site selection.

Elder's (1956) report dealing with the watering patterns of desert game is the only study I am familiar with which dealt, even in part, with mourning doves drinking at wildlife watering devices. Bailey and Cowan (1959) stated in a popular article that guzzlers made additional areas available for mourning dove nesting in California.

The reliance of the western mourning dove on free water is well documented. Merriam (1888) reported that this dependence on free water was capitalized upon by early desert travelers who used the presence of mourning doves as an indication of water nearby. Bent (1932) reported that doves congregated about water holes in the desert, especially in the evening. Cowan (1952) also observed that doves drank following feeding and throughout the day. McClure (1950) concluded that the distribution of the mourning dove in the West was probably limited by available water. This belief also was reported by Dahlgren (1955) and Stair (1958).

This apparent reliance on free water was supported by the laboratory studies of G. A. Bartholomew and his associates. Bartholomew and Dawson (1953) reported that active mourning doves required either free water or succulent vegetation as a water source, though resting mourning doves could theoretically replenish respiratory water loss with metabolic water when on a pure carbohydrate diet. Bartholomew and Dawson (1954) also found that doves could survive for 4 or 5 days without water. Bartholomew and MacMillen (1960) reported that confined mourning doves given succulent vegetation as a water source lost weight, as did the birds deprived of all water. From this, they concluded that free water was essential to mourning dove survival. In addition, MacMillen (1962) reported that weight loss per day following water deprivation was greater than the daily water intake of mourning doves, which suggested that water deprivation reduced feeding by mourning doves.

There are several other publications dealing with various phases of the ecology of the western mourning dove. Bryant (1926) wrote a general life history of the mourning dove with emphasis on the dove in California. Haynes (1961 and 1962) also wrote general articles on the dove in Idaho. Downing (1959) and Fichter (1959) both dealt with nesting and production of the mourning dove in western Oklahoma and Idaho respectively. Martin, Zim, and Nelson (1951), Browning (1959 and 1962), and Ward (1964) supplied information as to the food habits of the western mourning dove. Funk (1964) published a paper dealing with the migration of doves from Colorado. Gallizioli's (1961) paper dealt primarily with mourning dove management problems and hunting data.

STUDY AREA

The Howell-Blue Creek watershed, approximately 20 miles west of Tremonton, Box Elder County, Utah, comprised the study area (Figure 1). This area was about 20 miles long and 9 miles wide and was bounded on either side by low mountain ranges. The northern and southern boundaries were chosen arbitrarily as shown in Figure 1.

The study area varied in elevation from 4400 feet on the floor of the southern end of the valley to 7000 feet on some of the mountain peaks (Northern Utah Soil Conservation District *et al.*, 1965).

Mean annual precipitation was 12-14 inches, with about one-third falling as rain from April through June. Since most of the remaining precipitation fell during the fall and winter, the summer months were very dry. Blue Springs, in the center of the valley, was the only flowing stream in the watershed. Water for game and livestock was also available from several smaller springs in the surrounding hills and from stock watering tanks filled from wells.

The valley floor and lower slopes were primarily dry farmed. Principal crops were alfalfa (*Medicago sativa*) and cereal grains, chiefly wheat (*Triticum aestivum*).

The upper slopes were not farmed because of the gradient and shallow soil. These were in natural

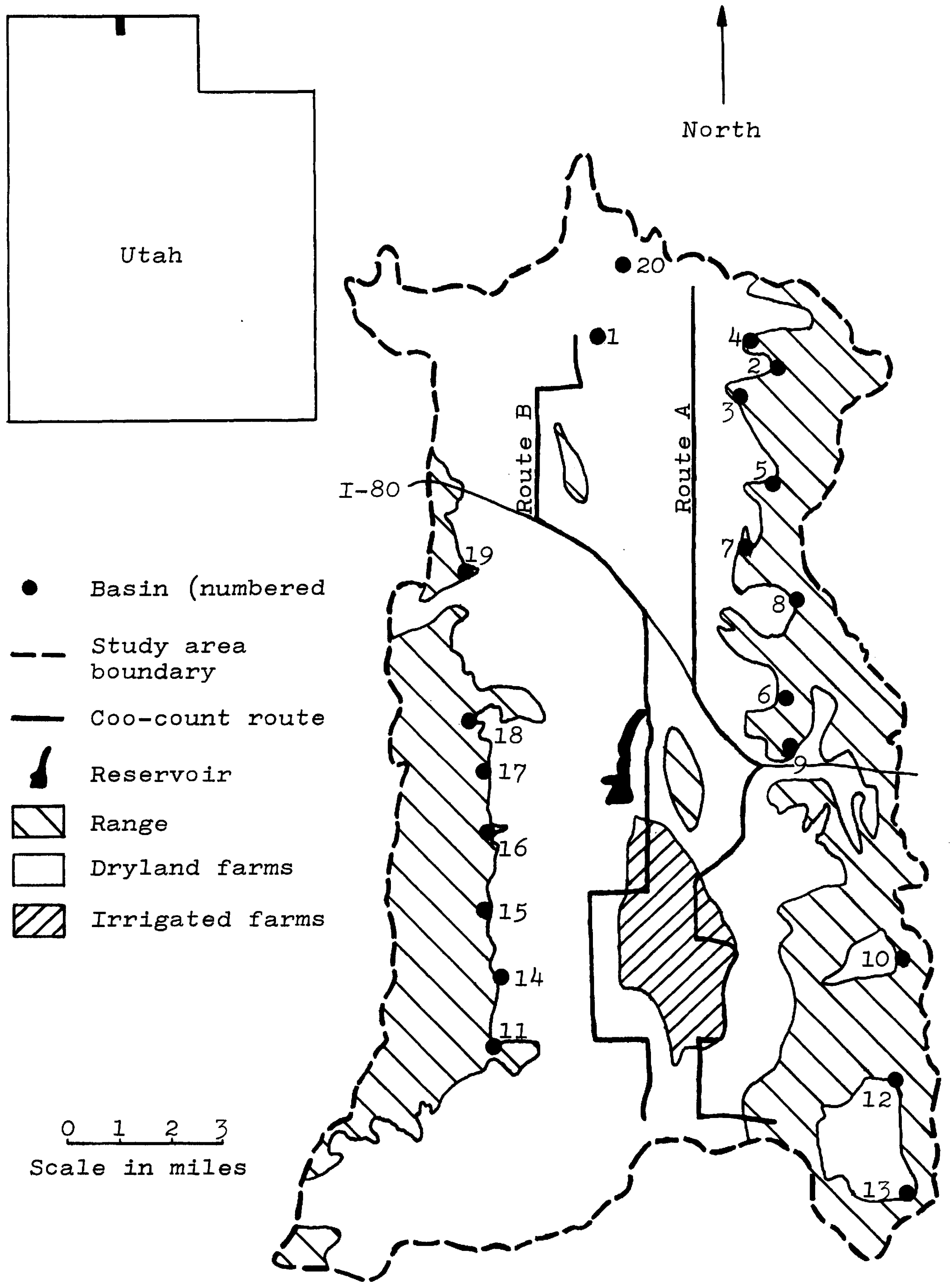

Figure 1. The Howell-Blue Creek Watershed in northern Utah, showing land use, basin locations, and mourning dove coo-count routes used in 1966.

vegetation which consisted primarily of big sagebrush (*Artemisia tridentata*), bitterbrush (*Purshia tridentata*), and bunch grass (*Agropyron inerme*).

The water catchments were installed on the lower slopes of the hills at the juncture of the range and farm lands (Figure 1).

MATERIALS AND METHODS

The Basins

The basins located on the study area were large fiberglass tanks placed flush with the ground (Figure 2). One half of the basin was covered by a pyramidal fiberglass hood to reduce evaporation. On one side, the basin was modified into a sloping ramp with four steps to allow small animals to drink as the water level dropped.

A flat 18-foot-square apron made of roofing steel collected precipitation and channeled it into the basin. A 3-foot-high woven wire fence enclosed a 38-foot-square area around the basin. After construction of the basins, the areas within the fences were initially quite bare. For cover, a seed mixture of alfalfa and wheat grasses was scattered within the fence.

Observation of Doves Drinking

Elder (1956) found that an observer seated in a vehicle caused no appreciable disturbance when watching animals drink at water holes as long as he remained reasonably still. This procedure was used whenever possible, with the vehicle frequently parked within 30 feet of the basin. The only time doves appeared to be disturbed by this technique was when the vehicle approached or left.

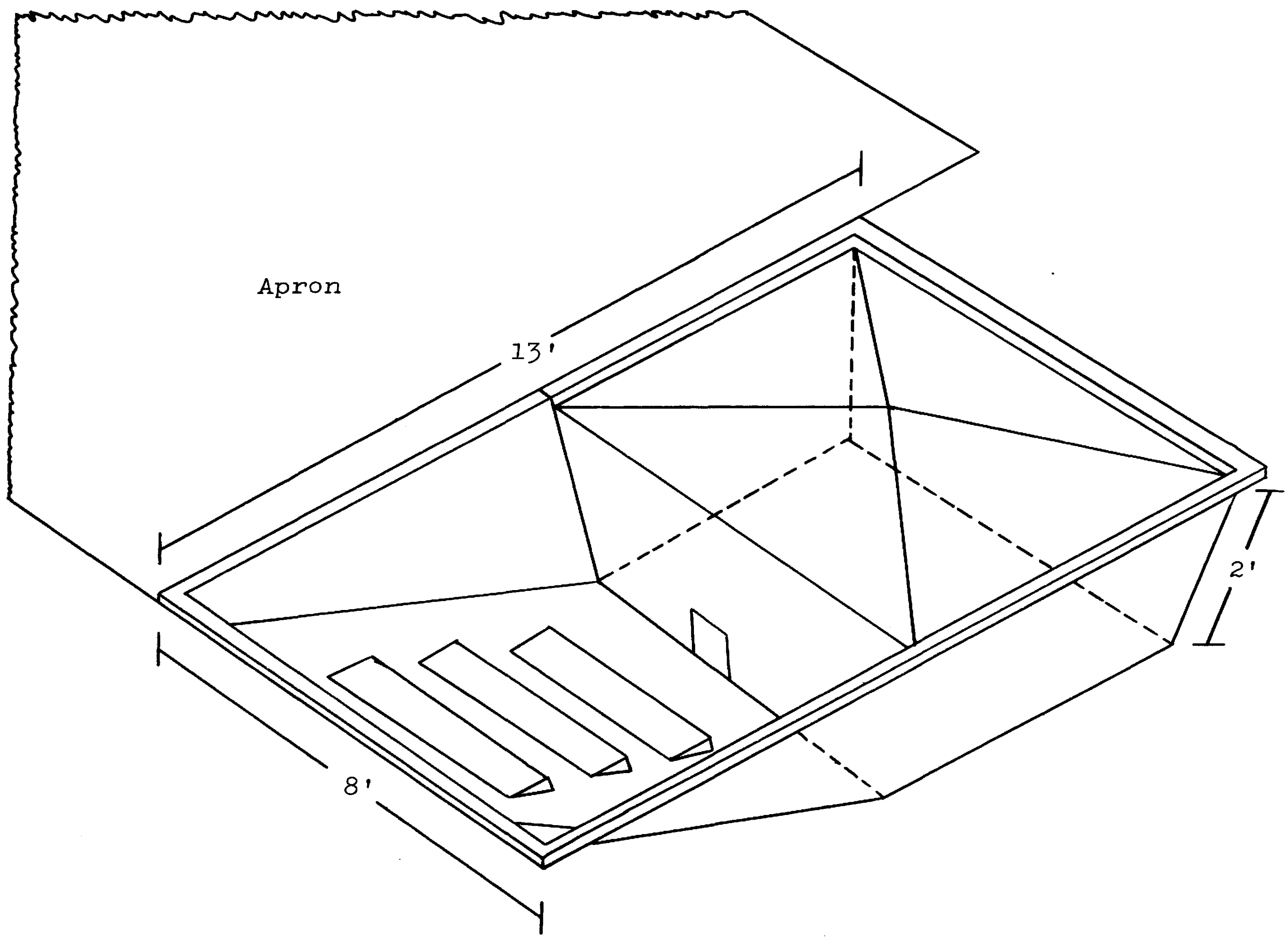

Figure 2. The basins installed in Howell-Blue Creek Watershed from 1962 to 1965.

Therefore, the vehicle was always positioned at least one-half hour before observations were begun.

Only five basins were observed in July and August of 1965. Each was observed for two 10-hour periods on successive days. On one day the observation began 1 hour before sunrise, and on the next about 10 hours before sunset. When combined, the two observations were used to determine the drinking patterns during a 17-hour "day."

In 1966, all 20 basins were observed for two 1-hour periods during the first 10 days of each month from May to August. Four basins per day were observed for hourly periods beginning 2 1/2 and 5 hours after official sunrise and 4 and 1 hours before official sunset. Due to the dove hunting season, the basins were observed from September 14th through 23rd rather than from the 1st through the 10th. Though the 14th and 15th were open to hunting, practically all hunting had ceased by that time, and no disturbance was encountered.

The number of doves drinking per hour and associated factors were recorded for each 1-hour observation period (Table 7). Those ecological variables which changed from day to day were recorded at the time of observation. The less variable factors were recorded once at the start of the summer and again at the end.

Since time allowed each basin to be observed for only two of the four hourly periods per month, the sampling procedure gave a one-half replication of a 20x4x4 factorial design, with 20 basins, 4 months, and 4 hourly periods (Table 8).

The fractional replication required some confounding of variables for the analysis of variance, particularly the confounding of the error term, the second order interaction and the first order interaction between hour and basin.

In addition, part of the hour-month interaction was confounded with the basin effects. This was not important in the analysis since the effects could be separated, but the confounding plan used in May and August was different from that of June and July. This necessitated separate analysis of the data from each of these 2-month groups.

To determine the area of influence, i.e., that area which contained the doves drinking at a given basin, two factors were considered. These were the distance that doves moved to water and the proximity of other permanent sources of water. It was decided that the area of influence of the basin should include only the area that was closer to the basin than to any other water source. Thus, this area was initially a polygon (Figure 3), and was then further modified so that no part of it was farther from the basin than the maximum distance doves in the area moved from water. Many of the alternate sources of water, such as stock ponds, dried up on approximately July 1, 1966. This made a revision of the areas of influence necessary.

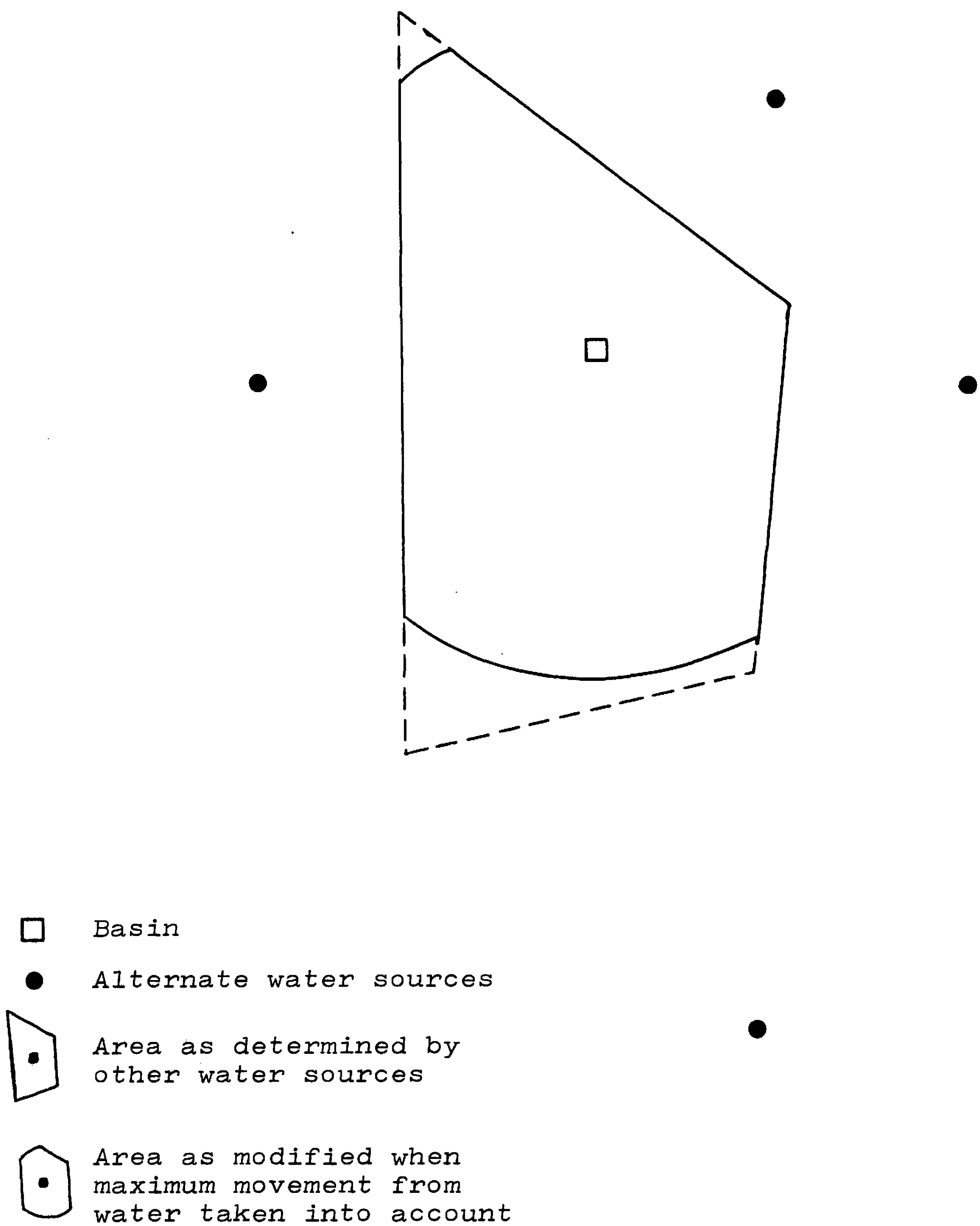

Figure 3. *The method of delineating the area of influence of the basins used by mourning doves in 1966.*

Before a statistical analysis of the effect of all the factors recorded (Table 7) was attempted, the data were examined, and some of the factors were eliminated on the basis of preliminary tests. Two groups of factors remained. The first contained those factors which were constant for any one month and basin (Table 1). The effect of these factors was evaluated using a step-wise deletion multiple regression analysis with the mean number of doves drinking as the dependent variable and the mean levels of the various factors as the independent variables.

The second group of factors, those which changed from day to day, were treated as independent covariables in an analysis of covariance with the number of doves drinking during any one hourly period as the dependent variable.

Movement to Water

Two methods were used to determine the distance mourning doves moved to water. Both involved extrapolation of regression lines of dove density versus distance from water to the point at which dove density became zero.

The first method consisted of establishing radial, linear transects at nine different basins, one transect at each basin. I sat in a vehicle 1 mile from the basin approximately 1$^1/_2$ hours after official sunrise and counted the doves seen flying toward the basin during a 15-minute interval. I then moved one-fourth mile closer and in a like manner counted the doves seen. This procedure was

Table 1. Variables tested for significance of effect on the number of doves drinking at a basin in 1966

Independent variables for multiple regression analysis	Covariates for analysis of covariance
Exposure	Precipitation during observation period
Area in natural vegetation	Cloud cover
Area in summer fallow	Temperature
Area in wheat	Wind velocity
Number of other basins within 2 miles	Occasional water
Crown cover	Predators or antagonists* present (6 classifications: magpies, shrikes, blackbirds, raptors, badgers, and others)
	Perimeter available for drinking

*Antagonists were those animals whose presence or aggressive activities appeared to frighten mourning doves.

repeated at one-half and one-fourth miles from the basin. The next morning the process was repeated at the same basin, but I started from one-fourth mile and moved to 1 mile from the basin. The two counts were then combined to compensate for time bias and were recorded as the count for one basin. Each of the nine basins was observed on two successive mornings from July 20 to August 30, 1966. The number of doves seen at any distance from the basin was considered as an index to the number of doves coming to drink from beyond that distance. The number of doves seen at each distance, corrected for the proportion of the total area sampled, was then expressed as a percentage of the total doves seen on a transect, and a simple linear regression of dove numbers versus distance to basin was computed.

To obtain the second estimate, the positions of all doves seen while I drove along the coo-count routes or from one basin to another were recorded on maps. The distance of each dove from the nearest water source was later measured to the nearest one-eighth mile. The amount of time I spent in each distance class was estimated, and the number of doves seen was then prorated for the time spent in the various distance classes. A regression line was determined for corrected dove density versus distance from water.

Local Movements

The doves that used each basin were being considered a unit for purposes of evaluating ecological factors. Therefore, it was necessary to gain some information regarding movement of doves between basins. For this reason, doves were trapped, marked, and released at selected basins. The tail feathers were colored with alcohol solutions of organic dyes to allow easy sight identification of the doves. Leg bands also were placed on the birds, and sex (Grinnell, Bryant, and Storer, 1918) and age (Pearson and Moore, 1940) data, from plumage characteristics, were recorded.

Adult and juvenile doves were banded and marked at basins 6, 12, and 19 during June and July, 1966, and later sightings were recorded.

Coo Counts

Two 20-mile coo-count routes were established (Figure 1) and were run according to standard procedures (Peters, 1952) during the first week of each summer month of 1966. Thus, the routes were run from one-half hour before to about 1 1/2 hours after sunrise. However, since Peters (1952), Duvall and Robbins (1952), McGowan (1952 and 1953), Mackey (1954), Cohen, Peters, and Foote (1960), Frankel and Baskett (1961), and Jackson and Baskett (1964) all reported that calling rates declined following the first half hour after sunrise, each route was run twice per month, once in each direction. In this manner each station on the route was visited during the first hour of the counting period.

In addition to these routes, 16 stations were established in sagebrush near basins. These stations were visited during the first 10 days of each summer month of 1966, and the number of doves and coos heard in a 3-minute period was recorded. Counts were made only from one-half hour before to one-half hour after official sunrise.

Hunting Season Data

Two types of information were collected during the 1966 hunting season. Food habits information from 146 crops of doves killed by hunters was analyzed. The contents were identified to genus when possible, and the volume of each type was measured.

The second type of information was an index to hunting pressure at the basins. During the first 5 days of the hunting season, September 1-5, which were the days of greatest hunting pressure, each basin was observed once in the morning and once in the evening, and the presence or absence of hunters was recorded. The relative hunting pressure at each basin was then approximated by the total number of times, of a possible 10, that hunters were present. The information obtained was then compared to the number of doves remaining after the hunting season to assess the effect of hunting pressure on dove use of the basins.

Statistical Analysis

The simple statistical tests used were taken from Snedecor (1956) and Fryer (1966). The analysis of covariance on the fractional replicate data was performed by Dr. David White of the Department of Applied Statistics, Utah State University.

RESULTS AND DISCUSSION

Counts of Doves Drinking at Basins

1965

The number of times doves drank in one 17-hour period varied from 148 at basin 4 to 1668 at basin 19 (Table 9). The number of times doves drank was used as an index to the number of doves using each basin as a water source. It was not the actual number of doves drinking, however, since some doves drank two or more times in one day. This was verified on at least five occasions when individuals could be recognized.

The number of doves drinking was recorded by hourly intervals, starting 1 1/2 hours before official sunrise, to determine the daily drinking pattern. The number of dove drinks per hour was expressed as a per cent of the total dove drinks for the 17-hour period (Table 9). The means of these percentages were then plotted (Figure 4). There were two distinct peaks in drinking activity. Highest use came in the final hour before sunset, with a lesser peak from 1 1/2 to 3 1/2 hours after sunrise.

Most investigators have found the same bimodal pattern observed in this study. Taylor (1941), McClure (1943), Cowan (1952), Dahlgren (1955), and Hon (1956) all reported that mourning doves drank both in the morning

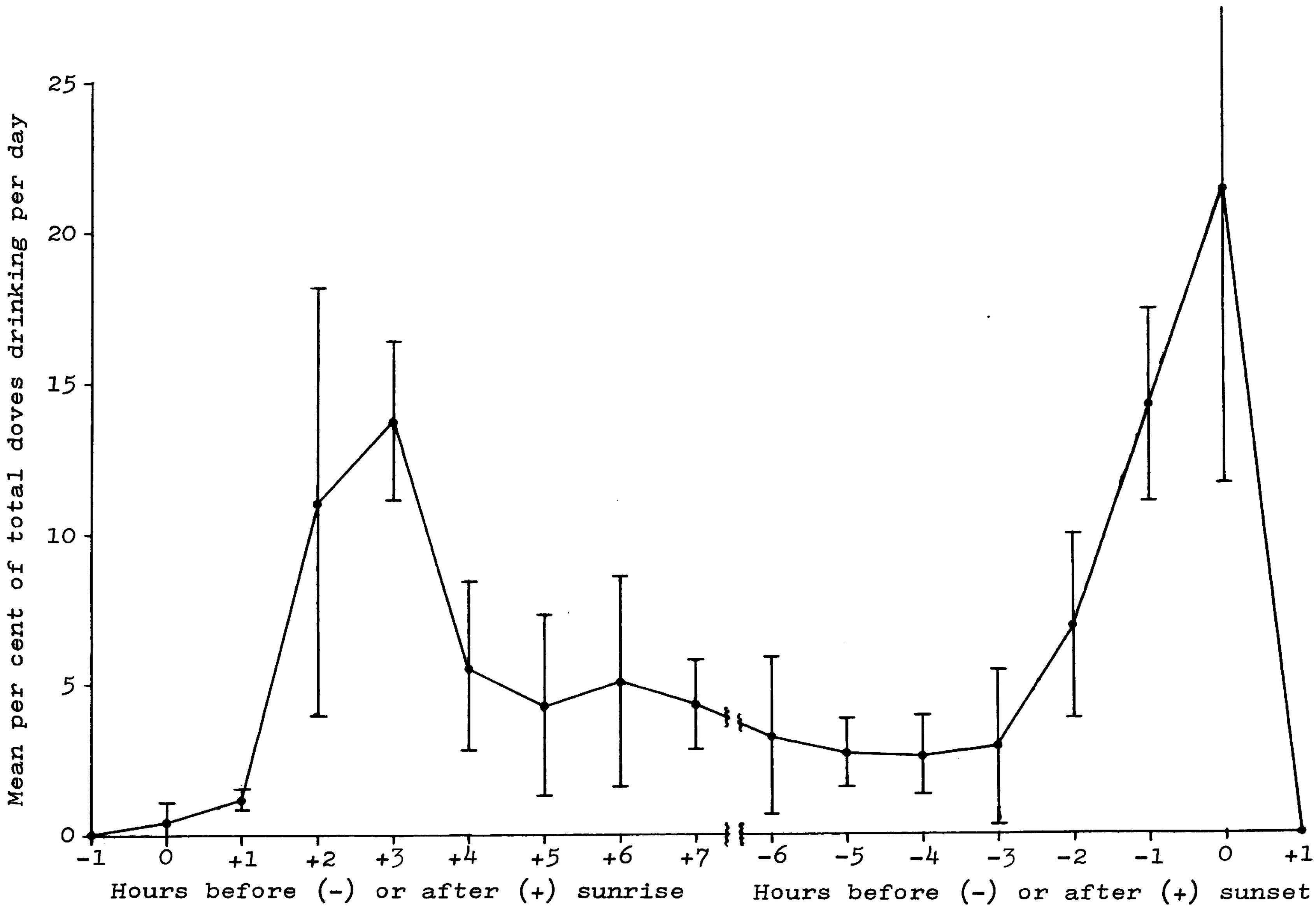

Figure 4. Mean hourly rates of doves drinking at five selected basins during July and August, 1965. Vertical lines show .95 confidence intervals.

and evening. Bent (1932), Webb (1949) and Quay (1954) mentioned doves drinking in the evening and at other times during the day. However, Elder (1956) reported relatively constant use throughout the day by mourning doves drinking at man-made waterholes. He found only slight peaks at 8 AM and 4 PM.

The watering pattern data were used to select four 1-hour observation periods for 1966. These were selected on the basis of low coefficients of variation. Also, at least 1 hour was allowed to travel from one basin to the next. The selected periods corresponded approximately to 3 and 5 hours after sunrise and 2 and 0 hours before sunset in Table 9 and Figure 4.

1966

The mean number of doves drinking per hour for the entire year varied from 4.8 at basin 4 to 64.3 at basin 19 (Table 10). The mean number of doves per count for the summer was used as an index to the dove population densities.

The number of doves drinking during 1966 generally conformed to the bimodal pattern expected from the 1965 data (Table 2). However, since each basin was observed for only two of the four possible hourly periods during each month, a simple comparison of numbers drinking was not adequate. Some basins were used by many more doves, and counts at these basins increased the means for the hourly periods when they were observed. Therefore, to examine the drinking pattern with each basin considered equal, the number of doves drinking during each hour was expressed as the per cent of the total number drinking for the summer. The means of these figures showed that the late evening period was always the period of most use, but that the bimodal pattern observed in late July and early August of 1965 apparently became most prominent in the late summer (Table 3). This seasonal change was confirmed by the significance of the hour-month interaction (Table 14) and perhaps this accounted for some of the difference between my data and that of Elder (1956) who made observations through the entire year.

Table 2. Mean number of doves drinking per hourly observation period, summer, 1966

Month	Doves drinking per hour				Mean
	Morning		Evening		
	Early	Late	Early	Late	
May	5.2	3.7	0.7	10.6	5.1
June	11.4	9.7	6.5	14.5	10.5
July	19.8	44.9	11.1	68.0	36.0
August	30.7	13.7	4.4	108.6	39.4
Mean	16.8	18.0	5.7	50.4	

Table 3. Numbers of doves drinking per hour expressed as mean per cent of total number drinking at a basin, summer, 1966

Month	Doves per hour as per cent of basin total				Mean
	Morning		Evening		
	Early	Late	Early	Late	
May	1.9	0.9	0.2	5.7	2.2
June	2.6	3.8	4.2	6.6	4.3
July	7.5	7.4	4.0	10.8	7.4
August	15.7	6.5	1.3	20.8	11.1
Mean	6.9	4.7	2.5	11.0	

Factors Affecting Dove Use of Basins

The correlations between the independent variables and the number of doves, variable 7, were low with only exposure and crown cover being significantly correlated at the .10 level (Table 11).

Only exposure, acres of summer fallow, and acres of wheat made significant contributions to the regression model (Table 12). The basins on the west side of the valley and those with the most summer fallow and least wheat in the area of influence had the highest dove populations.

The basins on the west side of the valley were also the newest basins, and it was difficult to separate these two factors. However, the analysis indicated that position was the more important of the two. The most obvious difference between the two sides of the valley was the daily temperature pattern. The mean temperature on the west side was 2.7 F lower than that on the east in 1966, as indicated by two thermographs placed opposite one another in the valley (Figure 5). Perhaps more important, the temperature of the west was almost 4 F cooler than the east during the hottest part of the day. In addition, the west side warmed up earlier in the morning and cooled off earlier in the afternoon. This temperature difference made the west side seem more habitable during the hot summer months.

The significance of area in summer fallow seemed relatively easy to explain. The crop content analysis discussed later in this paper indicated that waste grain in these fields was used as a food source in September. This grain was probably even more important as food in the spring when the seeds of the year had not developed. Since the spring was the time when nesting territories were being established, it seems reasonable that birds were found where food was available. In addition, the acreage in summer fallow increased with the total area of influence, which was a reflection of the nearness of other water sources. Thus, the significance of acreage in summer fallow also might have reflected heavier use at basins farther from other water sources. This was also

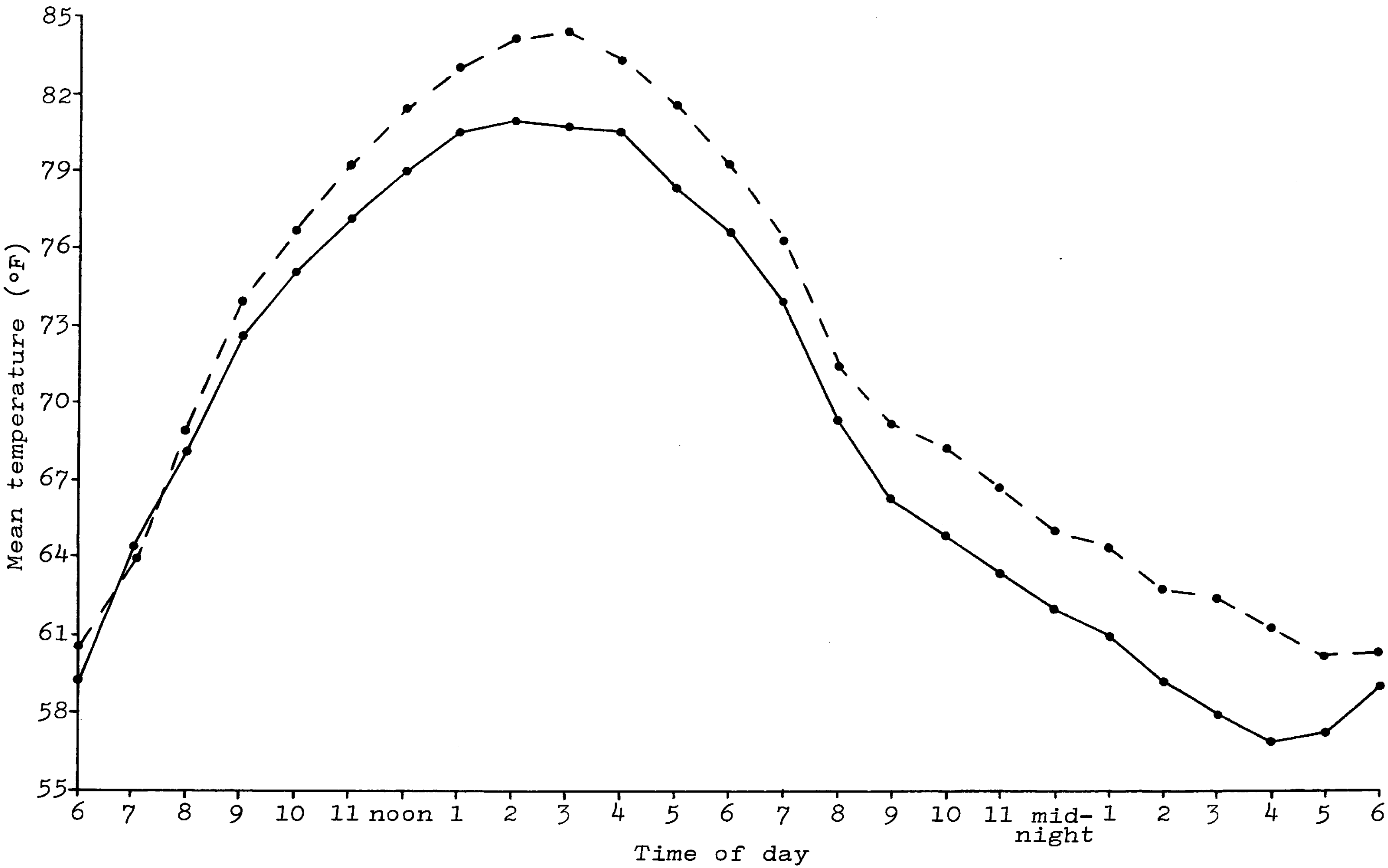

Figure 5. Variation in temperature with time of day on the east (dotted line) and west (solid line) sides of the study area as determined by 22 recordings from May-August, 1966.

indicated by the nearly significant negative correlation between other basins within 2 miles and number of doves drinking.

It was easiest to explain the significance of the acreage in wheat by considering wheat and summer fallow together as the amount of cultivated land in the area. Instead of the cultivated area being a simple sum of the two acreages, it was a weighted sum with the summer fallow more positive (.37) than the wheat was negative (-.35). Thus, if the acreages of wheat and summer fallow were equal, the mean number of doves using a basin in an hour would increase .01 dove for every 100 acres of cultivated land. As the relative proportion of cultivated land in wheat increased, the value of that cultivated land for doves would decrease. Conversely, as the proportion of wheat decreased, the value for doves would increase. Thus, the presence of cultivated land made the area attractive for doves, but only when nearly half of it was in summer fallow. Fichter (1959) thought the amount of wheat farming might have been a factor in determining the nesting density of doves in Idaho orchards.

Though only slightly significant by itself and eliminated early in the step-wise deletion program, the effect of crown cover deserves further investigation. When the crown cover was heavy, usually as a result of the alfalfa-wheat grass mixture planted at installation, I noticed that doves gathered on the fence surrounding the basin and on the collecting apron and then flew or walked directly to the edge of the basin where they drank. In contrast, doves at basins with sparse crown cover landed on the ground within the fence, as well as on the fence and the apron, and frequently walked around before approaching the basin and drinking. It appeared that the doves were less apprehensive when they could see around them, and this might explain a "preference" for basins with less vegetative cover.

The previous analysis tested significance of more permanent factors which might be used in habitat improvement programs or for selecting sites for further basin installation. The factors in the covariance analysis were used to assess the census technique of counting doves drinking, *i.e.*, these more variable factors, such as rainfall or presence of predators, were less likely to indicate the general season-long habitat conditions than to indicate conditions which might affect the number of doves drinking in a specific hourly period.

The significance of the covariates was quite different for the two sets of data (Table 13). For the May-August set of data only the length of time badgers (*Taxidea taxus*) were present was significant, but in June and July Brewer's blackbirds (*Euphagus cyanocephalus*), black-billed magpies (*Pica pica*), and badgers all had a significant effect on the number of doves drinking.

The above determination of significance is based solely on the size of the correlation coefficients with no regard to sign. However, all of the variables deemed significant were in the category of "predators or antagonists," and they were included in the analysis because their presence might inhibit the number of doves drinking. Thus, the correlation between the length of time these species were present and the number of doves drinking should have been negative. When the simple correlation and regression coefficients were positive, as were those for badgers in May-August and blackbirds in June-July, the data simply indicated that for some reason badgers and doves in one case and doves and blackbirds in the other drank during the same hourly period. These results were not of value in this study.

In addition to those covariates which were found significant in the statistical analysis, several others were known to have been significant, at least in some cases. All of the predators or antagonists were included because they disturbed the drinking doves at least at some times of the year. The reaction to badgers and raptors, primarily marsh hawks (*Circus cyaneus*) and golden eagles (*Aquila chrysaetos*), was extreme. When one of these animals approached the basin, the doves in the area flew away. No dove drank at any time during the 2 years of the study when one of these animals was present. Generally badgers or raptors remained only a short time, less than 5 minutes, and so had little effect on the number of doves drinking in an hour. The effect of other species such as blackbirds, loggerhead shrikes (Lanius ludovicianus), and magpies seemed to vary. Blackbirds and shrikes were more aggressive at certain times of the year, especially in the spring. The effect of magpies seemed to vary with the number present. A group of four or more generally drove the doves away, but a single bird or pair usually did not bother the doves.

Thus, the effect of these species on drinking doves was not completely revealed by the statistical analysis either because of the short duration or variable nature of their effect.

Precipitation also affected the number of doves drinking. During moderate or heavy rains no doves drank or were even seen flying. For this reason, if an hourly period was "rained out," the observations were made again. Thus, it was known that precipitation retarded dove activity. However, in the range of precipitation where observations were made, light showers usually lasted 15 minutes or less, and no significant effect on the number of doves drinking was observed.

It should be emphasized that the significance or non-significance of variables in this study was only valid for the range of variation observed.

There was little difference between the adjusted and raw analyses of variance (Table 14). However, there were differences between the analyses for the May-August and June-July periods. The principle difference was in precision of the experiment, *i.e.*, the magnitude of the error term. Though variation due to basin differences for the two sets of data was about equal, the basin effect for May-August was not significant because of the much greater error term. As a result of the fractional replication, the error mean square was the sum of several effects which were assumed to be negligible. Therefore, the increase in the May-August error term may have been due to an actual increase in experimental error or to an increase in any or all of the terms which were assumed negligible.

With the exception of the basin effects for May-August, the main effects, basin, hour, and month, were significant (Table 14). The interaction between hour and month was significant in both sets of data as was the interaction between basin and month for the June-July data.

The significance of the month effects for both sets of data indicated that the means for each of the months in the two sets of data were different. The means for May and August, 5.1 and 39.4 respectively, differed widely, as did those for June and July, 10.5 and 36.0 (Table 2). Though there was no common estimate of experimental error, one might also infer that the means of May and June were similar, as were those of July and August.

Local Movements

In 1966, 103 doves (65 adults and 38 juveniles) were trapped, color marked, banded, and released. Fifteen sightings of these birds were recorded (Table 4).

Table 4. Movement of marked doves in the study area in 1966

Number of doves	Date seen	Date marked	Distance from marking location	Age of doves
6	7-6-66	6-21-66	0.0 miles	adult
1	7-10-66	6-21-66	2.9 miles	juvenile
3	7-14-66	6-21-66	0.0 miles	adult
1	8-1-66	7-14-66	3.8 miles	juvenile
1	8-10-66	7-14-66	0.0 miles	juvenile
2	8-10-66	7-19-66	0.0 miles	adult
1	8-12-66	7-19-66	1.0 miles	adult

The mean distance moved for the three juveniles sighted after marking was 2.2 miles, and for the 12 adults, less than 0.1 mile. Although the sample sizes were small, they did conform to a general pattern of comparatively sedentary adults and mobile juveniles during the nesting season reported by Cowan (1952), Dahlgren (1955), and Haynes (1961) in the West, and Nice (1922 and 1923), Pearson and Moore (1939), McClure (1943, 1946, and 1950), Webb (1949), Boldt and Hendrickson (1952), Hanson and Kossack (1957 and 1963), and Tomlinson, Wight, and Baskett (1960) in the Midwest and East. Therefore, it seemed likely that adult doves in the study area established nesting territories and frequented the same areas throughout the summer. Juveniles were more mobile and moved from their rearing area in July and August. Thus, the number of adult doves using a given area should stabilize following the cessation of spring migration, and the number of doves drinking at a basin should be influenced by young production and movement.

Movement to Water

The maximum movement to water, as indicated by both the transects and the observations during the monthly census, was about 1.9 miles (Figures 6 and 7). This is lower than the estimates of 3 to 5 miles of Loyd (quoted by Merriam, 1888) or 2 to 3 miles of McClure (1950). Haynes (1961) also stated that doves might fly several miles to water.

In spite of this evidence, the estimate of 1.9 miles is probably realistic since almost all of the study area was within this distance from some permanent water source. However, this should not be taken as an estimate of the distance that doves might fly to water if water sources were more dispersed.

Coo Counts

Table 5 presents only the results of the coo counts taken in the first hour of counting, one-half hour before to one-half hour after sunrise, to avoid the time bias discussed in the methods section of this paper. Many more doves were heard at the stations located in the sagebrush hills than were heard in the valley proper, which was predominantly farm land. In addition, of 197 cooing doves that could be specifically located, only 6 were cooing

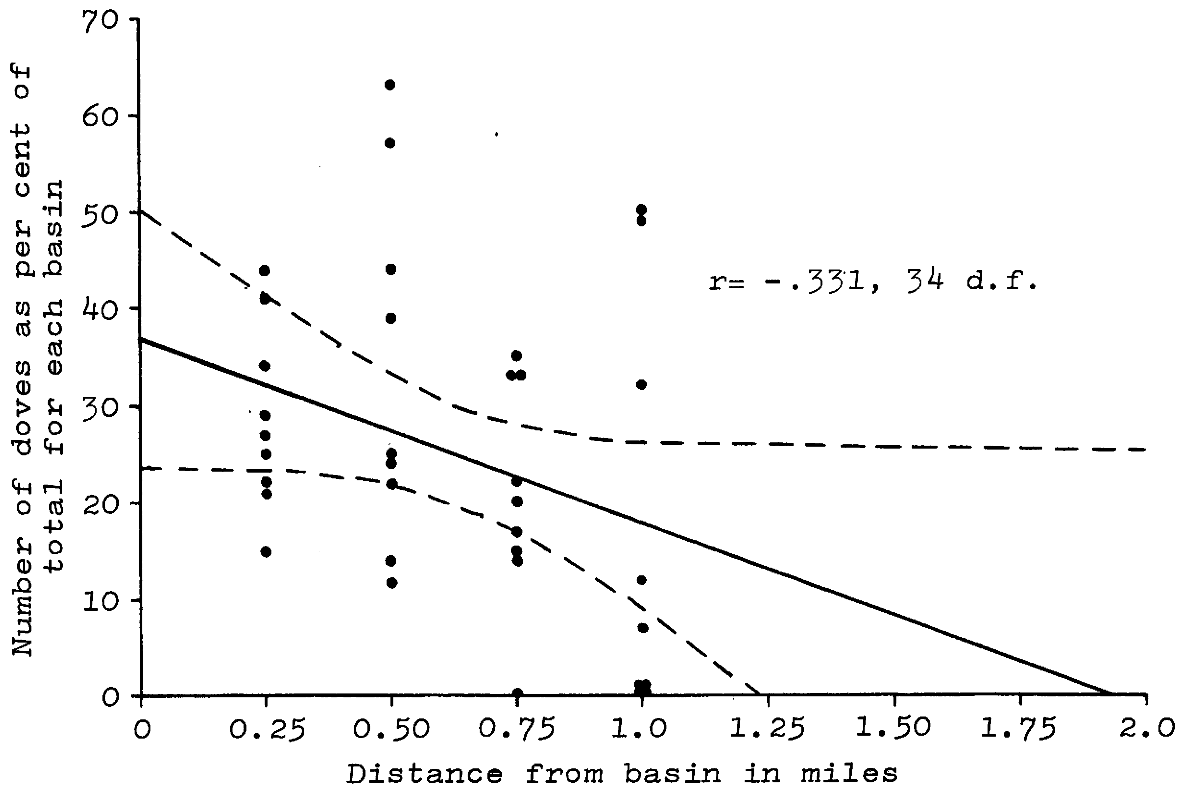

Figure 6. Decrease in dove numbers with increase in distance from basin as determined by counts on linear transects at selected basins, July-August, 1966. Dotted lines are the .95 confidence interval of $\hat{y}$.

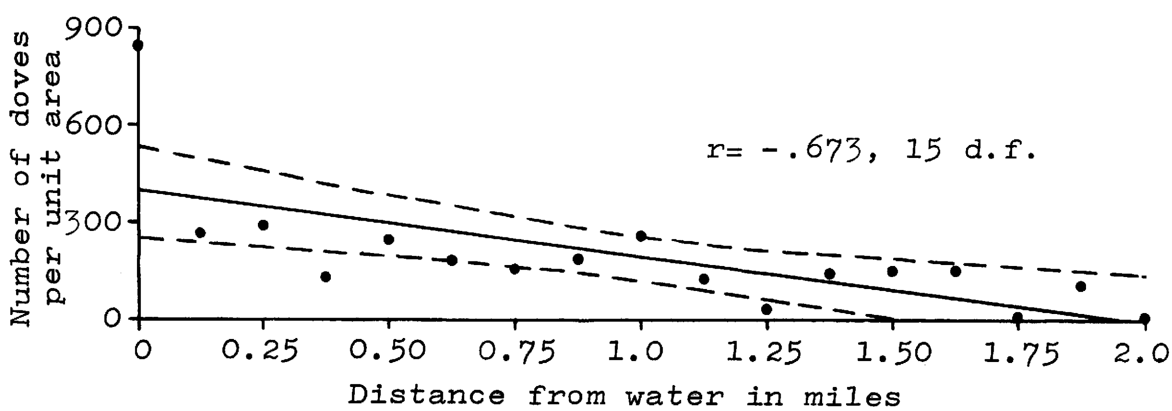

Figure 7. Decrease in dove numbers with increase in distance from water as determined by observations while conducting monthly counts, May-August, 1966. Dotted lines are the .95 confidence interval of $\hat{y}$.

other than at farmsteads or in sagebrush. Since cooing is associated with reproduction, probably for mate attraction (Jackson and Baskett, 1964), it seems likely that cooing occurs near nesting sites. If so, it may be inferred from the coo counts that doves in the study area nest primarily in areas of natural vegetation with little nesting in intensively farmed areas other than in trees around farmsteads.

Table 5. Number of doves heard per 20 stations from one-half hour before to one-half hour after sunrise during coo counts, summer, 1966

Location	Cooing doves per 20 stations			
	May	June	July	August
Route A (farm land)	10	15	17	7
Route B (farm land)	22	22	33	11
Stations in sagebrush	54	59	68	30

Food Habits

The diet of doves collected in September of 1966 was composed almost entirely of plant seeds, with sunflower and wheat composing 94 per cent of the total volume (Table 6). This heavy reliance on seeds has been found in every mourning dove food habits study to date. Only the kind and relative proportion of seeds vary with

Table 6. Occurrence of food items in crops of 146 doves collected during the hunting season, September 1-15, 1966, in Howell-Blue Creek Watershed, Utah

Food item	Per cent of total volume			Frequency as per cent		
	Adults[a]	Young[a]	Total	Adults	Young	Total
Sunflower (Helianthus spp.)	69.1	62.2	67.1	92.5	63.6	79.5
Wheat (Triticum aestivum)	24.3	34.6	27.3	85.0	74.2	80.2
Pigweed (Amaranthus spp.)	5.3	2.4	4.5	77.5	43.9	62.3
Wild mustard (Brassica spp.)	0.5	0.1	0.4	8.8	1.5	5.5
Prickly poppy (Argemone sp.)	0.2	0.0	0.1	5.0	0.0	2.7
Wild lettuce (Lactuca sp.)	Trace[b]	0.4	0.1	12.5	19.7	15.8
Stipa grass (Stipa sp.)	0.1	0.3	0.1	13.7	6.1	10.3
Knotweeds (Polygonum spp.)	0.1	Trace	0.1	18.8	13.6	16.4
Stone seed (Lithospermum sp.)	0.1	Trace	0.1	3.8	1.5	2.7
Sedge (Carex spp.)	0.0	Trace	Trace	0.0	1.5	0.7
Legumes (Leguminosae)	0.1	Trace	0.1	16.3	1.5	9.6
Borages (Boraginaceae)	Trace	0.0	Trace	2.5	0.0	1.4
Unidentified seeds	0.1	Trace	0.1	25.0	6.1	16.4
Animal material	0.1	0.0	0.1	26.3	0.0	14.4

[a]Sample size: 80 adults and 66 juveniles. Total crop volume 769.8 cc for adults and 314.5 cc for juveniles.
[b]Items forming less than 0.1 per cent of the total volume were recorded as trace.

location and season. Dahlgren (1955), in the only other Utah study, found sunflower and wheat ranked second and third for his September collection, and third and first for the entire summer. Spiderflower (Cleome spp.) was first in volume in his September collection, but it was not found in my samples.

Wheat was not grown in 1966 in several of the areas where crops were collected. However, old grain left from the 1965 harvest was available in fallow fields and found in abundance in crops of doves collected in those areas. This information coupled with incidental observations throughout both summers of field work led to the conclusion that summer fallow fields serve as important feeding areas, especially in the spring and early summer when seeds of the year have not yet matured.

The dove crops collected in this study were analyzed by age groups and, though sunflower, wheat, and pigweed seeds were the most important foods in each group, a chi-square test showed a significant difference at the .01 level between the age groups in frequency (χ^2=30.38, 10 d.f.) of food items. This was a result of the more varied diet of the adults. With the exception of wild lettuce and sedge, all food items occurred more frequently in adult crops. Oberheu and Klimstra (1961) reported a significant difference between the proportionate volumes of foods of adults and juveniles collected during the hunting season. This difference with age deserves further investigation since it may form an important source of bias in food habits studies.

Hunting Pressure Index

The fall dove migration probably began with a movement of the early juveniles away from their rearing area. By mid-September most doves had left northern Utah. This is substantiated by the fact that the September count of doves drinking averaged only 2.4 doves per hour as compared with 39.4 for August. It seemed likely that hunting was responsible in part for this disappearance, either directly through hunting mortality or indirectly through inducing doves to leave the area. A negative correlation, significant at the .10 level ($r=-.451$, 15 d.f.), was found between the hunting pressure index and doves drinking in September expressed as a percentage of those drinking in August.

CONCLUSIONS

The west side of the valley which formed the study area had higher populations of doves than did the east. This was probably due to the temperature differential with the west side being slightly cooler.

Attractive areas for doves contained some cultivated land. The most important cultivated type was summer fallow since the waste grain provided a good food source. In addition, brush and trees such as found in range land provided good nesting areas. Also, those basins installed farthest from other basins were used most.

The number of doves drinking in a particular hour was influenced by the presence of predators or antagonists, but the effect varied with circumstances. Raptors and badgers caused the most extreme reaction.

No doves drank while rain was falling, but light showers lasting less than 15 minutes had no significant effect on the number of doves drinking in an hour. Temperature, wind velocity, and cloud cover also had no effect.

The doves in the area showed a bimodal drinking pattern with a peak 2 to 3 hours after sunrise and a more pronounced peak just before sunset. This pattern changed with the month and became most pronounced in the late summer.

Mourning doves in the study area moved as far as 1.9 miles to water, but not enough area was available more than 2 miles from water to test whether the doves might move farther.

An analysis of crops collected in September indicated that doves ate almost entirely seeds, primarily sunflower and wheat. Adults and juveniles differed significantly in regard to frequency of occurrence of food items with the adult diets being more varied.

Hunting pressure decreased the proportion of doves remaining in the area either through hunting mortality or through increased migration.

RECOMMENDATIONS

1. (On the basis of this study,) water installations primarily for mourning doves should be at least 2.5 miles apart and near feeding and nesting areas. In an area similar to my study area these would be areas in summer fallow and natural vegetation.

2. A study should be conducted to determine the value of the present basins for increasing mourning dove and other small game populations. Such a study would probably involve closing off some or all of these basins and observing the changes in distribution and abundance of the game animals. A study of this nature would require at least 4 years, 2 years with basins and 2 years without.

3. Further study into the effect of vegetation surrounding and within the basins is needed. This study should include control of the vegetation within and immediately surrounding the fenced area as well as the algae and moss in the basin and the effects of this control on water use.

4. A study should be made of the increased return to hunters as a result of these basins. This study would not necessarily be concerned with the increase in game populations but with the concentrating effects of the basin and the subsequent availability of game to hunters.

An economic evaluation of installations in an area such as this where the land is privately controlled might be interesting, especially in light of the closing of much of this area to hunting.

SUMMARY

A study of the mourning doves using artificial catchment basins as water sources was conducted during the summers of 1965 and 1966 in the Howell-Blue Creek Watershed in northern Utah. The objective of the study was to determine the environmental factors affecting dove use of water in catchment basins.

Five basins were observed from dawn to dusk in 1965 to determine the drinking patterns and variation therein for doves in the study area. In 1966, doves drinking at each of 20 basins were counted during four representative 1-hour periods spaced throughout the day from May through August. The doves demonstrated a bimodal drinking pattern with morning and evening peaks. This pattern changed with the months and was most extreme in late summer.

The number of doves using a basin was influenced by the exposure, with the west side of the valley being more favorable than the east, and by the amount of cultivated land in the area. The area in summer fallow was of primary importance since the waste grain provided food for the doves, particularly before the seeds of the year became available. Those basins farther from other basins were used by more doves.

A comparison of coo counts made on the valley floor with those from the hills indicated that the sagebrush covered hills were the primary nesting areas.

The number of doves drinking in a particular hour was decreased by rain and by the presence of certain animals. However, the effect of the other animals varied with their behavior.

A hunting pressure index was determined at each basin during the 1966 season and was found to be correlated with the proportion of doves remaining in the latter part of September.

The distance doves moved to water as determined by two procedures was estimated to be up to 1.9 miles, the maximum possible in the study area.

Data from an extremely small sample of marked doves indicated that during the summer adult birds did not switch from one basin to another and that juveniles were more mobile.

An analysis of crops collected during September of 1966 indicated that doves ate primarily seeds with sunflower and wheat constituting over 90 per cent of the diet. Adults and juveniles differed significantly in frequency of occurrence of food items with the individual adults eating a much wider variety of food than did the juveniles.

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APPENDIX

Table 7. Methods of measuring and recording ecological factors considered during an observation period in 1966

Ecological variables recorded during each 1-hour observation period*		
Variable	Method of recording	Method of measuring or source of information
Date	Month and day number	Calendar
Cloud cover	Per cent of sky covered in quartiles	Visual estimate
Wind velocity	Miles per hour	Dwyer wind guage
Temperature	Degrees Fahrenheit in shade	Thermometer
Precipitation	Minutes during which rain fell	Clock
Time of observation	Hours from sunrise or sunset	
Temporary water source	Present or absent	Direct observation
Crown cover within fence	Per cent of ground covered in quartiles	Visual estimation
Space available for drinking	Nearest 10 per cent of perimeter	Visual estimation
Predators or antagonists present	Species and length of time present in minutes	Direct observation and clock

*All variables recorded 15 minutes before actual counting began.

Table 7. Continued

Variables recorded before and after July 1, 1966		
Variable	Method of recording	Method of measuring or source of information
Date of installation	Fall, 1962; spring, 1963; spring, 1964; spring, 1965	Utah State Department of Fish and Game
Exposure	East- or west-facing	Direct observation
Total area of influence of basin	Acres in hundreds	Maps prepared from aerial photos
Area in wheat	"	"
Area in fallow	"	"
Area in natural vegetation (includes planted grass lands)	"	"
Area in other vegetation	"	"
Roads in area	One-eighth miles	"
Trees in area	Absent or present	Directly from aerial photos
Elevation	Nearest 100 feet	Contour maps, U.S. Dept. of Agric.
Water sources other than basins within 2 miles	Number	Maps prepared from aerial photos
Other basins within 2 miles	"	"

Table 8. Basins visited at each 1-hour period during the first 10 days of the month in 1966

Hourly period	Basin numbers																			
	Day of the month																			
	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9
					April										September					
1	20	3	19	14	5	18	12	15	1	11	7	8	2	13	6	10	17	16	9	4
2	1	5	18	15	3	19	11	14	20	12	8	7	4	10	9	13	16	17	6	2
3	4	7	6	16	8	9	10	17	2	13	3	5	1	11	19	12	15	14	18	20
4	2	8	9	17	7	6	13	16	4	10	5	3	20	12	18	11	14	15	19	1
					May										August					
1	15	14	3	19	20	11	1	12	18	5	13	17	4	2	10	8	7	16	9	6
2	14	15	5	18	1	12	20	11	19	3	10	16	2	4	13	7	8	17	6	9
3	17	16	7	6	4	13	2	10	9	8	11	15	20	1	12	5	3	14	18	19
4	16	17	8	9	2	10	4	13	6	7	12	14	1	20	11	3	5	15	19	18
					June										July					
1	14	12	19	15	1	20	3	11	18	5	16	4	10	17	8	6	7	13	9	2
2	17	13	9	16	4	2	8	10	6	7	15	1	11	14	3	18	5	12	19	20
3	15	11	18	14	20	1	5	12	19	3	17	2	13	16	7	9	8	10	6	4
4	16	10	6	17	2	4	7	13	9	8	14	20	12	15	5	19	3	11	18	1

NOTE: Time periods and days are as designated in the text. The numbers in the table are those of the basins (see Figure 1).

Table 9. Number of dove drinks per 1-hour period expressed as per cent of total for a 17-hour day at each of five selected basins, July and August, 1965

Basin number	Per cent of total dove drinks: Hours before (-) and after (+) sunrise									Per cent of total dove drinks: Hours before (-) and after (+) sunset								Total number of drinks
	-1	0	+1	+2	+3	+4	+5	+6	+7	-6	-5	-4	-3	-2	-1	0	+1	
4	0	1.4	1.0	6.1	10.1	4.4	3.7	6.1	5.7	1.7	3.7	3.7	1.0	9.5	17.9	24.0	0	148
8	0	0.0	1.3	4.0	14.2	6.9	8.2	9.6	5.3	2.1	1.8	2.8	4.6	8.3	11.9	19.0	0	303
11	0	0.0	1.5	13.5	14.4	4.7	4.2	3.6	3.6	1.8	1.8	1.3	0.4	3.4	11.8	34.0	0	1166
12	0	0.2	1.4	14.9	15.6	8.8	1.5	2.9	2.9	6.6	2.7	1.8	3.7	7.9	15.2	14.0	0	590
19	0	0.3	0.7	17.0	14.5	3.2	3.9	3.5	4.0	4.2	3.5	3.6	5.0	5.4	14.8	16.4	0	1668
Mean	0	0.4	1.2	11.1	13.8	5.6	4.3	5.1	4.3	3.3	2.7	2.6	2.9	6.9	14.3	21.5	0	—
Standard deviation	0	0.6	0.3	5.7	2.1	2.2	2.4	2.8	1.2	2.1	0.9	1.1	2.1	2.5	2.6	7.9	0	—
Coef. of variation	0	145	28	51	15	40	57	54	27	64	34	41	73	36	18	37	0	—

Table 10. Mean number of doves drinking at basins for each month of the summer of 1966

Basin number	Doves per hour				Mean
	May	June	July	August	
19	6.0	7.5	183.5	60.0	64.3
11	9.5	2.0	47.0	191.0	62.4
18	6.0	23.5	160.5	4.0*	48.5
14	0.5	5.0	12.5	105.0	30.8
3	2.0	9.5	50.5	52.5	28.6
10	7.0	28.0	46.5	13.5	23.8
15	1.0	5.0	10.0	77.0	23.3
20	1.0	8.5	48.0	31.0	22.1
7	8.5	14.0	24.5	41.0	22.0
8	12.5	11.5	20.5	37.5	20.5
17	5.5	19.0	17.0	27.0	17.1
12	14.0	7.5	20.5	18.0	15.0
6	5.5	11.0	16.5	24.5	14.4
2	1.0	16.5	14.5	15.0	11.8
5	0.5	6.5	14.5	25.0	11.6
9	4.5	10.5	9.5	18.0	10.6
13	0.0	3.0	3.0	22.0	7.0
16	4.5	6.0	1.5	14.5	6.6
1	4.0	14.5	1.5	1.5	5.4
4	7.5	1.5	1.0	9.0	4.8
Mean	5.1	10.5	35.2	39.3	22.5

*Basin 18 almost entirely dried up before the August count.

Table 11. Correlation coefficients, "r" values, for each pair of variables in the multiple regression analysis of the counts of doves drinking in the summer of 1966

Variable		1	2	3	4	5	6	7
No.	Name	Correlation coefficients						
1	Exposure	1.00	-.28	-.07	-.07	-.21	-.03	.59**
2	Crown cover		1.00	.23	-.20	-.15	-.36	-.40*
3	Other basins within 2 miles			1.00	-.15	.04	-.29	-.37
4	Area in summer fallow				1.00	.81**	-.55**	.32
5	Area in wheat					1.00	-.68**	-.04
6	Area in natural vegetation						1.00	-.02
7	Mean number of doves drinking							1.00

*Significant at .10 level with 18 d.f.
**Significant at .05 level with 18 d.f.

Table 12. Multiple correlation and regression coefficients for successive models generated in the step-wise deletion multiple regression analysis

Number of independent variables in model	Error d.f.	Regression coefficients: Independent variable numbers and names						Correlation coefficients	"F"[a]
		1 Exposure	2 Crown cover	3 Other basins	4 Summer fallow	5 Wheat	6 Natural vegetation		
6	13	10.41	-9.78	-5.72	.30	-.51	-.10	.835	1.69
5	14	16.57	-3.70	-3.72	.32	-.32	—	.811	.89
4	15	18.35	—	-4.48	.33	-.30	—	.797	1.41
3	16	18.41	—	—	.37	-.35	—	.775	5.09**
2	17	21.81	—	—	.16	—	—	.689	4.11*
1	18	20.94	—	—	—	—	—	.589	9.56**

[a]"F" ratios indicate significance of contribution of additional independent variables in R^2 (Fryer, 1966).
*Significant at .10 level.
**Significant at .05 level.

Table 13. Correlation coefficients from covariance analysis of data from summer, 1966, with number of doves drinking per hour as dependent variable

No.	Name	Simple correlation coefficient (35)[a]	Multiple correlation coefficient in combination with variable 10 (34)	Simple correlation coefficient (35)	Multiple correlation coefficient in combination with variable 8 (34)	Multiple correlation coefficient in combination with variables 6 and 8 (33)	Multiple correlation coefficient in combination with variables 6, 8, and 10 (32)
1	Precipitation	.013	.826	.018	.445	.544	.612
2	Cloud cover	-.187	.825	.137	.472	.495	.609
3	Temperature	.080	.826	-.122	.508*	.582	.632
4	Wind velocity	-.156	.832	.194	.440	.541	.608
5	Occasional water	.013	.825	.125	.452	.551	.613
6	Magpies	.137	.825	-.311*	.539**	—	—
7	Shrikes	.000	.825	-.115	.444	.541	.607
8	Blackbirds	-.046	.825	.440**	—	—	—
9	Raptors	-.197	.827	-.041	.440	.570	.633
10	Badgers	.825**	—	-.311*	.525*	.605*	—
11	Others	-.040	.826	-.082	.445	.547	.616
12	Perimeter for drinking	-.030	.825	-.069	.447	.546	.609

[a]Degrees of freedom shown in parentheses.
*Correlation or additional variation explained (Fryer, 1966) significant at .10 level.
**Correlation or additional variation explained significant at the .05 level.

Table 14. Analysis of variance, with and without correction for significant independent variables, of dove drinks per hour for the summer of 1966

Source	d.f.	Raw			Adjusted[a]		
		Sum of squares	Mean squares	"F"	Sum of squares	Mean squares	"F"
			May-August				
Hour	3	39,703.86	13,234.62	7.56*	16,609.12	5,536.37	6.35*
Month	1	23,529.80	23,529.80	13.43*	12,090.58	12,090.58	13.87*
Basin	18	31,870.30	1,770.57	1.01	15,565.64	864.76	.99
Hour x month	3	28,309.89	9,436.63	5.39*	9,609.33	3,203.11	3.67*
Basin x month	18	30,311.45	1,683.97	.96	15,794.15	877.45	1.01
Error	36	63,061.50	1,751.71		30,509.48[b]	871.70	
			June-July				
Hour	3	11,040.14	3,680.05	13.41*	11,956.80	3,985.60	20.96*
Month	1	12,127.81	12,127.81	44.18*	15,166.90	15,166.90	79.75*
Basin	18	44,816.33	2,489.80	9.07*	45,151.84	2,508.44	13.19*
Hour x month	3	7,176.48	2,392.16	8.71*	8,943.82	2,981.27	15.67*
Basin x month	18	34,907.42	1,939.30	7.06*	28,667.73	1,592.65	8.37*
Error	36	9,882.75	274.52		6,276.37[c]	190.19	

[a]Regression coefficients for May-August: X_{10}=51.98; June-July: X_6=-.78, X_8=.86, X_{10}=-.67. X_6=magpies, X_8=blackbirds, X_{10}=badgers.
[b]35 degrees of freedom.
[c]33 degrees of freedom.
*Significant at the .05 level.

VITA

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