Avian ecology on stock ponds in two vegetational types in north-central Montana
by Vaughn Marlan Rundquist

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of DOCTOR OF PHILOSOPHY in Fish and Wildlife Management
Montana State University

Abstract:
The avian ecology on natural and artificial impoundments in two vegetational types, grassland and sagebrush-grassland, in north-central Montana was studied from 1970 to 1972. Pond dimensions, water-level fluctuations, and selected characteristics of pond water were measured. Upland vegetation was described by a canopy-coverage method. Bird censuses were conducted during about 800 pond visits. The water level of all ponds declined during the summer, with a computed weekly rainfall of 1.35 inches being required for water-level stability. Due to a greater percent of bare soil and a more abrupt contour in the sagebrush-grassland type, ponds had a greater degree of turbidity, accompanied by less plankton and submergents than in the other type. Most of the 113 bird species observed were more numerous in the grassland type. Breeding waterfowl in this type numbered 45.5 pairs per square mile and used temporary waters in the form of natural potholes and reservoir flood-plains in addition to permanent waters. Considering all types of ponds, waterfowl in grassland numbered 1.81 breeding pairs per water-surface acre. Mallards (Anas platyrhynchos), pintails (A. acuta) American widgeon (Mareca americana), and blue-winged teal (A. discors) formed 74.9 percent of the waterfowl breeding population in grassland. No temporary waters were present in the sagebrush-grassland type, where waterfowl breeding pairs numbered 19.6 per square mile and 2.84 per water-surface acre. Mallards and American widgeon comprised 50.8 percent of the breeding population in sagebrush-grassland. A low density of duck nests Was associated with a 67-percent nest success, indicating that primarily nest spacing rather than vegetational cover provided security for nests. An 87-percent seasonal decrease in the water acreage of the grassland type was accompanied by a waterfowl reproductive success one-third as great as in the sagebrush-grassland type, where the seasonal water-acreage decrease was only 8 percent. Grassland had 9.8 broods per square mile, while the other type had 11.1 broods per square mile. Broods numbered 2.95 and 1.86 per water-surface acre in grassland and sagebrush-grassland, respectively. The low reproductive success in grassland may have been related to lowered water levels causing egress of breeding pairs, gonadal inhibition, or strife due to crowding. Fencing ponds was not recommended due to the initial cost involved and the maintenance required to achieve the intended effects.

AVIAN ECOLOGY ON STOCK PONDS IN TWO VEGETATIONAL TYPES IN NORTH-CENTRAL MONTANA

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VAUGHN MARLAN RUNDQUIST

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree

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ABSTRACT

The avian ecology on natural and artificial impoundments in two vegetational types, grassland and sagebrush-grassland, in north-central Montana was studied from 1970 to 1972. Pond dimensions, water-level fluctuations, and selected characteristics of pond water were measured. Upland vegetation was described by a canopy-coverage method. Bird censuses were conducted during about 800 pond visits. The water level of all ponds declined during the summer, with a computed weekly rainfall of 1.35 inches being required for water-level stability. Due to a greater percent of bare soil and a more abrupt contour in the sagebrush-grassland type, ponds had a greater degree of turbidity, accompanied by less plankton and submergents than in the other type. Most of the 113 bird species observed were more numerous in the grassland type. Breeding waterfowl in this type numbered 45.5 pairs per square mile and used temporary waters in the form of natural potholes and reservoir floodplains in addition to permanent waters. Considering all types of ponds, waterfowl in grassland numbered 1.81 breeding pairs per water-surface acre. Mallards *(Anas platyrhynchos)*, pintails *(A. acuta)*, American widgeon *(Mareca americana)*, and blue-winged teal *(A. discors)* formed 74.9 percent of the waterfowl breeding population in grassland. No temporary waters were present in the sagebrush-grassland type, where waterfowl breeding pairs numbered 19.6 per square mile and 2.84 per water-surface acre. Mallards and American widgeon comprised 50.8 percent of the breeding population in sagebrush-grassland. A low density of duck nests was associated with a 67-percent nest success, indicating that primarily nest spacing rather than vegetational cover provided security for nests. An 87-percent seasonal decrease in the water acreage of the grassland type was accompanied by a waterfowl reproductive success one-third as great as in the sagebrush-grassland type, where the seasonal water-acreage decrease was only 8 percent. Grassland had 9.8 broods per square mile, while the other type had 11.1 broods per square mile. Broods numbered 2.95 and 1.86 per water-surface acre in grassland and sagebrush-grassland, respectively. The low reproductive success in grassland may have been related to lowered water levels causing egress of breeding pairs, gonadal inhibition, or strife due to crowding. Fencing ponds was not recommended due to the initial cost involved and the maintenance required to achieve the intended effects.

INTRODUCTION

Wildlife management and agricultural practices constantly interact, producing both adverse effects and mutual benefits. A practice having adverse effects on waterfowl and some other wildlife species has been the drainage of wetlands in the Prairie Pothole Region (Burwell and Sugden 1964; Smith, Stoudt, and Gollop 1964; and Studholme and Sterling 1964). The effects of drainage have been partly offset through the construction of small impoundments. The impoundments were originally designed to supply drinking water for livestock in the arid West and to secure better distribution of grazing pressure. However, the added bonus of waterfowl production was soon apparent (Bue, Uhlig, and Smith 1964 and Edminster 1964). In eastern Montana alone, nearly 8,000 rangeland impoundments had been developed by the Bureau of Land Management before 1970, with a present annual construction rate of approximately 240 impoundments. Private and state agencies also construct many impoundments in this area (Jones 1970). Several workers have studied the value of small impoundments to waterfowl (Bue, Blankenship, and Marshall 1952; Smith 1953; Berg 1956; Shearer 1960; Keith 1961; and Gjersing 1971). Most of these studies were wholly or partly concerned with the relationship between grazing practices and waterfowl production.

The present study was designed to compare two vegetational types, grassland and sagebrush-grassland, with respect to the ecology of bird populations using the impoundments in each type. The study units in the two vegetational types were similar in all major aspects except vegetation. Field work was conducted from June 8 to September 25, 1970; from April 1 to September 20, 1971; and from March 21 to October 7, 1972.

DESCRIPTION OF THE STUDY UNITS

Both study units were located in southern Phillips County of north-central Montana (Figure 1). Phillips County has been described as a rolling plain dissected by rather deeply entrenched streams and coulees. Most of the stream borders and the more feebly glaciated areas are the sites of rough, broken land, often approaching a badland situation (Gieseker 1926).

The grassland unit was situated about 7.5 miles directly north of the sagebrush-grassland unit. Considering home-range size of waterfowl (Sowls 1955), the separation between study units tended to eliminate any interchange of locally breeding birds. On the other hand, the proximity of the two units provided similar weather conditions. The north and south units covered 8.5 and 8.0 contiguous square miles, respectively.

The grassland unit varied from 2570 to 2870 ft in elevation; the sagebrush-grassland unit varied from 2520 to 2760 ft. The contour of the former unit was somewhat less abrupt than that of the latter. The grassland unit was drained by Beaver and Second Creeks, which empty into the Milk and Missouri Rivers, respectively. The sagebrush-grassland unit was drained by Fourchette Creek, a tributary of the Missouri River. Five soil types occurred in the study units: Phillips loams, Pierre clay loams, Scobey loam, Scobey sandy loam, and Scobey stony loam (Gieseker 1926) (Appendix Figure 18). Four of the types occurred in the grassland unit, and two were found in the other unit.

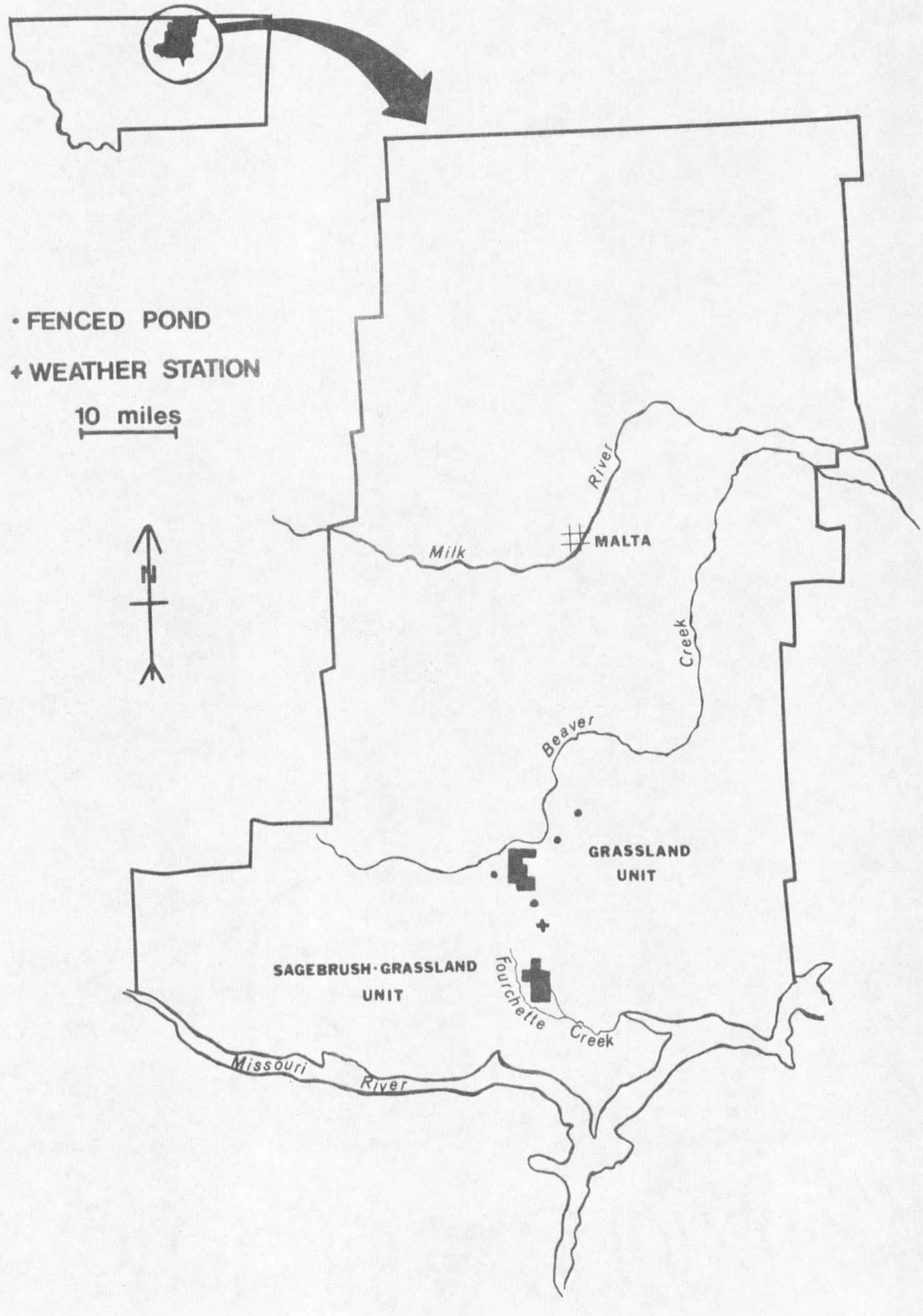

Figure 1. Location of the study units in southern Phillips County, Montana.

Annual temperatures on the study units averaged 41.9 F from 1970 to 1972. The frost-free period extended from mid-May to mid-September. Annual precipitation averaged 12.47 inches from 1960 to 1972. The study units received 3.29 and 1.95 inches above the average in 1970 and 1972, respectively, and 2.41 inches below the average in 1971. Over half of the precipitation falls in the period April through July. Winter snowfall is light. Strong westerlies are common to the area, with chinooks occurring occasionally during the winter (Gieseker 1926 and U. S. Department of Commerce 1960-1972).

The study included 31 unfenced ponds in the grassland unit, 17 unfenced ponds in the sagebrush-grassland unit, and 4 fenced ponds outside the units. The ponds were of three types: natural pothole, dugout, and retention reservoir (Appendix Table 11 and Figures 2 and 3). The natural potholes resembled the temporary and seasonal ponds described by Stewart and Kantrud (1971), while most of the artificial impoundments (dugouts and retention reservoirs) were much more permanent. In the grassland unit, natural potholes and artificial impoundments averaged 1.5 and 2.1 per square mile, respectively, for a total of 3.6 ponds per square mile. The other unit had only retention reservoirs, with an average of 2.1 per square mile. Half of the artificial impoundments in the grassland type had a floodplain in the upper end varying from 2.1 to 16.6 acres and averaging 7.8 acres (Figure 4). The floodplains were vegetated predominantly by spike-edge *(Eleocharis macrostachya)*

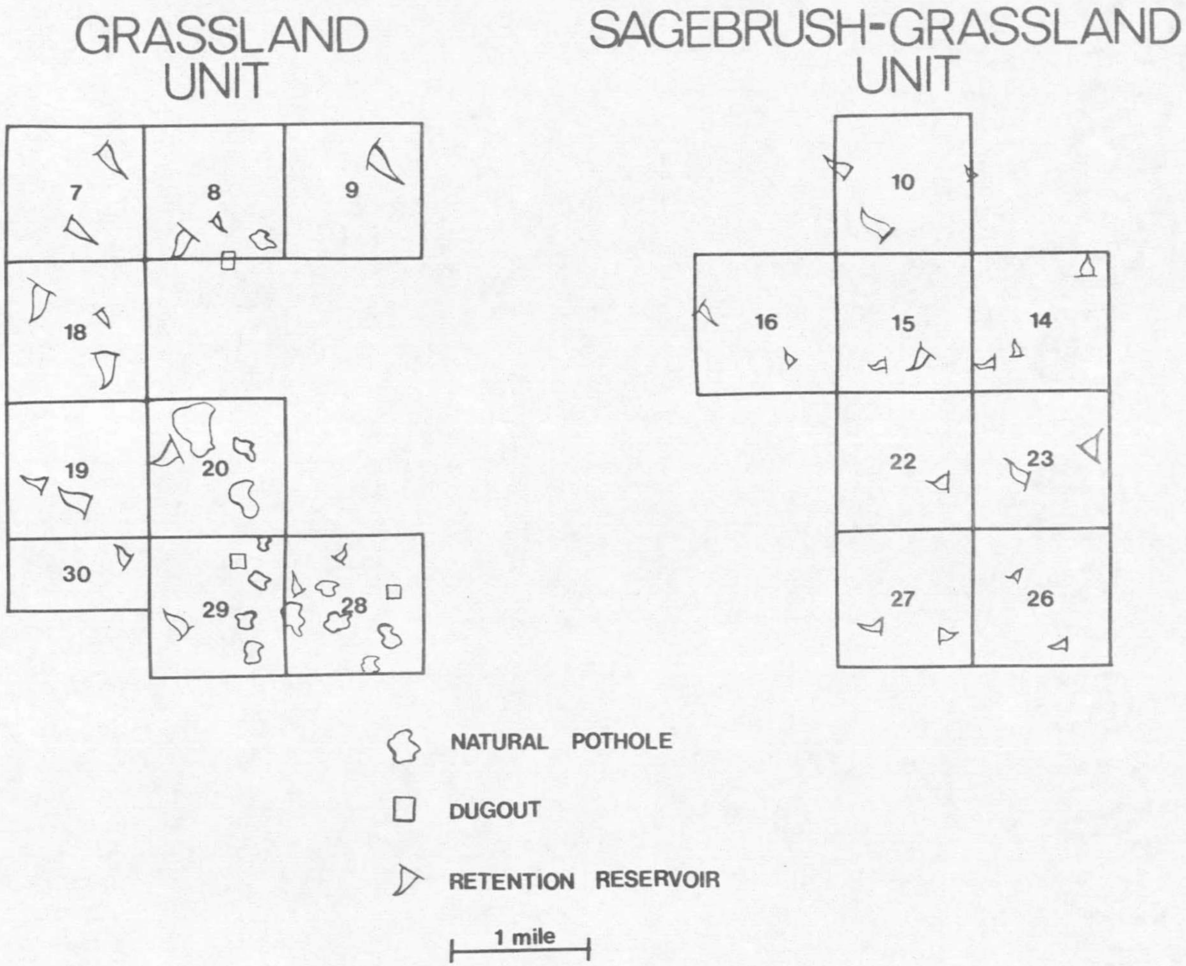

Figure 2. Types and locations of study ponds.

Figure 3. Fenced retention reservoir S2 in the sagebrush-grassland type.

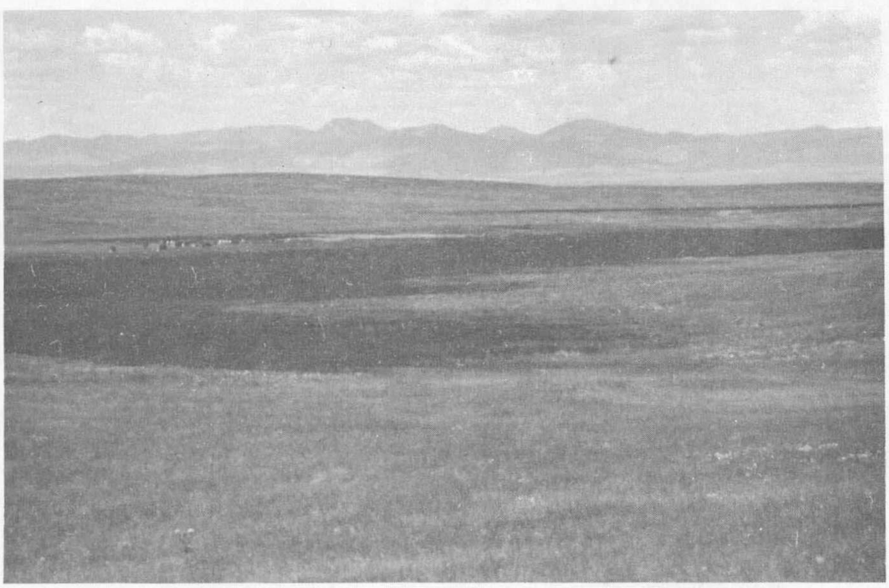

Figure 4. Floodplain at retention reservoirs 19G1 and 19G2 in the grassland unit.

(Appendix Figure 19). None of the retention reservoirs in the sagebrush-grassland type had floodplains. Floodplains apparently resulted from the more gentle topography in the grassland type which allowed impounded water to accumulate at the upper end of the pond basin.

Prominent upland floral components of the grassland study unit were bluestem *(Agropyron smithii)*, blue grama *(Bouteloua gracilis)*, Junegrass *(Koeleria cristata)*, Sandberg bluegrass *(Poa secunda)*, needle-and-thread *(Stipa comata)*, yarrow *(Achillea millefolium)*, fringed sagewort *(Artemisia frigida)*, needleleaf sedge *(Carex eleocharis)*, scarlet globemallow *(Sphaeralcea coccinea)*, lichens, and clubmoss *(Selaginella densa)*. In the sagebrush-grassland unit, the main upland components were the five grass species of the other unit in addition to big sagebrush *(Artemisia tridentata)*, fringed sagewort, needleleaf sedge, broom snakeweed *(Gutierrezia sarothrae)*, plains prickly-pear *(Opuntia polyacantha)*, lichens, and clubmoss. Vegetal cover was much less continuous in this unit than in the grassland unit, and patches of bare ground were common (Figure 5). The main shoreline species in each study unit was spike-sedge. Submergents most often found in each unit were western waterweed *(Elodea occidentalis)*, filamentous green algae, and American milfoil *(Myriophyllum exalbescens)*.

In addition to the avifauna, vertebrates seen on the study units include leopard frog *(Rana pipiens)*, plains garter snake *(Thamnophis radix)*, bull snake *(Pituophis catenifer)*, prairie rattlesnake *(Crotalus*

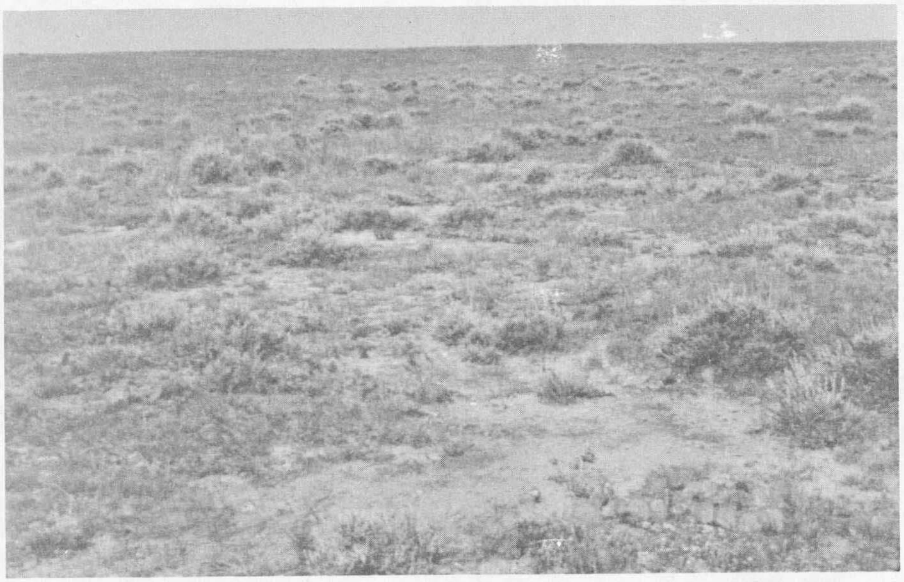

Figure 5. Patches of bare ground in the sagebrush-grassland unit.

viridis), painted turtle *(Chrysemys picta)*, blacktail prairie dog *(Cynomys ludovicianus)*, muskrat *(Ondatra zibethica)*, beaver *(Castor canadensis)*, mountain cottontail *(Sylvilagus nuttalli)*, whitetail jack-rabbit *(Lepus townsendi)*, striped skunk *(Mephitis mephitis)*, badger *(Taxidea taxus)*, red fox *(Vulpes fulva)*, coyote *(Canis latrans)*, prong-horn *(Antilocapra americana)*, and whitetail deer *(Odocoileus virginianus)*.

METHODS

Physical Factors

The initial choice of study units was aided by Bureau of Land Management area maps and by aerial inspection. Final selection of the study units was made following a study of aerial photographs and a reconnaissance from the ground. Hand-drawn maps including useful landmarks were then prepared. Four fenced ponds outside the main study units, two in grassland and two in sagebrush-grassland, were also chosen for study.

Depths of shallow ponds were determined by wading with a sounding pole. Deep ponds were sounded from a boat with a pole or line. In 1972, fluctuating water levels were studied by using a series of 20 metal or wooden stakes. A stake was placed in each fenced pond and in selected unfenced ponds of each study unit. The initial water level was marked on the stake, and the change in level was noted weekly over a period of 3 months beginning in early July. In addition, a visual estimate of water level was made on an irregular basis when ponds were visited during bird censuses. Dates were recorded on which ponds became dry. Pond perimeters were measured in 1971 and 1972 at low water level, and in 1972 at high water level. Perimeter measurements were made with a "tally whacker" used in conjunction with a bicycle wheel pushed along the edge of the water. Pond areas were determined by the weight method (Welch 1948), using paper models prepared from aerial photographs. Pond-water samples were collected for determining pH, turbidity, water color, and gross nature of suspended and settled matter. Turbidity and pH were measured with a Model DR-EL Hach colorimeter. Turbidity was measured following major rainfalls and during a relatively rainless period and was noted visually during periodic pond visits. Types of pond construction were determined by examination. Construction dates were obtained from Bureau of Land Management records and from interviews with landowners.

Precipitation and air-temperature data recorded at Malta 35S, a weather station located approximately midway between the two study units, were obtained from U. S. Department of Commerce (1960-1972). Personal records were also kept of daily temperature extremes, amounts and types of precipitation, extent of cloud cover, wind direction, and wind velocity.

Vegetative Study

Upland vegetation was analyzed by a canopy-coverage method (Daubenmire 1959a). For analytical purposes, the vegetation of each study unit was sufficiently homogeneous to be considered a single stand. Five 20x50-cm plots equally spaced along each of eight 100-m transects were deemed adequate for characterizing the upland vegetation of each study unit. The percent canopy coverage of each plant taxon; the percent coverages of bare ground, rock, and litter; and the maximum height of herbaceous and shrubby vegetation were recorded for each plot. All plant taxa not encountered in the plots but occurring in a strip 1 m wide adjacent to the transect were listed. Similar procedures were followed for measuring the upland vegetation on each side of the fence at one fenced pond.

Lowland vegetation was described by assigning one of five values (from 0 for none to 4 for fully covered) to the quantity of woody, emergent, and submergent vegetation.

In July 1972, low-altitude infrared aerial photographs were taken of a sample of the ponds in the grassland study unit by Dr. M. P. Meyer, University of Minnesota. The photographs were compared with pond cover maps made by a ground examination.

Daily phenological records were kept of most rangeland forbs from the date of first blossom through the period of anthesis.

Extent of cattle use of ponds and uplands was determined through

Bureau of Land Management records, interviews with ranchers, and periodic counts and estimates. Degree of shoreline trampling by cattle was recorded by using a five-point scale from "no trampling" to "very heavily trampled."

Plant names were taken from Booth (1950) and Booth and Wright (1959).

Bird Observations

Beginning in late June 1970, early April 1971, and late March 1972, bird censuses were conducted during a total of some 800 pond visits. Ten of the 13 natural potholes and one of the dugouts were not visited in 1970, but all ponds in Appendix Table 11 were visited in 1971 and 1972. Each pond was approached by vehicle because, in most cases, observing from the vehicle caused the least disturbance of birds. After one or two visits, the vantage point most suitable in terms of topography, shoreline configuration, and incidence of light was selected and used during most subsequent visits. Observations were made with a 7x35 binocular and a 15-60x variable-power telescope. Each pond was observed for an average of 29 min between early morning and early evening, with 79 percent of the observations beginning before noon. On the average, each pond was visited every 17.7 days in March, April, and May. Visits during the months June through September were made every 24.3 days.

Breeding pairs of waterfowl were censused by counting all pairs, males, and females. For surface-feeding ducks and redheads *(Aythya americana)*, the sum of pairs plus lone males was used for breeding-pair totals. Females were added into the totals only when it was apparent that they were not represented by a male. Pair totals for lesser scaup *(A. affinis)*, canvasbacks *(A. valisineria)*, and ruddy ducks *(Oxyura jamaicensis)* were obtained by adding pairs and females. The breeding population of Canada geese *(Branta canadensis)* consisted of all pairs plus females observed on nests (Hammond 1959). Besides the species, sex, and number of waterfowl, their activity and location of activity on the pond were recorded for both residents (species breeding on the study units) and migrants (species potentially breeding elsewhere). As waterfowl broods appeared, the species, age, brood size, activity, and location of activity were recorded. Brood production was computed by the method of Gollop and Marshall (1954).

During waterfowl censuses, all other birds present were censused by the same methods, with records made of the species, number, and sometimes the sex and relative age.

The species, location, clutch size, characteristics of surrounding vegetation, and fate of bird nests found incidentally were recorded. In June 1971, an organized search for waterfowl nests was conducted with the cooperation of biologists from Northern Prairie Wildlife Research

Center, Jamestown, North Dakota. Some 1,225 acres in grassland and sagebrush-grassland were searched with a cable-chain device (Higgins, Kirsch, and Ball 1969). For each nest found, the stage of incubation was determined with a field candler (Weller 1956) and other information was recorded as for nests found incidentally.

A daily record besides the censuses was kept of all bird species seen on the study units and environs. Bird names were taken from the American Ornithologists' Union (1957).

RESULTS

Water-Level Fluctuations

In 1972 the natural potholes had a maximum of water in early spring, and then decreased gradually. Spring and early-summer rains did not seem to accumulate in the potholes. These observations are supported by the conclusions of Eisenlohr and Sloan (1968) and Eisenlohr (1969), who found that runoff became a source of water for potholes in North Dakota only when the ground was either frozen or saturated. They found that a snow cover of any depth was effective in supplying potholes with water if it melted rapidly while the ground remained frozen, and rain became an important source of water in either a dry or a wet year if a large amount fell within a short period of time.

Retention reservoirs, particularly in the grassland unit, had a relatively low water level early in the spring of 1972, and many of them filled considerably with spring and early-summer rains. Other reservoirs seemed little affected by rainfall. There was thus some doubt concerning the best time to measure pond depths and shoreline lengths. The tendency was to measure ponds after the effects of spring and summer rains had been felt. Consequently many natural potholes were already dry by the time pond measurements were begun.

In general, natural potholes and the extensive floodplains of at least some of the artificial impoundments were dry by early July. In mid-July 1972, a 28-acre pothole was dry enough to permit its cover, predominantly spike-sedge, to be cut for hay. The seasonal loss of water from natural potholes and floodplains amounted to 87 percent of the water-surface acreage of the grassland unit, decreasing from 25.3 to 3.3 acres per square mile. The water acreage of the other unit decreased only 8 percent, from 6.5 to 6.0 acres per square mile. The more shallow reservoirs and dugouts with maximum water-surface area of less than an acre were generally dry by September. In mid-June 1972 it was noted that the creek in Section 14 of the sagebrush-grassland unit had been reduced to a series of intermittent pools.

The main factors causing fluctuations in pond water level were precipitation, and evaporation as a function of air temperature, relative humidity, wind, water-surface area, and pond depth. Cattle use and seepage were not measured but were thought to be insignificant in contributing to water-level changes.

The water level of all ponds declined during summer 1972 (Figure 6). It was calculated that a weekly rainfall of 1.35 inches during the period of water-level measurement would have been required for the level to remain stable (Figure 7). Ninety percent of the ponds increased or remained the same in level during at least 1 week due to rains. Whether rain caused a particular pond to increase or remain stable for a given week seemed to be determined by the characteristics of the pond watershed as well as by the degree to which the ground was saturated.

The direction and extent of the average weekly fluctuation in

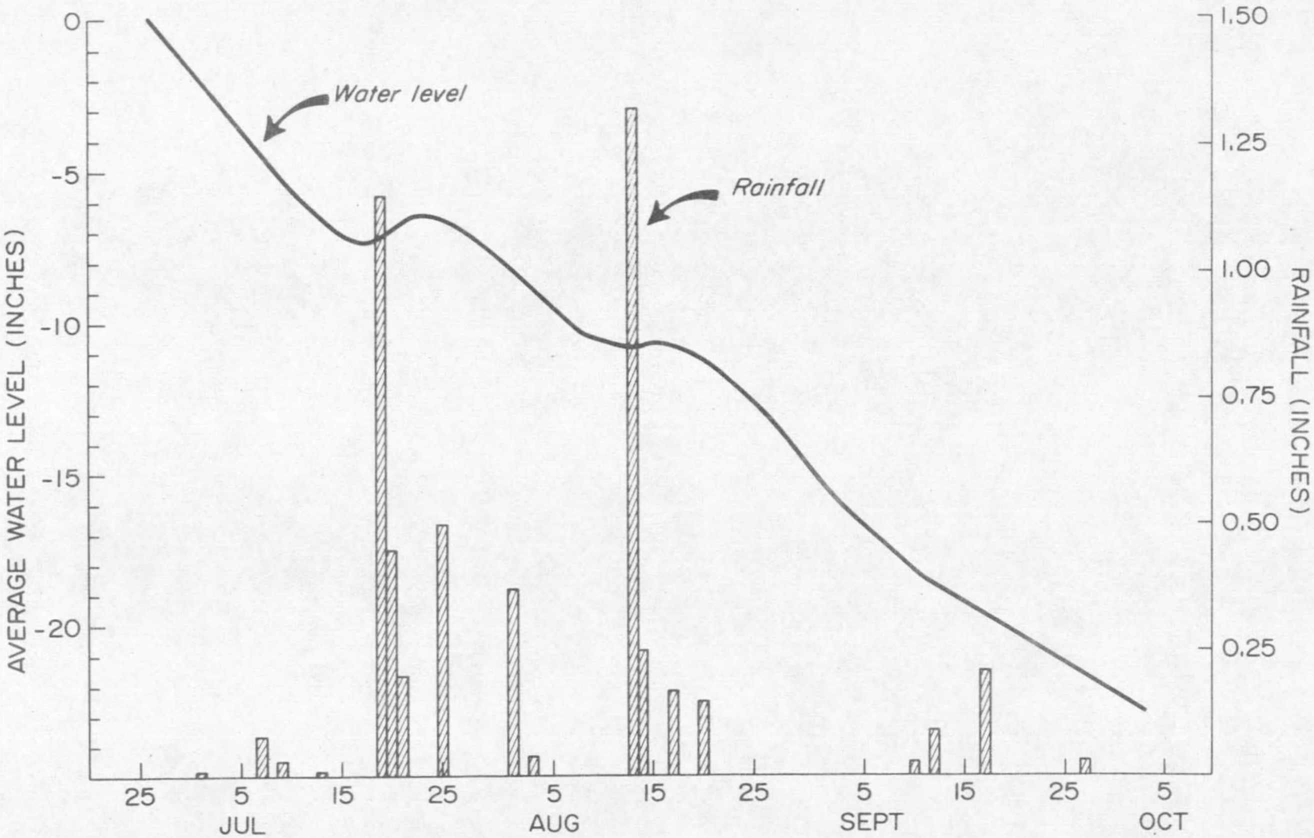

Figure 6. The effect of rainfall on the seasonal decrease of pond water level in 1972.

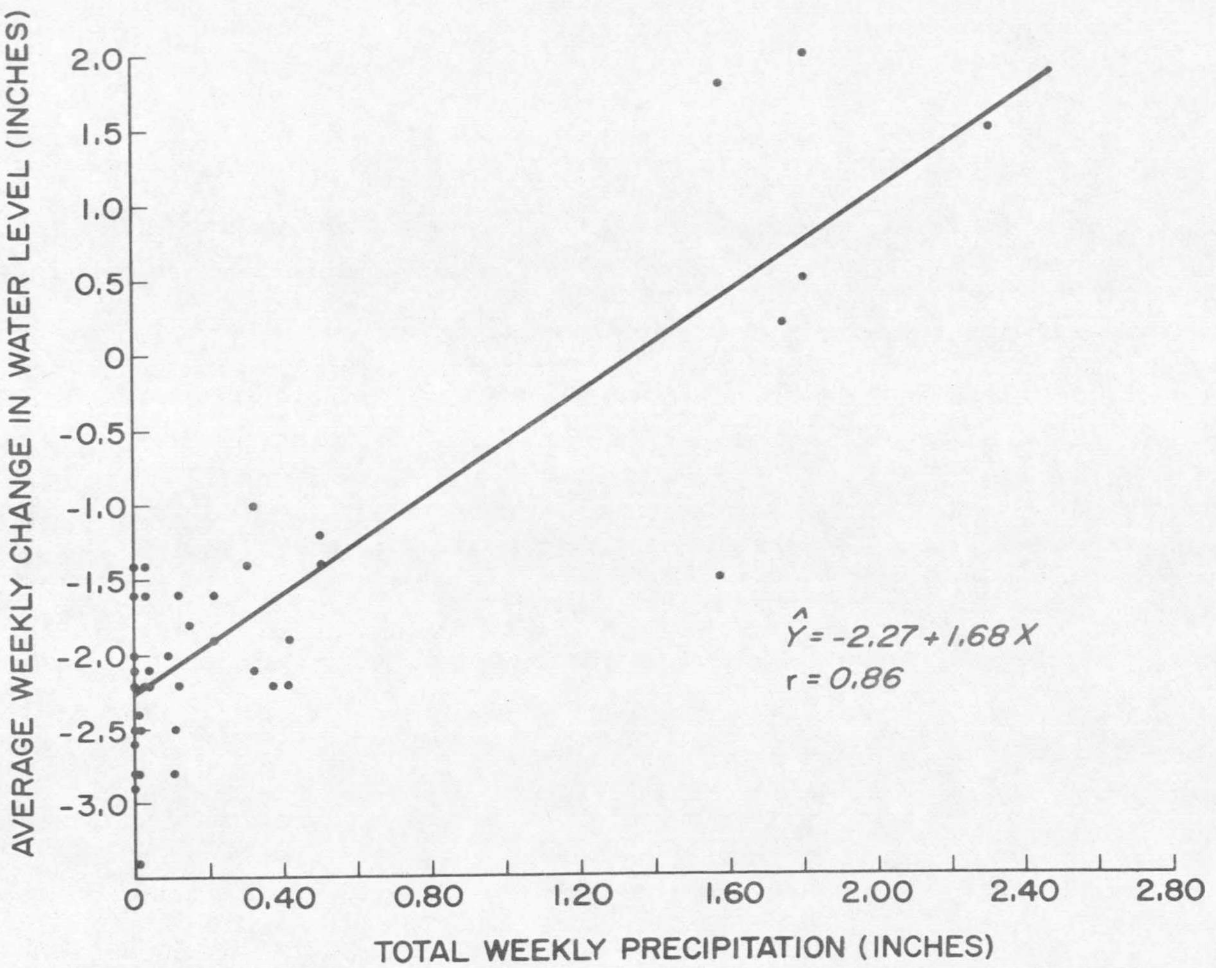

Figure 7. The linear regression of pond water-level fluctuation on precipitation for summer 1972.

water level were closely associated with total weekly precipitation; the linear correlation coefficient was 0.86. The coefficient between average weekly air temperature and water-level fluctuation was insignificantly small.

The linear correlation coefficient between pond depth and the average weekly water-level change was 0.22. The association between water-surface area and weekly change followed a logarithmic function (Figure 8) with a correlation coefficient of 0.77.

Water Quality

The water of 95 percent of the grassland reservoirs and dugouts was judged "clear" during most visits to these ponds in 1970. On the other hand, only 26 percent of the retention reservoirs in the sagebrush-grassland type were considered clear, with the others having various degrees of turbidity.

The water color of ponds in the grassland type ranged from colorless to greenish yellow, and phytoplankton, zooplankton, or detritus occurred in 52 percent of the water samples from this type. Organic matter was present in 29 percent of the sagebrush-grassland samples. No inorganic matter was seen in the grassland samples, but 71 percent of those from the other type contained visible inorganic material. The color of samples from sagebrush-grassland varied from colorless to very chalky.

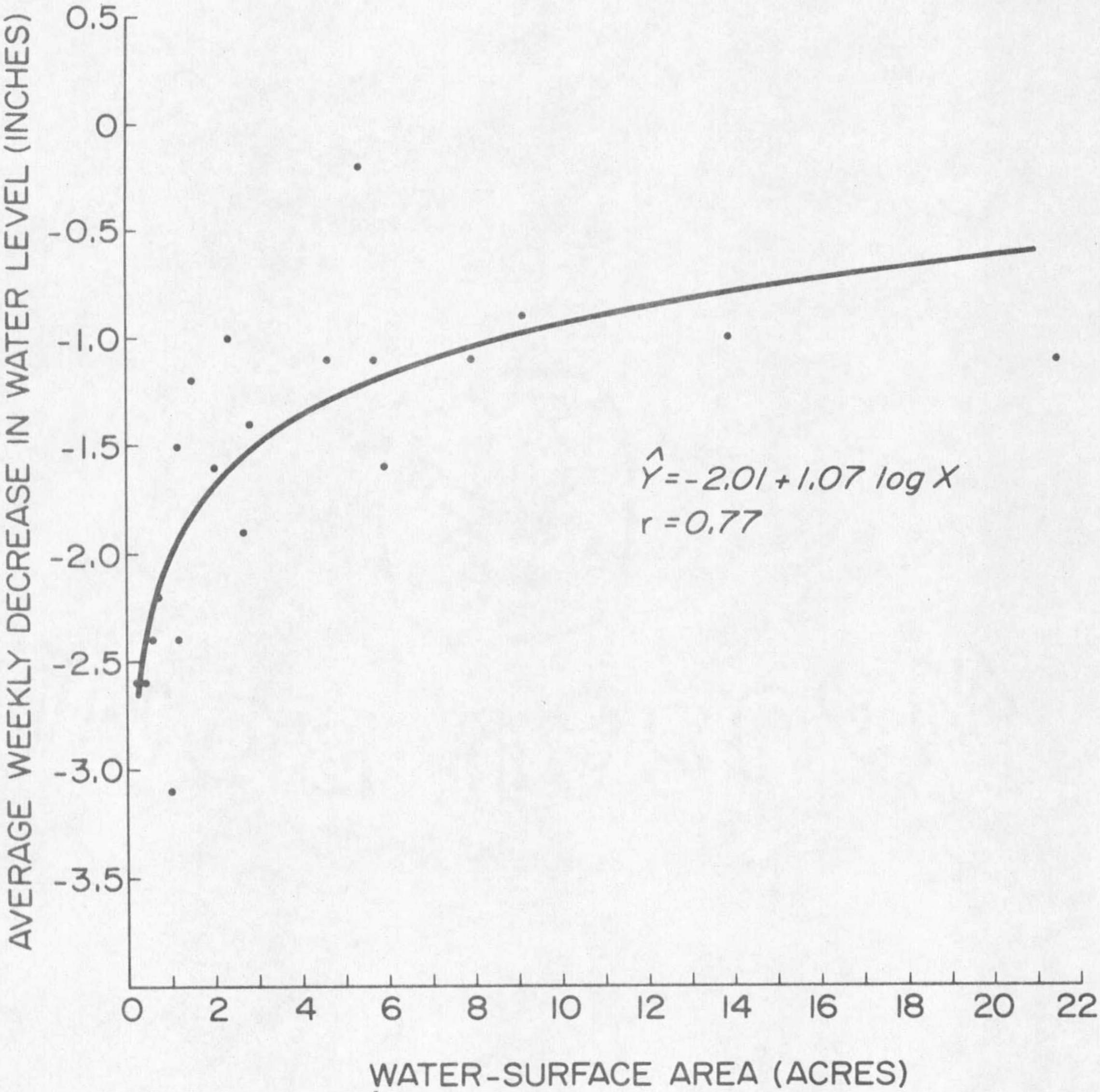

Figure 8. Weekly water loss in relation to water-surface area of study ponds from June 27 to October 3, 1972.

The turbidity measurements in each type in 1972 were used to prepare an analysis of variance for a two-factor factorial (Table 1), with each factor (vegetational type and rainfall intensity) having two levels and unequal subclass samples (Steel and Torrie 1960).

TABLE 1. ANALYSIS OF VARIANCE OF POND-WATER TURBIDITY MEASUREMENTS.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Treatments			
Vegetational type (V)	1	84,554	84,554
Rainfall intensity (R)	1	4,702	4,702
VxR	1	20,186	20,186
Experimental error	37	700,936	18,944
Total	40	810,378	

Using the experimental-error mean square, treatment means were compared by the least significant difference (or LSD) method (Ostle 1963) (Table 2). It was found that there was a difference between the two vegetational types in the effect of both low and high rainfall at the 90 and 95 percent levels of confidence, respectively. Different intensities of rainfall had no significant effect on the degree of pond-water turbidity in grassland, while in sagebrush-grassland there was

TABLE 2. MEASUREMENTS OF POND-WATER TURBIDITY FOLLOWING PERIODS OF LOW AND HIGH RAINFALL.

Vegetational type and relative intensity of rainfall	Turbidity (ppm)		
	Sample Size	Range	Mean[1]
Grassland (G)			
Low rainfall (L)	14	8-104	39.2
High rainfall (H)	8	10-110	38.1
Sagebrush-grassland (S)			
Low rainfall (L)	14	5-410	108.2
High rainfall (H)	5	14-610	190.4

[1]Comparison of treatment means by the least significant difference (or LSD) method (Ostle 1963) gives the following results, where n indicates no significant difference, s indicates a significant difference, and the decimals indicate the level of significance:

	GL	GH	SL	SH
GL	--	n, 0.01	s, 0.10	--
GH		--	--	s, 0.05
SL			--	s, 0.15
SH				--

a difference at the 85 percent confidence level. The differences between the two types were presumably due to a greater percent of bare soil subject to water erosion in the sagebrush-grassland (Appendix Table 12 and Figure 9), in conjunction with a more abrupt contour.

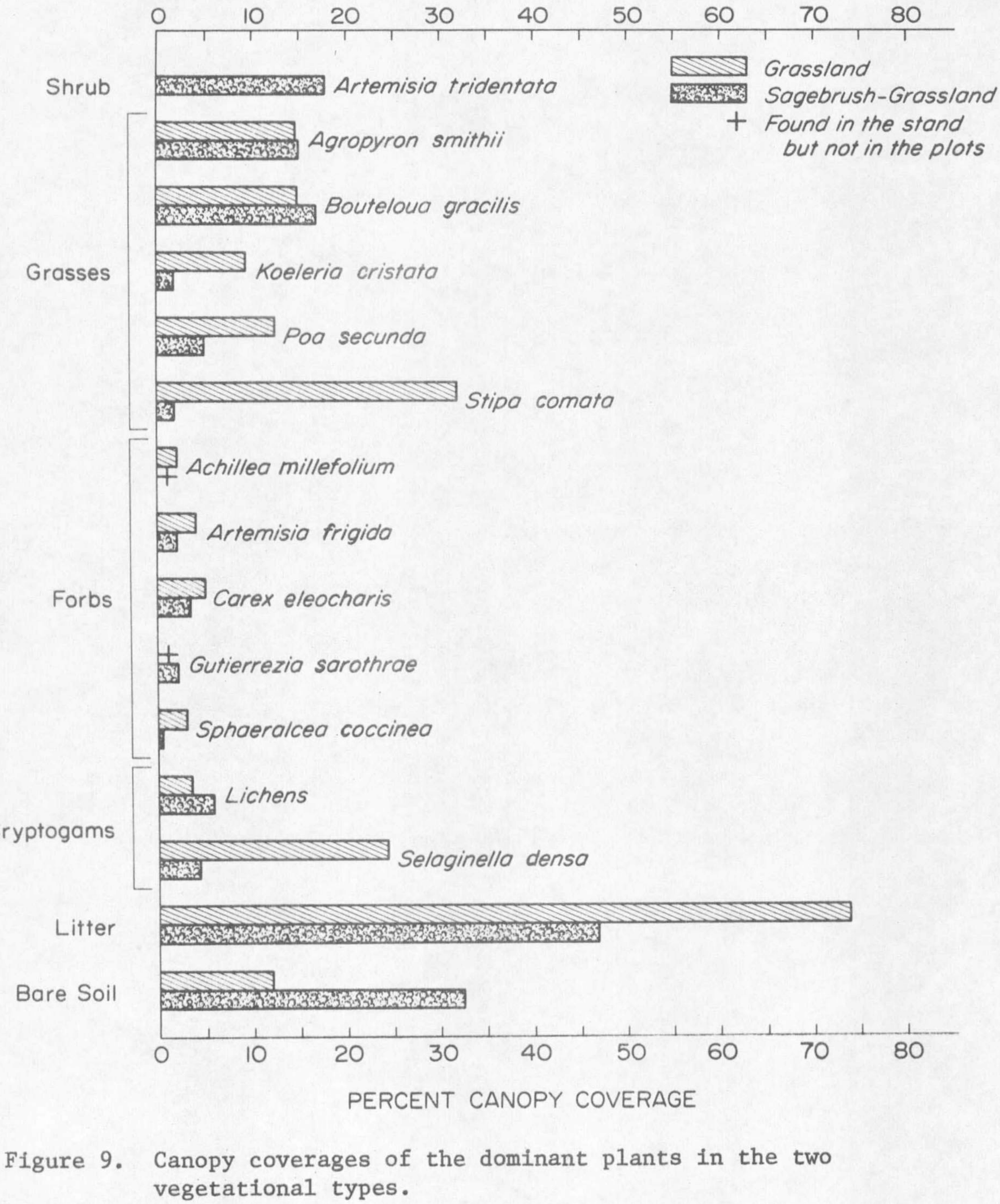

Figure 9. Canopy coverages of the dominant plants in the two vegetational types.

The pH of ponds measured in early October 1972 varied from 8.6 to 9.5 and from 8.3 to 9.8 in grassland and sagebrush-grassland, respectively. The average pH in each type was 9.1.

Upland Vegetation

The sagebrush-grassland type had the general appearance of a shrub community (Figure 10), with big sagebrush providing the most cover (Figure 9). Upland shrubs were almost entirely lacking in the grassland type, where the dominant seed-bearing plants were grasses (Figure 11). The same five species of grass contributed the most grass coverage in each type. The average canopy coverage of the five was 16.7 percent in the grassland unit, which was more than twice that in the other unit (8.1 percent). The most common grasses were needle-and-thread in grassland and blue grama in sagebrush-grassland (Appendix Table 12).

Although a great array of forbs occurred in each type (Appendix Table 13), they were minor in providing cover. Scarlet globemallow and spindle plantain *(Plantago spinulosa)* were the most common forbs in grassland and sagebrush-grassland, respectively, but needleleaf sedge, a grass-like forb, provided the most forb coverage in each vegetational type. It had a coverage of 4.9 percent in the grassland unit and 3.4 percent in sagebrush-grassland.

Clubmoss was an important contributor to grassland cover. Unlike the grasses and forbs, its mat-like growth form closely covered the soil

Figure 10. Aspect of the sagebrush-grassland unit; the dominant plant is big sagebrush.

Figure 11. General appearance of the grassland unit.

surface. As a result of its canopy coverage and growth form, the amount of bare soil in grassland was only about one-third that in the other type. In addition to protecting the soil, clubmoss composed a very high proportion of the litter in the grassland unit. Lichens occurred more frequently than clubmoss in each unit and were found with nearly equal frequency in the two units.

Herbaceous vegetation in the grassland plots ranged from 5 to 29 inches tall, with a mean height of 13.5 inches. That in the sagebrush-grassland plots varied from 4 to 16 and averaged 9.2 inches. Height of big sagebrush within the plots ranged from 1 to 18 and averaged 8.3.

The grassland type was more diverse floristically. Sixty-one plant taxa were identified along the transects, compared with 53 taxa along sagebrush-grassland transects. The number of taxa per grassland plot ranged from 7 to 15 and averaged 10.4; in the other type, the range was 3 to 14 with an average of 7.8. The averages were statistically different at the 99-percent confidence level.

Pond Vegetation

Two species of trees (plains cottonwood [*Populus deltoides occidentalis*] and peachleaf willow [*Salix amygdaloides*]) and five of shrubs were found at ponds in the two vegetational types (Table 3). In the sagebrush-grassland type, trees and shrubs were much more prominent in terms of plant maturity, quantity of woody growth, and percent of

TABLE 3. THE OCCURRENCE OF WOODY PLANTS ON RETENTION RESERVOIRS AND NATURAL POTHOLES.

Woody plant		Retention reservoirs				Natural potholes	
		G[1]		S[2]			
Latin name	Common name	No.	%	No.	%	No.	%
Artemisia tridentata	Big Sagebrush	1	5.9	0	0	0	0
Populus deltoides occidentalis	Plains Cottonwood	2	11.8	6	31.6	0	0
Ribes aureum	Golden Currant	1	5.9	3	15.8	0	0
Rosa woodsii	Woods Rose	4	23.5	11	57.9	3	23.1
Salix amygdaloides	Peachleaf Willow	5	29.4	8	42.1	0	0
Salix exigua	Slender Willow	3	17.6	13	68.5	0	0
Symphoricarpos occidentalis	Western Snowberry	0	0	2	10.5	0	0
Total having woody plants		9	52.9	14	73.7	3	23.1

1 Grassland vegetational type.
2 Sagebrush-grassland vegetational type.

ponds having woody species. Six species occurred in each type. In the grassland type, individual ponds had three species or less, while each pond in the other type had as many as six species. The age of a pond apparently did not determine the diversity of species present. They occurred at retention reservoirs and natural potholes, but none of the dugouts had woody vegetation. In general, the dams supported the most and oldest woody plants at reservoirs.

There seemed to be no relationship between pond age and presence of woody vegetation. A 5-year-old pond had a few young plants of slender willow *(S. exigua)* and plains cottonwood. At another pond of the same age were found slender willow and plains cottonwood in addition to a small amount of Woods rose *(Rosa woodsii)* and young peachleaf willow. Other ponds up to at least 25 years old had no woody vegetation.

Pond permanence seemingly did not determine the amount of woody growth present. Some of the permanent ponds lacked woody cover, while a small pond that tended to become dry each year supported a heavy growth of four woody species, one of which was of considerable age.

Important herbaceous plants in the ecotone between upland and shoreline cover in both vegetational types were foxtail barley *(Hordeum jubatum)* and bluestem (Appendix Figures 20, 21, and 22). Spike-sedge and needle spike-sedge *(Eleocharis acicularis)* were the dominant emergents of pond shorelines in each type. The basins of natural potholes were covered predominantly by the former species (Appendix Figure 23).

Five (26 percent) of the sagebrush-grassland ponds had heavy shoreline stands of common cattail *(Typha latifolia)*, a species not found at grassland ponds. The quantity of emergents seemed to vary directly with the amount of cattle use of ponds and the extent of floodplain adjoining pond basins.

In both types, the dominant submergent species was American milfoil, followed by filamentous green algae and western waterweed. In addition, pondweed *(Potamogeton richardsonii)* was relatively prominent in ponds in the sagebrush-grassland type. On a quantitative scale ranging from 0 to 4, the submergent values for grassland reservoirs varied from 1 to 4 with a mean of 3.4. Reservoirs of the other type had values ranging from 0 to 4 and a mean of 2.5. The lower mean value in sagebrush-grassland may be the result of the intolerance of submergents to higher levels of water turbidity. In both types, quantities of submergents were predominantly 3 and 4 for turbidity readings up to about 100 ppm, and 1 and 0 for higher turbidity readings.

Infrared photographs were useful for indicating the presence of submergents and for distinguishing lowland from upland vegetation. However, they could not be used to identify individual species of plants.

Livestock Grazing

Ownership of the grassland unit was 47.8 percent private and 52.2 percent public; the corresponding statistics for the other unit were

32.8 and 67.2 percent. Each unit was open to grazing except for 160 and 640 acres in grassland and sagebrush-grassland, respectively. Continuous grazing was permitted during the period April 10 to November 30 in the grassland unit, and April 1 to December 15 in the other unit. However, cattle generally were not turned into the pastures until late April when the vegetation became suitable for grazing.

The trampling of shoreline vegetation was an effect of grazing potentially influencing water-bird ecology (Figure 12). The least trampling occurred at natural potholes (Table 4), a tendency reflecting their presence only during a time of greater water abundance, coupled with a decreased demand for livestock drinking water due to more succulent vegetation and lower air temperatures. Dugouts received the most trampling for the small number of observations made in this study. In a study by Gjersing (1971), trampling reduced shoreline vegetation to a height of 3 inches or less within a period of 2 weeks, and recovery of the vegetation required about a year without grazing. On this basis, one would not expect a year-to-year change in the trampling index of the present study under the conditions of continuous grazing. Data on cattle numbers were inadequate to show any clear relationship between the intensity of trampling and the amount of shoreline available per cow, but an inverse relationship is presumed.

When water levels were low in late summer, cattle were able to enter the enclosure at three of the fenced ponds by going around the end

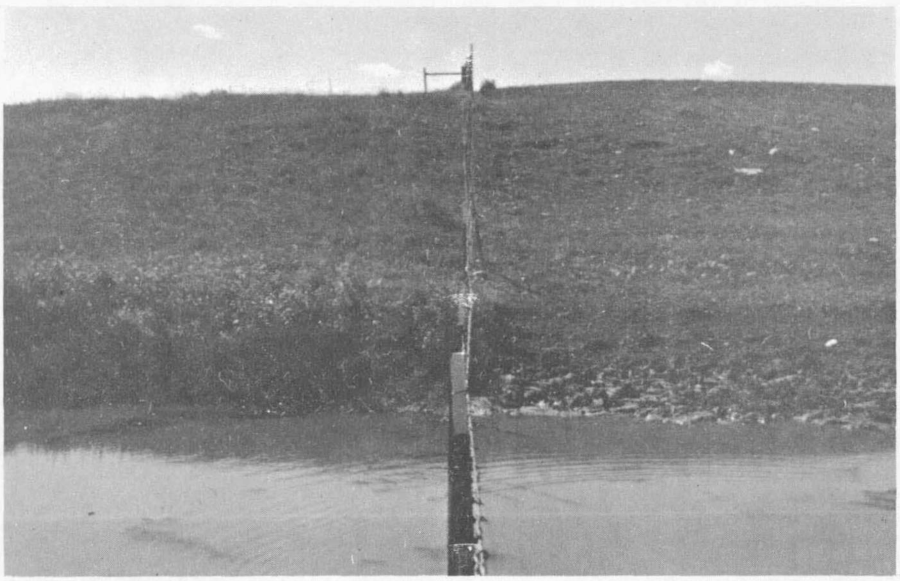

Figure 12. Fenced retention reservoir S3 in the sagebrush-grassland type; trampled shoreline on the right and typical shoreline cover on the left.

TABLE 4. SHORELINE TRAMPLING INDEX COMPARED WITH CATTLE USE OF PONDS, 1971 AND 1972.

Vegetational and pond types	1971						1972					
	Trampling index[1]			No. of cattle observed per pond visit			Trampling index			No. of cattle observed per pond visit		
	n[2]	R[3]	$\overline{X}$[4]	n	R	$\overline{X}$	n	R	$\overline{X}$	n	R	$\overline{X}$
Grassland												
Natural pothole	--	--	--	--	--	--	13	0-2	1.1	25	0-34	6.8
Dugout	1	--	3.0	--	--	--	3	3-4	3.3	5	0-9	1.8
Retention reservoir	12	0-4	2.5	--	--	--	17	0-4	2.5	58	0-175	20.6
Sagebrush-grassland												
Retention reservoir	16	0-4	2.4	142	0-102	6.5	19	0-4	0.9	104	0-75	4.1

1 The trampling index ranges from 0 for no trampling to 4 for very heavy trampling.
2 Sample size.
3 Range.
4 Mean.

of the fence which earlier in the season projected into the water. Cattle also entered via breaks in the fence. The number of cattle involved in these instances ranged from 3 to 34. Consequently trampling occurred on both sides of the fence at these ponds.

The other fenced pond was situated in sagebrush-grassland and had been fenced in 1966. Six years without grazing apparently made no difference in the height of upland herbaceous cover in plots within the fence. It ranged from 1 to 13 inches tall and averaged 6.0 inches, compared with a range of 1 to 14 and an average of 5.9 outside the fence. A single shrub 10 inches tall was encountered along the transect inside, while shrub height outside ranged from 3 to 13 inches with an average of 7.5 for a sample of six.

According to Stoddart and Smith (1955), Daubenmire (1959b), and Odum (1971), grazing tends to change floristic composition from many to fewer species, with the remaining species often increasing in number and size due to decreased competition. These effects were indicated at the fenced pond, where 42 plant taxa were identified along the transect within the fence, while only 30 were identified outside (Appendix Table 14). Canopy coverages of most of the dominant species were greater outside the fence. A change in floristic composition was not apparent from the number of taxa per plot, which ranged from 1 to 11 inside the fence and 2 to 11 outside. The averages per plot were 5.3 and 5.6 for the inside and outside, respectively; they were not statistically different at the 95-percent confidence level.

Studies of Birds Other Than Waterfowl

Bird species observed on or near the study units numbered 113, of which 11 (9.7 percent) were year-round residents, 16 (14.2 percent) were migrants outside their normal breeding ranges, and 86 (76.1 percent) were migrants within their breeding ranges (Appendix Table 15). Species recorded on or near the ponds numbered 93, eighty-two percent of the total.

The indications of abundance show that most species were more numerous in the grassland type. The abundance statistics may be somewhat biased, since, in traveling to the sagebrush-grassland type, the grassland type was crossed, providing additional opportunities for observation in that type. Nevertheless, on the basis of roadside counts of small birds, production figures of grebes and American coots *(Fulica americana)*, and nest records, it was concluded that the relative abundance statistics corresponded to existing numbers.

The profusion of small upland birds in grassland and their relative lack in the other vegetational type were obvious while traveling the roads in each type. In August 1972, a count of small upland species, mainly horned lark *(Eremophila alpestris)*, western meadowlark *(Sturnella neglecta)*, and chestnut-collared longspur *(Calcarius ornatus)*, was made along 4 miles of improved dirt road in each vegetational type under similar weather conditions. The counts were 59 birds per mile in grassland, but only four per mile in the other type.

The production of grebes and American coots followed a similar pattern (Table 5). The total production per water-surface acre for the three grebe species was twice as great in the grassland unit. Grebe production per acre on the two grassland fenced ponds was equal to that of unfenced ponds in the grassland unit, but there was no production on sagebrush-grassland fenced ponds. Coot production was likewise greater on grassland ponds, and the production on unfenced ponds in each unit was greater than on the corresponding fenced ponds. No young of grebes or coots were seen on natural potholes. There was no apparent reason for the decrease in grebe and coot production from 1970 to 1972. The decrease did not seem to follow yearly water-level changes.

Bird nests found in grassland numbered 35, while only 10 were found in sagebrush-grassland (Appendix Table 16). Nest success when determined by Kalmbach's (1939) method was similar to that in his report, even with small sample sizes (Table 6).

Waterfowl Studies

Nineteen species of waterfowl were observed in the study. The young of 12 of them were seen on study ponds. An additional species, cinnamon teal *(Anas cyanoptera)*, was also considered a summer resident on the study units, but no young were identified. The remaining six

TABLE 5. GREBE AND AMERICAN COOT PRODUCTION IN EACH VEGETATION TYPE, 1970-1972.

Species and vegetational type	1970		1971		1972		3-yr avg	
	No. young	No. young per acre of water surface	No. young	No. young per acre of water surface	No. young	No. young per acre of water surface	No. young	No. young per acre of water surface
Horned Grebe								
G[1] unit	0	0	0	0	4	0.09	1.3	0.03
S[2] unit	0	0	0	0	0	0	0	0
G fenced ponds	0	0	0	0	2	0.08	0.7	0.03
S fenced ponds	0	0	0	0	0	0	0	0
Eared Grebe								
G unit	1	0.02	3	0.07	0	0	1.3	0.03
S unit	7	0.14	3	0.06	16	0.32	8.7	0.17
G fenced ponds	7	0.30	9	0.38	0	0	5.3	0.23
S fenced ponds	0	0	0	0	0	0	0	0
Pied-Billed Grebe								
G unit	32	0.74	24	0.56	4	0.09	20.0	0.46
S unit	6	0.12	3	0.06	3	0.06	4.0	0.08
G fenced ponds	7	0.30	11	0.47	0	0	6.0	0.26
S fenced ponds	0	0	0	0	0	0	0	0
American Coot								
G unit	174	4.00	81	1.86	12	0.28	89.0	2.05
S unit	53	1.06	0	0	0	0	17.7	0.35
G fenced ponds	46	1.94	38	1.60	0	0	28.0	1.18
S fenced ponds	1	0.07	0	0	0	0	0.3	0.02

1 Grassland.

2 Sagebrush-grassland.

Table 6. THE SUCCESS OF FOUR TYPES OF BIRD NESTS.

Nest type	Nest success		
	Grassland	Sagebrush-grassland	Study by Kalmbach (1939)
Upland ground nests	50% (6)[1]	20% (1)	43%
Above-ground nests	67% (2)	100% (1)	52%
Waterfowl nests [2]	62% (13)	100% (4)	60%
Hole nests	100% (1)	--	73%

[1]Sample size.
[2]Including American coot and horned grebe *(Podiceps auritus)* nests.

species were recorded only during migration. Several waterfowl anomalies were also observed: a partially albino male gadwall *(A. strepera)*, a mallard-pintail hybrid, and a blue-winged teal-shoveler *(Spatula clypeata)* hybrid. Both hybrids were mentioned by Cockrum (1952) in his list of hybrid birds, and Kortright (1953) indicated that hybridism is rather common among wild waterfowl.

Waterfowl Breeding Populations

Canada geese, mallards, and pintails were found using the ice-free portions of study ponds when spring field work was begun (Appendix Table 15). Close subsequent arrivals included green-winged teal *(Anas carolinensis)*, redheads, American widgeon, shovelers, lesser scaup, and gadwalls. Blue-winged teal, canvasbacks, and ruddy ducks were the latest arrivals of waterfowl species breeding on the study units. This arrival sequence was similar to that reported by Ellig (1955) for Greenfields Lake in western Montana, by Sowls (1955) and Hochbaum (1959) for the Delta Marsh in south-central Manitoba, and by Keith (1961) for southeastern Alberta.

The 12 species listed above were represented in the sagebrush-grassland unit, and all except the canvasback were observed as breeding birds in the other unit. Totals for individual species and ponds appeared to be more stable in the sagebrush-grassland unit from 1971 to 1972 (Appendix Table 17). Based on averages for the 2 years, Canada geese and undetermined ducks together composed 3.5 and 4.8 percent of the breeding population in the grassland and sagebrush-grassland units, respectively (Table 7). Excluding these birds, the composition of the remaining ducks was 95.6 and 87.2 percent surface feeders, and 4.4 and 12.8 percent diving species in the two units. These data parallel those at Greenfields Lake, Montana, for eight species of surface-feeding ducks and four of divers in grassland and greasewood *(Sarcobatus vermiculatus)*-grassland, respectively (Ellig 1955).

Mallards, pintails, American widgeon, and blue-winged teal each contributed more than 10 percent of the breeding population in the grassland unit; together they comprised 74.9 percent of the population. Pintails, the largest contributor, made up a third of the breeding

TABLE 7. PERCENT COMPOSITION OF THE WATERFOWL BREEDING POPULATION AND BROOD PRODUCTION IN EACH STUDY UNIT.

Species	Breeding population		Brood production	
	G[1,3]	S[2,3]	G[3]	S[4]
Mallard	14.7	17.9	10.2	9.0
Pintail	32.6	8.3	18.1	2.6
Gadwall	6.6	7.7	6.0	9.8
American Widgeon	14.2	32.9	21.1	42.1
Shoveler	7.9	3.2	8.4	1.1
Blue-Winged Teal	13.4	8.9	21.7	15.4
Green-Winged Teal	2.8	4.2	0	0.4
Lesser Scaup	3.1	7.9	1.2	7.1
Redhead	0.9	0.6	0	0
Canvasback	0	3.2	0	1.5
Ruddy Duck	0.3	0.3	0	0
Canada Goose	3.4	3.5	6.0	1.9
Undetermined Duck	0.1	1.3	7.2	9.0
Total	100.0	99.9	99.9	99.9

[1]Grassland unit.
[2]Sagebrush-grassland unit.
[3]Averages of 1971 and 1972 data.
[4]Averages of 1970 to 1972 data.

waterfowl. Only two species, mallards and American widgeon, composed more than 10 percent of the population each in the sagebrush-grassland unit, and their total was 50.8 percent. Widgeon were numerically dominant in this unit, forming a third of the population.

The grassland unit had more than twice as many waterfowl pairs per square mile as the other unit (Figure 13). This population included pairs using natural potholes, a type of pond in grassland which held water only temporarily early in the breeding season. However, considering only retention reservoirs, the most permanent pond type, grassland still had half again as many pairs per square mile as sagebrush-grassland.

In addition to using natural potholes and retention reservoirs, breeding pairs used the three dugouts, and a few mallard and widgeon pairs were observed incidentally on the creek in the sagebrush-grassland unit. In the grassland unit, waterfowl used retention reservoirs more than twice as much as either natural potholes or dugouts with respect to pairs per water-surface acre (Table 8). Retention reservoirs and natural potholes in the grassland unit were used most heavily by pintails; dugouts were used mostly by blue-winged teal. Retention reservoirs in the other unit had the greatest use by widgeon. Natural potholes were not used by diving ducks, and the only divers using a dugout were a pair of redheads. Surface-feeding ducks used mostly the shallower portions of ponds, while the diving ducks generally favored the deeper parts. The occurrence of a greater population of divers in the