CHARACTERISTICS OF SMALL IMPOUNDMENTS IN WESTERN OKLAHOMA, THEIR VALUE AS WATERFOWL HABITAT AND POTENTIAL FOR MANAGEMENT

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CHAPTER I

INTRODUCTION

The continental waterfowl population declined during the late 1940's, apparently in response to an extensive drought (Cottom 1949). Agriculturalists who suffered economically during that period intensified their efforts to drain more wetlands and put them into production. The immediate effects of drought and drainage on the breeding waterfowl population were obvious, but quantitative data were not available from which long term consequences could be predicted (Collis 1951).

Researchers and managers realized that knowledge of waterfowl species and their habitat was lacking and that research had to be intensified so that responses of bird populations to changing habitat conditions could be thoroughly evaluated. Shaw and Fredine (1956) classified and measured the wetlands of the United States to identify key areas. During the same period other studies were initiated that delved into the many aspects of waterfowl life histories, and particular emphasis centered on breeding activities and associated habitat requirements.

A great deal of information has been compiled since those early efforts, and many new wetlands have been created through various government programs. Between the early 1950's and 1970 (OWRB 1970) 76728 ha of water had been impounded in Oklahoma in farm ponds and flood control reservoirs less than 10 acres in size. Approximately

5263 ha of small impoundments lie in the three counties (Custer, Dewey and Roger Mills) that surround the study area (OWRB 1970). These small ponds are generally considered valuable winter habitat for ducks (Buller 1964), however, little research has been conducted to understand the ecology of these ponds or their potential value as waterfowl habitat.

In addition to being used in winter by waterfowl, small ponds in Oklahoma are reported to support some nesting by species of dabbling ducks. Sutton (1967) reported that species occasionally nesting are mallard (Anas platyrhynchos), blue-winged teal (A. discors), pintail (A. acuta), shoveler (Spatula clypeata) and cinnamon teal (A. cyanoptera). Most of these reports are from western and northwestern areas in the state. George Wint (personal communication, ODWC), reports that during one season in the mid-1950's blue-winged teal nested extensively on the Concho Indian School lands in central Oklahoma. He indicated that during that period, grazing of the area was moderate and shoreline vegetation provided "good" habitat for nesting around stock ponds.

Anderson and Glover (1967), Drewien and Springer (1969), Mayhew (1955), Smith (1970), and Yeager and Swope (1956), in general, concluded that waterfowl will occupy suitable nest habitat where they find it. Drewien and Springer (1969) further suggested that breeding populations of waterfowl might be short-stopped at more southern areas in the spring if attractive habitat for breeding is made available.

W. H. Kiel (personal communication) reported that in wet years, numerous pairs of blue-winged teal nest successfully on the King Ranch in southern Texas. I have observed similar nesting in Ellis, Dewey, Blaine, Kingfisher and Garfield counties of western and central

Oklahoma, during the summers of 1973 and 1974, years of especially high rainfall. Considering the number of farm ponds and flood control lakes that exist in western Oklahoma, it appears that the frequency of waterfowl nesting should be much greater. Identifying factors that limit the use of these lakes by both wintering and breeding ducks should facilitate management of existing and future wetlands of Oklahoma so that they may benefit waterfowl during all seasons.

The objectives of this study were:

1. To develop a classification system, based on water characteristics and on plant and animal populations, for small impoundments in an area of Oklahoma where intensive pond construction had been implemented for flood control and water, soil and wildlife conservation.

2. To determine the extent of use of study impoundments by wintering and/or nesting waterfowl.

3. To identify some characteristics of each pond that influence its use or lack of use by waterfowl.

Study Area

Location and General Description

The study area is located in west-central Oklahoma in portions of Custer, Dewey and Roger Mills Counties (Figure 1). The area is bounded by the South Canadian River on the north, U. S. Highway 183 on the east, State Highway 33 on the south, and U. S. Highway 283 on the west.

By 1970, approximately 5263 ha of small impoundments had been constructed, primarily by the Soil Conservation Service (SCS), in the three counties surrounding the study area (OWRB 1970). Three hundred and fifty-three of these small impoundments occur within the study area.

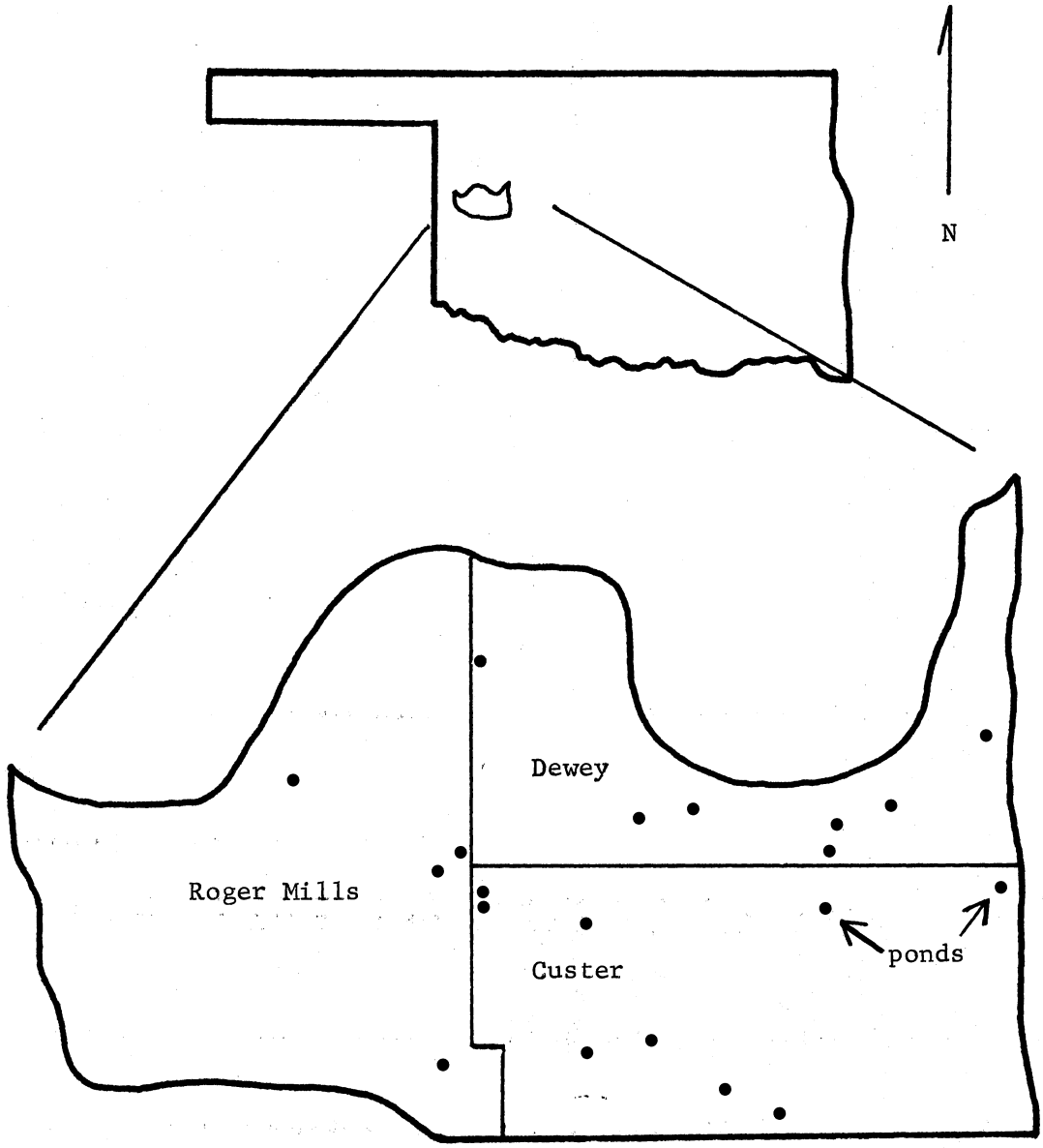

Figure 1. The Study Area, Custer, Dewey and Roger Mills Counties, Oklahoma

Although these lakes were built primarily for flood control and provision of stock and irrigation water, they incidentally created valuable wetlands that are presently used by wintering waterfowl (Due 1970-1974).

These man-made wetlands of the study area and surrounding counties generally fit Shaw and Fredine's (1956) inland deep fresh marsh (Type 4) or inland open fresh marsh (Type 5) classifications. Preliminary observations indicated that the impoundments within the study area differ greatly in the characteristics of their plant communities, invertebrate populations, water clarity, size and depth, and use by waterfowl. Therefore, the classifications designed by Shaw and Fredine (1956) are too general for describing farm pond type wetlands for research and management purposes.

Stewart and Kantrud (1971) and Cowardin and Johnson (1973), also, found Shaw and Fredine's (1956) classifications too general for their work in North Dakota and Minnesota, respectively. Those authors developed more specific methods for classifying natural wetlands associated with basins, lakes and rivers in their regions. Since their classifications apply specifically to natural wetlands, their systems, also, do not seem applicable to farm pond type wetlands.

Topography, Soils and Climate

The study area lies in a zone that was classified as Rolling Red Plains by Gray and Galloway (1959). They described the area as rolling with narrow stream bottoms and as having many steep, broken areas with narrow ridgetops.

Soils are of the Woodward-Carey-Quinlan Association (Gray and Galloway 1959), thin to moderately deep and of red, limy sandstone

origins. They are generally underlain by red clay beds, soft red sandstone or shales. Erosion is a serious problem in these soils.

Average monthly temperatures from 1961 through 1970 were 14.4° C (59.7 F), and average annual precipitation was 62.0 cm (24.4 in) during the same period (U. S. Department of Commerce 1961-1971). These measurements were made at Hammon, Oklahoma, on the southwest edge of the study area. The months of highest rainfall are usually May, June, September and October. The growing season varies from 190 to 225 days (Gray and Galloway 1959).

General Description of Vegetation and Land Use

Duck and Fletcher (1943) and Gray and Galloway (1959) classified the plant community of the Red Plains as a mixed grass prairie. Gray and Galloway (1959: 42) stated, "The kinds and growth habits of native grasses reflect low moisture at certain times in the year. Gramas and buffalo grass are dominant on clayey soils, gramas and tall grasses on the sandy soils." Harlan (unknown date: 101) described this mixed prairie as:

> a mixture of eastern prairie elements such as little bluestem, big bluestem, switch grass and Indiangrass together with steppe grass elements such as blue grama, and dropseed, buffalo grass, western wheatgrass and side-oats grama.

Small grain and cattle farming are the main enterprises in this area (Gray and Galloway 1959). A few dairy cattle are raised but most cattle are beef breeds. The major crops are wheat and grain sorghum; cotton is also grown. Cotton is the main irrigated crop. Some alfalfa is grown as winter feed for cattle. Gray and Galloway (1959) indicated that the majority of crops are grown on the Woodward and Carey soils; pastures are usually found on Quinlan soils.

CHAPTER II

MATERIALS AND METHODS

The 352 impoundments on the study area were numbered on Agricultural Stabilization and Conservation Service aerial photographs (scale 1:63.360), and a sample of 20 (Appendix A) was selected using a table of random numbers (Snedecor and Cochran 1971). From June 1973 to January 1974, aquatic and terrestrial plant communities, aquatic invertebrate populations, water depths, acreages, circumferences, and clarity were measured at each sample impoundment.

Measurement of Aquatic Plant Communities

Aquatic plant sampling techniques described by Allen (1956), Belonger (1969), Dix (1957), Jessen and Lound (1962), Modlin (1970), Sincock and Powell (1957), and Swindale and Curtis (1957) were reviewed, but the techniques used by Dix (1957) and Jessen and Lound (1962) applied more to the needs of this study and were adopted after being modified. The techniques of Jessen and Lound (1962) were developed for detailed sampling of large lakes. They followed transects to mark sampling sites with buoys, and returned to collect four vegetation samples with garden rakes at each site. Their method of marking plot locations was too time consuming for use on numerous small lakes, consequently I took one vegetation sample with a rake at approximately 15 m intervals while traveling each transect only once. Dix's (1957)

point-centered quarter method was designed for sampling terrestrial vegetation, but I was able to use his formulas for data analyses to calculate species density, percent relative abundance of each species and basal area of the total aquatic plant community.

The aquatic plant community was sampled along a series of parallel line transects that bisected the axis of the impoundment drainage at a perpendicular angle. The first transect bisected the impountment 12 paces from the shoreline of the dam, and successive transects were spaced 24 paces apart. Preliminary testing of the technique showed that as pond size increased, the distance between the transects could be doubled without affecting the final results of the data. Transects were spaced 48 and 96 paces apart for ponds larger than 2 ha and 4 ha, respectively. The length of each transect was dependent on the width of the pond at the location of the transect. Transects were established by pacing the distance between transects along one side of the pond and sighting along the duplicate azimuth of the first transect with a compass, to locate the other end of each transect on the opposite shore. Both ends of each transect were marked with surveyor's flags.

A canoe was used to traverse each transect and the plant community was sampled at approximately 5 m intervals. The first and last samples were taken approximately 45 cm from shore. Samples were collected by tossing with tines pointing downward a standard 35.6 cm wide, 14 tine garden rake with a 1.6 m handle and a 2.1 m nylon rope attached to the handle. Each rake sample was examined to identify the plant species collected, and each species present was assigned a density rating of from 1 to 4. A species that occurred in all tines of the rake was

assigned a density rating of 4. A species that occurred in 75, 50 or 25 percent or less of the rake tines was given a rating of 3, 2 or 1, respectively. Correll and Correll (1972) and Hotchkiss (1967, 1970) were the major references used for classifying aquatic plants.

Four of the smaller ponds were extremely turbid and obviously devoid of an aquatic plant community. In these ponds, six random casts were made with the rake from their shorelines to substantiate the apparent absence of vegetation in these ponds. No further sampling was conducted at these ponds.

The average density rating for a species was calculated by adding its individual density ratings and dividing that total by only the number of rake samples in which the species occurred in a particular pond. The average density rating for all rake samples was determined by dividing the total individual density rating for each species by the total number of all rake samples taken. The first parameter is an indicator of the density of a particular species in only that area of the pond in which it grows, and a comparison of the two parameters reflect the distribution or frequency of occurrence of species in the entire pond. The more similar the two values are, the more evenly distributed throughout the pond is the species.

Relative abundance of a species was calculated by dividing the number of rake samples in which that species occurred by the total number of occurrences for all species (Dix 1957). The percent relative abundance for all species in the community would then total 100 percent.

Basal area (Weaver and Clements 1938) was calculated by a method similar to that method of Dix (1957) which reveals the percentage of pond area in which vegetation is growing. This value is calculated by

dividing the number of rake samples in which vegetation was encountered by the total number of rake samples taken from a pond.

A total plant index was calculated for each pond as a gross but relative measure of the total food value to waterfowl of a pond's plant community. The plant index used in this study is similar to that described by Nesbitt (1974), but his formula was modified to use the data collected in this study. The magnitude of the index is dependent on the food value of each species to ducks, relative abundance, basal area of pond, and pond size. It is an index which reflects only food value and not cover value. The food value of each species was based on food habits studies of Anderson (1959), Bellrose and Anderson (1943), Martin and Uhler (1939), and the food value rankings of Nesbitt (1974). Food value was generally based on reported occurrences of certain food items observed in samples of foods consumed by various waterfowl species, and these type data usually reflect both availability of foods in areas where sampled waterfowl have fed and the nature of the feeding behavior of these waterfowl. Each species was assigned a rating of from 1 to 4 (poor=1, fair=2, good=3, excellent=4). Species that had no food value, such as Populus sp. and Salix sp., were rated at least a 1, because they do harbor invertebrates that occasionally are food for waterfowl. The following formulas were used to calculate an index for each species that occurred in rake samples from each pond.

$$\text{SI (submergent species)} = FV \times RA \times BA \times A$$

$$\text{SI (emergent species)} = \frac{FV \times RA \times BA}{A}$$

$$\text{Total Plant Index for Each Pond} = \Sigma SI$$

SI = Species Index

FV = Food Value Rating

RA = Percent Relative Abundance

BA = Basal Area

A = Pond Size (for emergents, if pond size is less than 1.0 acre or hectare, enter A as 1.0)

Bellrose and Anderson (1943) considered the more productive emergent species such as Scirpus sp. to be undesirable competitors of submergents, because dense communities of taller emergents often shade out other aquatic species, and even the food producing emergents produce less food per unit area than most submergents. Thus pond area was entered as a divisor in the index formula for emergent species. This induced an arbitrary penalizing effect into the formula for emergent species. If this was not done, the normally high density in which homologous communities of tall emergent species often grow, biases upward the total index for the combined plant community of the pond. In addition, the original calculations of this study were made, using acres rather than hectares for A, and for ponds smaller than 1.0 a (0.4 ha) A was entered as 1.0 for emergent species. If A had been entered as a fraction of 1.00 for the divisor, the divisor would have magnified SI rather than suppressed that value for emergent species. If hectares had been used as the unit of measure for pond area A would have been entered as 1.0 for emergents in ponds smaller than 1.0 ha.

Measurement of Terrestrial Plant Community

The terrestrial plant community surrounding each impoundment was measured by the point-centered quarter method (Dix 1957) to determine species composition and percent relative abundance within the community. The degree of grazing of surrounding grasslands was rated using SCS

standards (Ernest Snook, Range Scientist, SCS, personal communication) as poor, fair, good or excellent, and assigned a numerical value of 1, 2, 3 or 4, respectively. An intermediate rating such as low-fair and high-fair were designated values of 1.75 and 2.25, respectively. The numerical value facilitated statistical calculations, and provided a measure of the extent of grazing on pond shorelines. Waterfall (1969), Rechenthin (1954) and Correll and Correll (1972) were the primary references used for identification of terrestrial plants.

Eight reference sites were established around each impoundment at the ectotone between the shoreline or emergent plant communities and terrestrial communities. James McPherson (Botanist, School of Biological Sciences, Oklahoma State University) recommended the use of this technique for sampling terrestrial vegetation. These reference sites were located with a compass at the points where the four cardinal azimuths (0, 90, 180, 270) and their four intermediate azimuths (45, 135, 225, 315) bisected the ecotone.

A point-centered quarter measurement was made at five points located at random distances from each reference site, but less than 15.1 dm, counter clockwise around the pond's margin and then to the right: for example, 3.0 dm counter clockwise and 6.0 dm to the right. The distances measured to each of the five points were selected from a table of random numbers. The same technique was used at each reference site. At the fifth sample point of each reference site a 0.2 m^2 plot was marked on the ground with pins. All vegetation on this plot was clipped at ground level and placed in perforated plastic sacks. The vegetative material was air dried and later weighed to the nearest 0.1 g. The average of the eight samples from each pond was used as

an indicator of the volume of vegetation available as nesting cover.

Measurement of Aquatic Invertebrate Populations

Invertebrate samples were collected with a 12.2 X 12.2 cm Eckman dredge at 46 cm depths from five sites located randomly around the shallow water edge of each pond, as recommended by Margaret Ewing (Zoologist, School of Biological Sciences, OSU). Each sample was drained of excess water, rinsed with 10 percent formalin, placed in a gallon glass jar and stored. The specimens in each sample were identified to family, using the reference by Pennak (1953), counted, and the average number of specimens per dredge sample was calculated for each pond. This provided a relative measure of the invertebrate population of each pond that would permit comparisons among ponds. Density and species composition of invertebrates vary greatly between different water depths (Pennak 1953) and it was not within the scope of this study to measure the entire invertebrate population of each pond.

Measurement of Water Parameters

Depth of light penetration was measured in August, 1973, in each impoundment with a 23.9 cm secchi disc. One measurement was made during mid-day of sunny days from a canoe at a central location in each pond. At the same time that light penetration was measured, one measurement each was made of total alkalinity, hardness, dissolved oxygen, Ph and temperature of water in each pond. Water samples were collected at a depth of approximately 46 cm, and analyses were made using standard Hach Water Sampling Kits (Hach Chemical Co., Ames, Iowa 50010).

The distances from shore where water was 0.9 m deep were determined while sampling the aquatic vegetation and recorded as a contour on maps which had been drawn from aerial photographs and enlarged for each pond. Surface hectares and percent of surface hectares less than 0.9 m deep were measured on the map with a polar planimeter, and the circumference of each pond was measured with a cartometer. These data provided a measure of the percent of pond area available as shallow water feeding areas that might be used by dabbling ducks.

Waterfowl Inventories

Five aerial waterfowl inventories were conducted (21 November 1973, 11 December, 12 February, 18 March, 2 April 1974) to determine total numbers and species of waterfowl feeding and resting on the 20 sample impoundments and to determine the percent of time each impoundment was occupied by waterfowl. Inventories were made during mid-day and the flight route, which was determined on the basis of convenience, was flown in a Cessna 206. Each lake was observed from an altitude of 45 to 60 m to estimate the numbers of each species of waterfowl present.

Data for the five inventories were totaled according to respective impoundments and were recorded either as all species combined or as divers and dabblers. Only these totals were used in the statistical calculations. Totals by species were not used because of the small sample sizes of some species.

The percentage of time that each impoundment was occupied by waterfowl was calculated as the percentage of the five inventory periods that one or more waterfowl were observed on each pond. This calculation is hereafter referred to as percent occupancy.

Incidence of nesting was determined by remaining alert for activity of waterfowl while measuring the other parameters for each pond. In addition, landowners were questioned to determine their knowledge of current or past attempts by waterfowl to nest on study ponds or any other ponds within the study area.

Classification and Analyses of Impoundments

"All animal life ultimately depends on plants for food and shelter." (Jahn and Moyle 1964: 295). This generalization may apply more specifically to the wetland community if the limitations of wet soils and water are combined with marsh plants. The differences in animal and plant species observed in wetlands usually reflect community responses to climate, soils, water depth and quality, and age of the impoundment (Cook 1964, Jahn and Moyle 1964, Meeks 1969, Yocom 1950, Kadlec 1962). Land use, such as crop and livestock production on the watershed, may also affect the characteristics of an aquatic plant community (Bue et al. 1952, Burgess et al. 1965, Dwyer 1970, Glover 1956, Kirsch 1969). Therefore, the plant community of a particular pond may be interpreted as a response to or indicator of the accumulative environmental interactions associated with that pond and, furthermore, as an indicator of the animal populations that may be expected to inhabit the community.

On this premise, the parameters of the aquatic plant community measured at each pond were the basis by which ponds were classified. These data were coded on computer cards and analyzed using a program clustering analysis (McCammon and Wenninger 1970) that grouped ponds according to similarities of their plant communities. Each group was

interpreted as a separate pond class.

Two analyses were tested, one using both measurements of density and percent relative abundance of each species for each pond and the other using only percent relative abundance of each species. Because of the relationship between density and percent relative abundance of each species, the results of both analyses were nearly identical. Therefore, the analysis using only percent relative abundance of each species was used to identify pond classes.

Three major and two minor classes of ponds were identified that differed primarily in the presence and abundance of specific plant species. Analyses of variance (Snedecor and Cochran 1971) were computed to test for differences between classes in the values of all other parameters. Analyses of variance were computed only between the three major classes, because the sample sizes for the two minor classes were only one and two. Correlation coefficients were also calculated to determine relationships between various measurements.

CHAPTER III

RESULTS AND DISCUSSION

Sampling Statistics

Aquatic Plant Communities

Seventeen plant species (Table I) were identified in rake samples collected from the 20 sample impoundments (Appendix A). All species but one, *Juniperus virginiana*, were aquatic or riparian species. *Juniperus* sp. is not normally encountered in aquatic communities; however, the water level of one sample impoundment was high enough to flood several seedlings around its margin, enabling that species to appear in one rake sample. Fifteen species inhabited one impoundment; however, no more than eight species were encountered in any of the remaining impoundments (Table II).

A total of 1574 rake samples were collected; 1162 (74 percent) contained vegetation (Table II). More than one plant species often appeared in each rake sample, and a total of 1657 observations were made of individual species in those samples containing vegetation.

Depending on pond size, 1 to 4 hr. was usually required to sample (including unloading and loading of equipment) the aquatic plant community of each pond.

TABLE I

PLANT SPECIES ENCOUNTERED DURING RAKE SAMPLING IN THE STUDY IMPOUNDMENTS

Specific Name	Common Name	Percent Relative Abundance
Amorpha fruticosa	indigobush	1.03
Cephalanthus occidentalis	common buttonbush	0.06
Ceratophyllum demersum	coontail	0.06
Chara sp.	chara	35.55
Cynodon dactylon	bermuda	0.06
Eleocharis obtusa	blunt spikerush	0.54
Juniperus virginiana	red cedar	0.06
Najas flexilis	naiad	22.81
Polygonum sp.	smartweed	0.48
Populus deltoides	eastern cottonwood	1.87
Potamogeton pectinatus	sago pondweed	10.98
Salix nigra	black willow	6.22
Scirpus acutus	hardstem bulrush	1.03
Scirpus americanus	common threesquare	0.72
Sparganium sp.	burreed	2.17
Tamarix gallica	salt cedar	0.19
Typha angustifolia	narrowleaf cattail	16.17

TABLE II

NUMBER OF SPECIES COLLECTED IN VEGETATION AND INVERTEBRATE SAMPLES AT THE SAMPLE IMPOUNDMENTS, SUMMER, 1973

Impoundment Number	Rake Samples			Dredge Samples		Point-Centered Quartered Samples
	Number of Samples	Number With Vegetation	Number of Species	Number of Invertebrates	Number of Species	Number of Species
1	123	54	5	572	19	21
2	185	128	15	948	14	13
3	143	16	1	188	8	14
4	17	4	1	161	3	10
5	16	0	0	194	9	20
6	205	203	6	323	15	15
7	64	61	8	353	18	10
8	144	133	5	821	15	12
9	6	0	0	2	2	9
11	41	29	6	93	8	14
12	6	0	0	443	5	13
13	60	58	3	346	14	20
14	31	26	4	1338	20	11
15	12	12	3	348	18	16
16	6	0	0	3	3	16
17	145	134	4	561	17	15
18	179	131	8	512	14	11
17	82	81	5	363	9	13
20	103	92	8	341	12	16
21	6	0	0	34	8	16
Totals	1574	1162		7943		

Terrestrial Plant Community

One hundred and sixty point-centered quarter measurements were made of the terrestrial plant communities around each impoundment; therefore, 3200 total observations were made. Fifty-eight species of grasses, forbs and woody and riparian plants were encountered (Table III), and between 9 and 21 terrestrial species appeared in plant samples from each impoundment.

Terrestrial plant sampling required 1.5 to 2.5 hours on each pond, depending on pond size and variety of plant species encountered.

Aquatic Invertebrate Populations

One hundred dredge samples (five from each sample impoundment) were collected. Forty species of aquatic invertebrates were identified in these samples (Table IV), and a total of 7944 individual specimens were counted (Table II). The total number of species observed in samples from each pond varied from 2 to 20, and the total number of individuals varied from 2 to 1338 (Table II).

Sampling of each pond usually required 30 to 45 min., but sampling of those ponds with sparse or no aquatic vegetation was more time consuming. Dredge samples collected in contact with mud bottoms contained silt which had to be washed from the sample. This often required several minutes of flushing water through the dredge to break soil particles down so they would pass through the screen. Approximately 1.0 to 1.5 hours of laboratory time was required to count and classify invertebrate specimens in each dredge sample.

TABLE III

PRAIRIE AND RIPARIAN PLANT SPECIES IN ASSOCIATION WITH SAMPLE IMPOUNDMENTS AND THEIR PERCENT RELATIVE ABUNDANCE

Specific Name	Common Name	Percent Relative Abundance
Ambrosia psilostachya	western ragweed	2.63
Andropogon gerardi	big bluestem	1.22
Andropogon saccharoides	silver bluestem	6.84
Andropogon virginicus	broomsedge	0.63
Antennaria campestris	field pussytoes	0.06
Aristida purpurascens	arrowfeather threeawn	0.03
Artemisia frigida	herbaceous sagebrush	0.06
Aster sp.	aster	0.66
Astragalus mollissimus	woolly loco	0.06
Baptisia minor	blue wildindigo	0.03
Bouteloua curtipendula	sideoats grama	3.41
Bouteloua hirsuta	hairy grama	1.53
Bouteloua gracilis	blue grama	1.41
Bromus sp.	brome	5.38
Buchloe dactyloides	buffalograss	7.22
Carex sp.	sedge	2.47
Cenchrus pauciflorus	sandbur	2.28
Chloris verticillata	windmillgrass	0.06
Cynodon dactylon	bermudagrass	18.47
Digitaria sanguinalis	crabgrass	0.33
Echinochloa crusgalli	barnyardgrass	7.38

TABLE III (Continued)

Specific Name	Common Name	Percent Relative Abundance
Eleocharis obtusa	blunt spikerush	3.44
Elymus canadensis	Canada wildrye	0.38
Eragrostis cilianensis	stinkgrass	0.19
Eragrostis intermedia	plains lovegrass	0.41
Equisetum hyemale	horsetail; scouringrush	0.22
Gutierrezia dracunculoides	annual broomweed	1.03
Halopappus ciliatus	wax goldenweed	0.03
Juncus sp.	rush	0.03
Lactuca scariola	wild lettuce	0.16
Melilotus sp.	sweetclover	0.25
Oxalis sp.	oxalis	0.06
Panicum capillare	common witchgrass	0.81
Panicum virgatum	switchgrass	1.94
Plantago sp.	plantain	0.03
Polygonum sp.	smartweed	0.81
Populus deltoides	eastern cottonwood	0.03
Prunus mexicana	Mexican plum	0.03
Rhus glabra	smooth sumac	0.03
Rudbeckia hirta	blackeyedsusan	1.97
Salix nigra	black willow	0.16
Salsola kali	russianthistle	0.03
Schendonnardus paniculatus	tumblegrass	0.47
Schizachyrim scoparium	little bluestem	10.88

TABLE III (Continued)

Specific Name	Common Name	Percent Relative Abundance
Scirpus acutus	hardstem bulrush	0.03
Scirpus americanus	common threesquare	3.28
Setaria viridis	green bristlegrass	0.44
Sorghastrum nutans	indiangrass	0.41
Sorghum halipense	johnsongrass	0.09
Solanum rostratum	buffalobur	0.13
Sporobolus asper	tall dropseed	7.60
Symphoricarpos orbiculatus	buckbrush	0.06
Tamarix gallica	salt cedar	0.06
Typha angustifolia	narrowleaf cattail	0.19
Verbena rigida	prostrate vervain	0.66
Vernonia baldwini	baldwin ironweed	0.06
Xanthium strumarium	cocklebur	0.41
Yucca glauca	small soapweed	0.03

TABLE IV

RELATIVE ABUNDANCE OF INVERTEBRATES IN
CLASSES A THROUGH E IMPOUNDMENTS

Class Order Family	Total Individuals--Percent of Total Within Class of Impoundment				
	A	B	C	D	E
Insecta					
Coleoptera					
Haliplidae	6-- 0.2	5-- 0.1	2-- 0.2	2-- 0.4	1-- 0.3
Hydrophilidae	3-- 0.1	8-- 0.2	1-- 0.1	2-- 0.4	
Dytiscidae		1-- T			
Cucujidae		1-- T	6-- 0.6		
Diptera					
Stratiomyiidae	2-- 0.1				
Dixidae	2-- 0.1				
Tendipedidae	290--10.8	491--14.2	219--21.3	20-- 4.5	53--15.2
Ceratopogonidae	56-- 2.1	43-- 1.2	11-- 1.1		
Tabanidae	1-- T				1-- 0.3
Tipulidae				1-- 0.2	
Culicidae	2-- 0.1				25-- 7.2
Ephemeroptera					
Ephemeridae	9-- 0.3	32-- 0.9	10-- 1.0	41-- 9.2	7-- 2.0
Baetidae	209-- 7.8	430--12.5	55-- 5.4	66--14.8	5-- 1.4
Hemiptera					
Notonectidae			3-- 0.3		
Corixidae			5-- 0.5		
Reduviidae					1-- 0.3
Mesoveliidae	1-- T				
Homoptera					
Aphididae	1-- T			2-- 0.4	2-- 0.6

TABLE IV (Continued)

Class Order Family	Total Individuals--Percent of Total Within Class of Impoundment				
	A	B	C	D	E
Hymenoptera					
Formicidae		2-- 0.1			
Lepidoptera					
Pyralididae			2-- 0.1		
Odonata					
Libellulidae	51-- 1.9	109-- 3.2	30-- 2.9	23-- 5.2	15-- 4.3
Gomphidae		8-- 0.2		9-- 2.0	
Coenagrionidae	119-- 4.4	203-- 5.9	33-- 3.2	25-- 5.6	9-- 2.6
Trichoptera					
Hydroptilidae		10-- 0.3			
Philopotamidae		2-- 0.1			
Limnephilidae		1-- T			
Psychomyiidae	1-- T			1-- 0.2	
Crustacea					
Amphipoda					
Gammaridae	855--31.8	583--16.9	1-- 0.1	78--17.5	
Cladocera					
Daphniidae	103-- 3.8	338-- 9.8	1-- 0.1	4-- 0.9	83--23.9
Eucopepoda					
Diaptomidae	2-- 0.1	23-- 0.7	61-- 5.9		14-- 4.0
Cecapoda					
Cambarinae	1-- T				
Isopoda					
Asellidae	2-- 0.1			1-- 0.2	
Arachonoidea					
Hydracarina					
Arrenuridae	6-- 0.2	23-- 0.7	3-- 0.3		3-- 0.9

TABLE IV (Continued)

Class Order Family	Total Individuals--Percent of Total Within Class of Impoundment				
	A	B	C	D	E
Gastropoda					
Pulmonata					
Physidae	275--10.2	581--16.8	13-- 1.3	76--17.0	28-- 8.0
Planorbidae	11-- 0.4	59-- 1.7		2-- 0.4	2-- 0.6
Lymnaeidae	2-- 0.1			12-- 2.7	
Pelecypoda					
Eulamellibranchia					
Sphaeriidae	1-- T	1-- T			5-- 1.4
Oligochaeta					
Plesiopora					
Tubificidae	513--19.1	394--11.4	573--55.7	25-- 5.6	91--26.1
Hirudinea					
Rhynchobdellida					
Glossiphoniidae	157-- 5.8	98-- 2.8		42-- 9.4	3-- 0.9
Piscicolidae		5-- 0.1		14-- 3.1	
Total	99.6	99.7	100.0	99.7	100.0
Average Invertebrate Specimens/Dredge	111.9	138.0	30.2	44.6	69.6

Water Analyses

Results of measurements of various water parameters of each impoundment are presented in Table V. Sterling Burks (Limnologist, School of Biological Sciences, Oklahoma State University) assisted with interpretation of these data, and, due to small sample size and the nature of some of these parameters to fluxuate with time of day and season, recommended that only the depth of light penetration would be useful in determining water characteristics of impoundment classes. The other measurements listed in Table V do, however, reflect general water characteristics of impoundments within the study area.

Classifications and Ecological Descriptions of Impoundments

Odum (1963) stated that the species diversity of fresh-water plant communities is relatively low because of their young geological age. Limited species diversification was observed to a degree in this study; only 17 aquatic plant species were found while rake sampling at the 20 study impoundments (Table I). Regardless of the low species diversity, however, variations were observed in species composition, distribution, density and even in the presence of aquatic plant communities.

Relative abundance of each plant species encountered in each sample pond was the base data from which pond classifications were determined. The dominant species (those of highest relative abundance within the samples for each pond) that reflected major differences between the pond classes were *Chara* sp., *Najas flexilus*, *Potamogeton pectinatus*, *Typha angustifolia*, *Scirpus acutus*, *S. Americanus*, and

TABLE V

WATER PARAMETERS MEASURED AT SAMPLE IMPOUNDMENTS 8 OCTOBER THROUGH 18 OCTOBER 1973

Impound-ment Number	Dissolved Oxygen PPM	Hardness Grains per Gal.	Alkalinity Grains per Gal.	Tempera-ture °C	Depth of Light Penetration cm	PH
1	9	15	5	17.0	122.0	8.5
2	8	72	7	15.5	315.0	17.5
3	10	40	6	25.0	20.0	9.0
4	7	5	7	21.0	15.0	8.0
5	8	7	6	15.0	41.0	8.0
6	11	49	7	17.0	152.0	8.0
7	8	64	5	16.0	213.0	8.0
8	13	45	4	16.0	122.0	9.0
9	9	5	5	16.0	3.0	8.0
11	10	34	5	16.0	168.0	7.5
12	8	8	7	21.0	5.0	7.5
13	11	31	5	22.0	112.0	9.0
14	8	104	5	21.0	79.0	8.0
15	5	8	11	18.0	61.0	7.0
16	7	5	4	14.0	5.0	7.0
17	9	36	6	18.0	109.0	8.0
18	8	46	8	13.0	132.0	8.0
19	6	44	6	17.0	107.0	8.0
20	11	74	5	17.0	274.0	8.0
21	7	8	7	20.0	13.0	8.5
Averages	8.7	35	6.1	17.8	103.4	8.0

Sparganium sp. These plants, as well as those appearing less frequently, are all of varying importance to waterfowl as either food, nest cover and/or escape cover (Martin and Uhler 1939, Anderson 1959, Bellrose and Anderson 1943, Chura 1961, Sugden 1969).

Significant differences were, also, observed between pond classes in total area, water depths, turbidity, invertebrate populations and waterfowl use. These characteristics were considered as factors that either influenced the composition or density of the plant community of each pond or were a result of the existing plant community. For example, pond size and depths may influence the number of plant species present and their density within a pond, whereas, invertebrate populations and waterfowl use of a pond may be interpreted as a response to that plant community. Therefore, five groups (Classes A-E) of ponds were identified by characteristics of their aquatic plant communities.

Class A Impoundments

Class A ponds composed 25 percent of the sampled impoundments. In general this class contains large ponds with clear water that support well established, diverse plant communities. Their aquatic plant communities generally contained a greater number of species than those of other classes, and this was the only class of ponds wherein all species were encountered (Table VI). The dominant plant species of Class A ponds were Chara sp., Typha angustifolia, Najas flexilis, Potamogeton pectinatus, Sparganium sp., Scirpus acutus and S. americanus. The plants of unique importance to this class were Chara sp., T. angustifolia, Sparganium sp., S. acutus and S. americanus.

TABLE VI

RELATIVE ABUNDANCE OF PLANTS COMMONLY ENCOUNTERED IN CLASS A IMPOUNDMENTS AND THEIR RATING AS FOOD PRODUCERS FOR WATERFOWL

Species	Food Rating	Percent Relative Abundance for Impoundment Numbers					Average
		2	6	17	18	20	
Najas flexilis	2	7.1	0.4	6.4	12.4	14.1	8.1
Chara sp.	3	18.7	63.5	50.3	38.8	68.1	38.8
Potamogeton pectinatus	4	7.5	10.0	7.5	7.1	0.9	6.6
Typha angustifolia	1	26.2	24.9	35.8	31.2		23.6
Sparganium sp.	3	7.1	0.8		5.3		2.6
Scirpus acutus	4	3.2	0.4			3.4	1.4
Scirpus americanus	4	3.2				3.4	1.3
Polygonum sp.	4					0.9	0.2
Ceratophyllum demersum	4				0.6		0.1
Cephalanthus occidentalis	3	1.6					0.3
Eleocharis obtusa	2	0.4					0.1
Amorpha fruticosa	1	6.0					1.2
Salix nigra	1	10.7			1.2	5.1	3.4
Populus deltoides	1	6.3			3.5		2.0
Tamarix gallica	1	1.2				3.4	0.9
Juniperus virginiana	1	0.4					0.1
Cynodon dactylon	1	0.4					0.8

The average relative abundance for Chara sp. in Class A ponds was 47.9 percent. A high density of this species is expected in large ponds because it has a broad tolerance to water depths (Keith 1961, Nesbitt 1974) as compared to the other species encountered which are more competitive at shallower depths. An average of 68.7 percent of the surface area of Class A ponds was greater than 0.9 m deep (Table VII), consequently, a large portion of their plant communities were characteristically dominated by Chara sp.

The relative abundance of Sparganium sp. was not as great as in Class A ponds, as the other species mentioned above, nor was it observed in all ponds of this class. However, with the exception of one Class D pond, its presence was unique to the ponds of Class A.

The emergent plant zone of Class A ponds was composed of Typha angustifolia or a combination of that species and Scirpus sp. The average relative abundance was 23.6, 1.4 and 1.3 percent for T. angustifolia, S. acutus and S. americanus respectively. These emergents are an important component of the Class A ponds because they could provide nest and brood escape cover and do provide habitat for invertebrates which are important foods for ducklings of age Class I and II (Chura 1961). The two species of Scirpus also produce seeds that are readily consumed by waterfowl (Chura 1961, Bellrose and Anderson 1943, Smith 1971, Stoudt 1971, Sugden 1969, Martin and Uhler 1939).

The plant index, which is a relative measure of the total food value of plants produced in each pond, was significantly higher ($P < 0.01$) for Class A ponds. The average plant index for these ponds was 1,647.5 (Table VII) and varied from 829.0 to 2803.0. The next highest

TABLE VII

VALUES OF VARIOUS PARAMETERS MEASURED
AT CLASS A IMPOUNDMENTS

Impound-ment Number	Area (ha)	Shoreline Length (m)	Shoreline Length (m/ha)	Percent Surface ha < 0.9m Deep	Total Plant Index	Total Plant Index per ha	Percent Basal Area	Depth of Light Penetration (cm)	Average Terrestrial Forage Weight (g per 0.2 m^2 Plot)	Range Condition
2	7.34	3029.6	412.8	25.0	1538.7	209.6	69.2	315.0	64.3	High-Fair
6	3.64	1613.4	443.2	39.4	2096.0	575.8	99.0	152.0	34.3	High-Fair
17	2.18	901.2	413.4	21.7	970.8	445.3	92.4	109.0	40.1	Fair
18	2.77	1248.0	450.5	27.6	829.0	299.3	73.2	132.0	54.6	Good
20	5.27	1313.7	249.3	48.0	2803.0	531.9	89.4	274.0	39.7	Poor
Average	4.24	1626.6	383.6	32.3	1647.5	388.6	84.2	214.4	46.6	High-Fair

average was only 297.3 for Class B ponds. On a per hectare basis, however, the plant index for Class A (388.6 per surface ha) was the second lowest average.

Invertebrate samples averaged 111.9 individuals per dredge sample for Class A ponds, and ranged from 64.6 to 189.6 (Table IV). In Table III percentages less than 0.1 are entered as a trace (T).

Between classes of ponds significant differences also existed in surface hectares ($P < 0.05$) and percent shallow water ($P < 0.01$). Ponds of Class A averaged 4.24 surface hectares, ranging from 2.18 to 7.34 ha (Table VII). The average percentage of the pond less than 0.9 m deep was 32.3 percent, and varied from 21.7 to 48.0 percent.

Significant differences ($P < 0.01$) in depth of light penetration also were observed between pond classes. Light penetration was the deepest in Class A ponds, averaging 214.4 cm and ranging from 132 to 315 cm.

Weights of five forage clippings from each Class A pond averaged 46.6 grams (Table VII) and ranged from 34.3 to 64.3 g.

Class B Impoundments

Class B ponds represented 25 percent of all impoundments sampled. These ponds were generally small, and supported plant communities primarily composed of submergent species.

Species commonly occurring in this class of ponds were *Najas flexilis* and *Chara* sp. (Table VIII). *Najas flexilis* was the dominant species with an average relative abundance of 57.8 percent; average relative abundance for *Chara* sp. was 20.7 percent. Water depths of Class B ponds were predominantly shallow, and although *Chara* sp. was

TABLE VIII

RELATIVE ABUNDANCE OF PLANTS COMMONLY ENCOUNTERED IN CLASS B IMPOUNDMENTS

Species	Percent Relative Abundance for Impoundment Numbers					Average
	1	8	13	14	19	
Najas flexilis	47.5	53.4	92.3	41.2	54.4	57.8
Chara sp.	30.4	24.1	4.6	44.1		20.7
Potamogeton pectinatus		11.1		5.9	26.8	8.8
Salix nigra	17.2	9.6	3.1		10.7	8.1
Scirpus acutus	1.3					
Scirpus americanus		1.4				0.3
Polygonum sp.				8.8		1.8
Eleocharis obtusa	3.6				4.0	1.5
Populus deltoides					4.0	0.8

encountered at depths as shallow as 3.0 dm, this species was apparently not competitive with Najas flexilis at depths less than 0.9 m.

The emergent plant communities of Class B ponds were either non-existent or sparse. Scirpus acutus, S. americanus and Salix nigra were the species encountered.

Plant indexes for this class varied from 91.8 to 726.6 and averaged 297.3 (Table IX). On a per hectare basis, however, their average plant index was 450.5.

Invertebrate samples averaged 138.0 specimens per dredge sample in Class B ponds and ranged from 71.2 to 267.6 individual specimens (Table IV).

Surface area ranged from 0.16 to 1.41 ha and averaged 0.66 ha (Table IX). Only one pond, however, was smaller than 0.4 ha in size. Their surface area less than 0.9 m deep averaged 72.2 percent and varied from 24.6 to 98.5 percent.

Light penetrated to depths of 79 to 122 cm.

Weights of forage samples clipped from around Class B ponds averaged 56.1 g (Table IX) and varied from 27.9 to 92.2 g.

Class C Impoundments

Thirty-five percent of the ponds (numbers 3, 4, 5, 9, 12, 16 and 21) were Class C. These ponds were usually small, shallow, extremely turbid and devoid of vegetation. Only ponds 3 and 4 contained vegetation, and each contained only one plant species (Table X).

They were subject to periodic drying, and during these periods some aquatic plant species occasionally established on the mud flats. Pond Number 4, for example, had dead stalks of one year old Polygonum

TABLE IX

VALUES OF VARIOUS PARAMETERS MEASURED
AT CLASS B IMPOUNDMENTS

Impound-ment Number	Area (ha)	Shoreline Length (m)	Shoreline Length (m/ha)	Percent Surface ha < 0.9m Deep	Total Plant Index	Total Plant Index per ha	Percent Basal Area	Depth of Light Penetration (cm)	Average Terrestrial Forage Weight (g per 0.2 m^2 Plot)	Range Condition
1	0.77	662.2	860.0	24.6	165.7	215.2	43.9	122.0	92.2	High-Fair
8	1.41	462.2	327.8	95.8	726.6	515.3	92.4	122.0	37.9	Fair
13	0.47	583.4	1241.3	98.5	237.0	504.3	96.7	112.0	49.3	Fair
14	0.16	209.2	1307.5	57.7	91.8	573.8	83.9	79.0	41.8	Poor
19	0.48	605.5	1261.5	84.2	275.6	574.2	98.8	107.0	59.3	High-Good
Average	0.66	504.5	764.4	72.2	297.3	450.5	80.0	108.2	56.1	Fair

TABLE X

RELATIVE ABUNDANCE OF PLANTS COMMONLY ENCOUNTERED IN CLASSES C, D AND E IMPOUNDMENTS

	Percent Relative Abundance			
	Class			
	C	D		E
	Impoundment Numbers			
Species	C	7	11	15
Potamogeton pectinatus		29.3	31.1	42.1
Najas flexilis			8.9	21.1
Chara sp.	50.0	38.0	20.0	
Amorpha fruticosa		1.1	2.2	
Salix nigra		5.4	11.1	36.8
Typha angustifolia		14.1	26.7	
Polygonum sp.	50.0			
Sparganium sp.		7.6		
Cephalanthus occidentalis		1.1		
Populus deltoides		3.3		

sp. plants standing in its shallow water. This pond had obviously been dry approximately one year prior to sampling, allowing this species to pioneer and be flooded as the pond refilled. Pond Number 3 supported only a sparse community of Chara sp., and because of extreme water fluctuations and turbidity, no other species were able to survive in this pond. As an indicator of the turbidity of Class C ponds, maximum depth of light penetration was 41 cm and averaged only 15.0 cm (Table XII).

Pond indexes averaged a low of 48.8 per pond and 72.6 per ha (Table XI). These low indexes are to be expected in highly turbid water (McCallum 1964).

Invertebrates averaged 30.2 individuals per sample (Table IV), and averages varied from 0.5 to 88.6 individuals per sample for each pond. This low incidence of invertebrates in Class C ponds demonstrates the importance of relatively stable water levels and plant communities to the existence of high density invertebrate populations (Kadlex 1962, Kruil 1970).

Class C ponds averaged 0.67 surface ha. This figure is misleading, however, because pond Number 3 measured 3.6 ha (Table XI). All other Class C ponds were 0.31 ha or smaller, and averaged 0.19 ha. Eighty-five percent of their total area was 0.9 m or less in depth. Here again, pond Number 3 was a low extreme at 63.5 percent.

Average weights of vegetation clippings were 48.4 g per 0.5 m^2 of ground surface (Table XI).

Class D Impoundments

Class D ponds composed 10 percent of the ponds sampled. This is a

TABLE XI

VALUES OF VARIOUS PARAMETERS MEASURED
AT CLASS C IMPOUNDMENTS

Impound-ment Number	Area (ha)	Shoreline Length (m)	Shoreline Length (m/ha)	Percent Surface ha < 0.9m Deep	Total Plant Index	Total Plant Index per ha	Percent Basal Area	Depth of Light Penetration (cm)	Average Terrestrial Forage Weight (g per 0.2 m^2 Plot)	Range Condition
3	3.60	1856.6	515.7	63.5	298.4	81.8	11.2	20.0	50.7	Low-Fair
4	0.19	222.9	1173.2	69.8	43.2	227.4	23.5	15.0	74.1	Poor
5	0.21	221.3	1053.8	81.4	0.0	0.0	0.0	41.0	41.5	Fair
9	0.15	279.0	1860.0	100.0	0.0	0.0	0.0	3.0	34.5	Low-Fair
12	0.31	340.0	1096.8	89.3	0.0	0.0	0.0	5.0	43.8	Poor
16	0.15	235.4	1569.3	91.9	0.0	0.0	0.0	5.0	60.1	Low-Good
21	0.09	108.2	1202.2	100.0	0.0	0.0	0.0	13.0	34.2	Low-Fair
Average	0.67	466.2	695.8	85.1	48.8	72.6	----	15.0	48.3	High-Poor

TABLE XII

VALUES OF VARIOUS PARAMETERS MEASURED
AT CLASSES D AND E IMPOUNDMENTS

Impound-ment Number	Area (ha)	Shoreline Length (m)	Shoreline Length (m/ha)	Percent Surface ha < 0.9m Deep	Total Plant Index	Total Plant Index per ha	Percent Basal Area	Depth of Light Penetration (cm)	Average Terrestrial Forage Weight (g_2 per 0.2 m^2 Plot)	Range Condition
Class D										
7	0.52	581.4	1118.1	22.2	328.5	631.7	95.3	213.0	58.7	Good
11	0.21	312.4	1487.6	10.7	121.5	578.6	70.7	168.0	13.8	Good
Average	0.36	446.9	1241.4	16.5	225.0	625.0	85.7	190.5	36.3	Good
Class E										
15	0.03	94.8	3160.0	98.2	53.7	1790.0	100.0	61.0	93.1	Low-Fair

distinctive group because it includes ponds that were built in canyons, rather than on open terrain where watersheds slope gently.

Only two ponds were in this class and their sizes were 0.21 and 0.52 ha (Table XII). Because of their small size and the acute slopes of their bottoms, these ponds had a small amount of shallow water in comparison to deep water, resulting in an aquatic plant community unique to ponds of their size.

Potamogeton pectinatus, Chara sp. and Typha angustifolia were the dominant species present. Their average relative abundance was 30.2, 29.0 and 20.4 percent, respectively (Table X). An average of 83.6 percent of the area of Class D ponds were deeper than 0.9 m (Table XII), consequently a relatively high occurrence of Chara sp. was to be expected. Due to shorelines that sloped abruptly, the water edges of these ponds were heavily silted, resulting in a substratum that enables species that sprout from rhizomes to compete well (Ernest Snook, personal communications). This may have influenced the dominance of Potamogeton pectinatus over other submergents in the shallow water zone of these ponds.

Plant indexes averaged 225.0 or 625.0 per ha (Table XII) and invertebrate counts averaged 44.6 specimens per sample (Table IV).

Light penetrated to an average depth of 190.5 cm (Table XII).

Weights of forage clippings averaged only 36.3 g (Table XII), reflecting the sparse nature of the vegetation supported by the steep shorelines.

Class E Impoundments

Only pond Number 15 was classified as a Class E pond. Although

it is difficult to describe this class based on one sample, this pond differed greatly from other ponds.

Pond Number 15 measured 0.03 ha, 98.2 percent of which was less than 0.9 m deep (Table XII). Light penetrated to at least 61 cm; measurement at greater depths was impossible, however, because rank vegetation prevented the secchi disc from sinking any deeper.

Potamogeton pectinatus, Najas flexilis and Salix nigra were the only species in the plant community (Table X). This pond was heavily silted in, which may explain the high (42.1) percent relative abundance for Potamogeton pectinatus.

The plant index for this pond was 53.7 or 1790.0 per hectare (Table XII). This index per hectare was higher than for any other classes.

The average number of invertebrates counted per sample was 69.6 individuals (Table IV), and the average forage clipping weight was 93.1 g (Table XII).

Summary of Differences Between Pond Classes

The parameters characteristic of the five pond classes are fairly specific for each class, however, some overlap exists between classes. This could be expected in a population having normal distribution (Snedecor and Cochran 1971).

The two major distinguishing features of each class are their sizes and their unique plant communities. In the case of Class D ponds, their site will identify them. A general description of the characteristics that would be useful to an observer for classifying ponds and for grossly evaluating plant indexes and invertebrate

populations is presented in Table XIII.

Classes A, B and C ponds are of major importance, because they comprised 85 percent of all ponds sampled. A few generalizations are sufficient for their identification. Class A ponds are larger than 2.0 ha, they usually support an extensive emergent plant community and a submergent plant community that is always dominated by Chara sp. Class B ponds are larger than 0.4 ha, generally contain only a sparse community of emergent plants and support submergent communities dominated by Najas flexilis and Chara sp. Class C ponds are usually smaller than 0.4 hectares, are highly turbid, support almost no aquatic vegetation and may be described as "mud holes".

Class D ponds may be classified on the basis of having been constructed in canyon sites, resulting in abrupt shorelines and pond bottoms having 45 degree or greater slopes. Class E ponds are difficult to describe on the basis of one sample; however, the one pond was extremely small and shallow and it supported an aquatic plant community, in contrast to Class C ponds which are generally devoid of vegetation.

Relationships Between Plant and Invertebrate Populations and Other Parameters

Shaw and Fredine (1956) described the plant communities usually associated with natural wetlands of the United States. Their data indicate that certain relationships exist between the geographical location, wetland size, water depths, stability or permanence of water and the characteristic plant community of a particular type of wetland. Jahn and Moyle (1964) also discussed many of these factors in relation to aquatic plant succession.

TABLE XIII

GENERAL DESCRIPTION OF PLANT COMMUNITIES, MAXIMUM OR MINIMUM IMPOUNDMENT SIZE, PLANT INDEX AND NUMBER OF INVERTEBRATES THAT CHARACTERIZE CLASSES A THROUGH E IMPOUNDMENTS

Class	Plant Community	Hectares	Total Plant Index	Average Invertebrates Per Five Dredge Samples
A	Extensive emergent community dominated by Typha angustifolia and Scirpus sp.; submergents dominated by Chara sp.	> 2.02 ha	> 800 Average 1,648	> 60 Average 112
B	Submergent community dominated by Najas flexilis and Chara sp.; emergent species absent or sparse.	Usually > 0.40 ha	< 800 Average 297	> 70 Average 138
C	Water highly turbid and shallow; aquatic plants absent or sparse in both density and diversity.	< 0.40 ha	< 300 Average 49	< 50 Average 30
D	Aquatic plant community similar to Class A but pond is constructed in canyon; shoreline and pond bottom slope abruptly.	< 0.81 ha	< 300 Average 225	< 70 Average 45
E	Aquatic plant community similar to Class B.	< 0.20 ha	< 100 Average 54	< 70

Cook (1964), Kadlec (1962), and Meeks (1969) studied successional responses of aquatic plants to fluctuations of water level and reported that such fluctuations generally resulted in improved fertility of wetland soils. As waters receded, soils dried and aerobic nitrification and reduction of soluble iron resulted in greater availability of the nutrients previously trapped in the wetland soils. Plant growth benefited from the increased fertility. The number of plants per unit area increased because emergent species often require an exposed seed bed for germination.

Johnsgard (1956) and Yocom (1950) concluded that although water fluctuations were beneficial to winter habitat they were detrimental to nesting habitat because they destroyed species that provide preferred cover for nesting.

Livestock may also modify aquatic plant communities. Keith (1961) reported that cattle readily consumed Typha sp. and, particularly, Scirpus sp. on his study area in Alberta. Bue et al. (1952), Burgess et al. (1965), Dwyer (1970), Glover (1956), Kirsch (1969) and Lokemoen (1973) reported that heavy grazing by cattle destroyed shoreline vegetation either by excessive removal of vegetation or trampling.

Influence of Land Uses on Emergent Species

This study indicates that the extent of grazing pressures on lands bordering the impoundments, in conjunction with sizes of ponds, did affect the frequency of occurrence or the species composition of the aquatic plant communities associated with the ponds.

No significant differences in range conditions of watersheds were measured between classes (Tables VII, IX, XI, XII), and the average

rating (based on relative abundance of species encountered - see Table III) was a Low-Fair (Ernest Snook, personal communication). On a scale of 1.0 to 4.0, with 2.0 representing Fair range conditions, the average numerical rating was 1.84 ($\pm$0.25, $P < 0.05$). This was interpreted to mean that cattle stocking rates were similar for all watersheds, and all watersheds were generally heavily grazed.

Cattle did seem to influence the composition of the aquatic plant communities, but their effect appeared to be dependent on pond size rather than on their stocking rates in the watersheds. Length of shoreline of each pond (Tables VII, IX, XI, XII) increased as pond size increased ($r=+0.959$, $P < 0.01$), and significant differences ($P < 0.05$) in shoreline lengths were measured between pond classes. Shoreline lengths of Class A, B and C ponds averaged 1626.6, 504.5 and 466.2 m, respectively (Tables VII, IX, XI). The stocking rate for cattle, according to range conditions, appeared similar in all watersheds. Consequently, it appeared that cattle had a greater impact on the smaller impoundments with less shoreline.

Reference has already been made to the fact that cattle readily graze *Typha* sp. and *Scirpus* sp., and based on the shoreline lengths, grazing pressure would be three times greater on Class B ponds than on Class A ponds. This difference in grazing intensity is, apparently, the reason that the larger emergent species are generally absent from the plant communities of Class B ponds (Table VIII). In addition, significant correlations ($P < 0.01$) existed between length of shorelines and the percent relative abundance of *Typha angustifolia* ($r=+0.670$) and *Scirpus* sp. ($r=+0.687$.

If the abnormal shoreline length of pond Number 3 is excluded, shoreline lengths of Class C ponds average only 234.5 m. These ponds are small enough that cattle trample their entire shoreline and sometimes the entire pond bottoms. Severe trampling results in turbidity and reduced light penetration, and plants are unable to survive in these ponds (McCallum 1964). Emergents were also absent from the Class E pond (Table X). The Class D ponds provide an interesting comparison of the influence of cattle on emergent species. Since these ponds are located in canyons, their shorelines are not as accessible to cattle. Both Class D ponds supported relatively extensive stands of *Typha angustifolia* (Table X).

Turbidity resulting from cultivation on a watershed was observed in only one pond. Pond Number 3 was surrounded by cultivated fields in close proximity to its shoreline, and it appeared that erosion associated with cultivation did contribute to the high turbidity of this pond.

Relationships Between Plants and Other Parameters

Two measurements were used as indicators of plant production in each pond: the total plant index per pond and the plant index per hectare of surface area. The larger ponds supported higher total plant indexes, but the smaller ponds, excluding Class C ponds, generally supported higher plant indexes per hectare (Tables VII, IX, XI, XII).

Total plant indexes were significantly correlated with surface area ($r=+0.885$, $P<0.01$) and the number of plant species present in a particular pond ($r=+0.775$, $P<0.01$). The number of plant species present was correlated with hectares ($r=+0.832$, $P<0.01$). This simply

means that the aquatic plant communities of larger ponds are more diverse, and due to this greater diversity and size, larger ponds had greater plant indexes. Considering the significant difference ($P < 0.05$) in size that existed between classes, it is easy to understand the differences ($P < 0.01$) that were also observed in total plant indexes.

Plant indexes per hectare were significantly correlated with the percent of surface hectares less than 0.9 m deep ($r=+0.809$, $P < 0.01$) and the meters of shoreline per surface hectares of water ($r=+0.764$, $P < 0.01$). The percent shallow water was correlated with meters of shoreline per hectare of water ($r=+0.876$, $P < 0.01$). These data indicate that smaller ponds have a higher ratio of shoreline length to surface hectares of water and also a greater ratio of shallow to deep water. Therefore, small ponds have a greater plant index on a per hectare basis than do larger ponds. This is primarily because of the increased diversity of plant species encountered in the shallow water zone. Although the Class A ponds support a greater number of plant species, only one species (*Chara* sp.) was encountered in deep water (Table VI). Another factor that contributes to the lower index per hectare in larger ponds is that Class A ponds usually support a lower percent basal area than smaller ponds (Tables VIII, IX, XI and XIII) because some of the deep portions of large ponds do not support plant growth.

Chara sp. was the only species that was significantly correlated with the amount of water deeper than 0.9 m ($r=+0.859$, $P < 0.01$). *Najas flexilis* ($r=+0.873$, $P < 0.01$) and *Potamogeton pectinatus* ($r=+0.671$, $P < 0.01$) were significantly correlated with the amount of water 0.9 m

deep or shallower.

No significant correlations existed between shallow water and presence of the emergents Typha angustifolia ($r=+0.280$) and Scirpus sp. ($r=+0.327$) presumably because of the influence of cattle. The abundance of Typha sp. ($r=+0.670$, $P<0.01$) and Scirpus sp. ($r=+0.687$, $P<0.01$) was correlated with increased shoreline lengths.

No measure of siltation was made, but where silt deltas were observed, particularly in Class A and D ponds, Typha angustifolia was abundant. In small ponds where a large portion of shallow water zones was silted in (Classes D and E ponds) Potamogeton pectinatus was the dominant plant (Table X). Potamogeton sp. and Typha sp. sprout from rhizomes (Correll and Correll 1972) and both aquatic and riparian species that have rhizomes typically pioneer and compete well in silty soils (Ernest Snook, personal communications).

Relationships Between Invertebrate Populations and Other Parameters

The relationships between invertebrate populations and plant communities have been studied by Berg (1949), Chura (1961), Kadlec (1962), Krecker (1939), Krull (1970) and McGaha (1952). These authors generally concluded that many invertebrate species reside only on a limited number of plant species, and that a variety of plant species is necessary to support a diverse population of invertebrates. Krull (1970), for example, found that a few invertebrate species of the families Hirudinae, Haliplidae, Tendipedidae, Physidae and Planorbidae were common on many plant species; however, 60 percent of all invertebrate species were encountered on three or fewer species of plants.

Kadlec (1962) reported that relatively stable water levels were necessary to support high densities of invertebrate populations and that populations diminished during drawdown periods.

Invertebrate specimens from 40 families (Table IV) were collected from the 20 sample impoundments of this study, and observations relative to species composition and densities were similar to those reported by the above authors.

Significant differences ($P<0.05$) were observed in the average total numbers of invertebrates collected per sample, among all pond classes except A and B (Table IV). The average invertebrate populations for Classes A and B ponds were 111.9 and 138.0 individuals per sample, respectively, and the dominant species encountered in those ponds were also similar. Major invertebrates common to both classes of ponds were flies (Tendipedidae, Ceratopogonidae), mayflies (Baetidae), dragonflies (Libellulidae), damselflies (Coenagrionidae), gammarus (Gammaridae), daphnia (Daphniidae), snails (Physidae), round worms (Tubificidae) and leeches (Glossiphoniidae). These same species were also encountered as dominants in ponds of Classes D and E, but their population densities were lower (the three ponds averaged 52.9 individuals). Their lower populations may have been due to the more restricted distribution of various plant species in Classes D and E ponds, as compared to broader species distribution (reflected by relative abundance of species) in Class A and B ponds (Tables VI, VIII and X). Class C ponds supported the lowest densities of invertebrates with an average of 29.7 individuals per sample. This apparently was a consequence of the lack of plant communities in Class C ponds, because their invertebrate populations were dominated by flies (Tendipedidae) that

are not dependent on plants for their existence, and on round worms (Tubificidae) that live primarily in the pond substratum (Pennak, 1953).

The greater populations of invertebrates were significantly correlated with plant indexes per hectare ($r=+0.670$, $P<0.01$) and percent shallow water ($r=+0.748$, $P<0.01$), but the highest correlation was with number of plant species present ($r=+0.814$, $P<0.01$). These data indicate that the highest invertebrate populations were in ponds that supported abundant and diverse plant communities. This agrees with the findings of the above authors.

Production Habitat Requirements, Potential and Limiting Factors

"One of the most critical periods in the lives of ducks is that between the selection of a breeding site by a pair in the spring and the attainment of flight by their progeny in late summer" (Smith 1971: 1). Likewise, habitat conditions on which waterfowl are dependent during this period are also critical. Reproductive efforts may be hampered, if not futile, without the necessary association of water and vegetation that provides a medium of cover and food for nesting and brood rearing.

Drewien and Springer (1969), during their studies of blue-winged teal in South Dakota, found that the condition of production habitat was most critical during early spring when pairs were searching for nesting areas. Anderson and Glover (1967) reported similar findings in the San Luis Valley of Colorado where they flooded vegetation prior to spring migration and attracted nearly triple the normal densities of

nesting ducks.

Wetland types and, particularly, their size have been documented as important characteristics of habitats for both nesting and brood rearing (Berg 1956, Drewien and Springer 1969, Smith 1971, Stoudt 1971). Dabblers generally prefer wetlands of less than 0.2 ha (0.5 a) for nesting and 0.2 to 0.4 ha for brood rearing. Divers prefer ponds up to 2.0 ha for brood rearing, and usually depend on diving in open water for escape (Smith 1971). These authors also reported that use per area is highest on smaller Types 1 to 3 wetlands (Shaw and Fredine 1956), although larger Type 4 and 5 wetlands are also used for nesting and brood rearing. Furthermore, the larger types were the more dependable production areas because they are usually the only areas available during drought years. Lokemoen (1973) compared brood use on stock-watering ponds in North Dakota and South Dakota. He also observed higher brood use per area on ponds less than 0.2 ha, but discovered that survival rates were highest on 0.9 to 2.0 ha ponds.

Cline (1965) and Griffith (1948) concluded that cover, rather than food, adjacent to water is more often the factor limiting the attractiveness of an area for nesting. The importance of residual vegetation and litter from previous growing seasons was stressed by Leopold (1933) and Nelson (1972), because early nesters, such as mallards and pintails, select nest sites before plant growth begins in spring.

Some species of ducks nest only in specific vegetative communities. Canvasbacks (*Aythya valisineria*), redheads (*A. americana*) and ruddy ducks (*Oxyura jamaicensis*), for example, select cattails (Stoudt 1971), pintails prefer wheat stubble (Milonski 1958) and blue-winged teal select hay meadows (Glover 1956, Martz 1967, Stoudt 1971).

Duebbert (1969) observed mallard hens flying several kilometers to nest in rank grasslands set aside under the Crop Adjustment Program in South Dakota.

Overgrazing by livestock has been cited by Burgess et al. (1965), Dwyer (1970), Glover (1956), Gunnel and Smith (1972) and Kirsch (1969) as destructive to both shoreline and rangeland nest habitat. Berg (1956) and Bue et al. (1952) studied wetlands in Montana and South Dakota, respectively, and reported that ponds used most frequently by brooding pairs for nesting and brood rearing were those with shorelines protected by fencing. Bue et al. (1952) and Nelson (1972) stated further that long term protection of shoreline vegetation can also be detrimental. Some type of vegetative disturbance is desirable at least every 10 yr to maintain an early stage of plant succession.

Potential for Production and Limiting Factors

No waterfowl reproduction was observed on the study area during the sampling period. Interviews with landowners also indicated that nesting by waterfowl had never been observed on the study impoundments. A potential may exist, however, to manage Class A, B and C ponds so that they would be attractive to waterfowl as habitat for nesting.

Waterfowl have been reported to nest in grasslands several miles from wetlands (Duebbert 1967, Glover 1956, Martz 1967, and Stoudt 1971), but this type cover probably does not exist on the study area, due to the grazing pressures which have already been discussed.

Assuming that Class A, B and C ponds would be utilized by breeding waterfowl if they were suitable, it now appears that the limiting factor common to these ponds may be the absence of cover for nesting.

All watersheds containing sample ponds rated an average of Low-Fair range condition. It would be convenient if these type data and data on volumetric weights of vegetation available for nest cover such as in Tables VII, IX, XI and XII, were available for prime nesting areas, but these data were not found in the literature. It is obvious, though, that the availability of cover for nesting will be lower when range conditions are less than Fair than under conditions of more moderate grazing. Shorelines were grazed to the water edges, and the larger emergent plants were present only in Class A and D ponds. Therefore, the first priority in management must be to encourage and protect growth of riparian and terrestrial vegetation in proximity to pond shorelines.

Cover for brood rearing exists only in Classes A and D ponds, and is limited to emergent aquatics. Shoreline cover is also important to brood survival, but did not, generally, exist around any impoundments. Both shoreline and emergent vegetation provide escape cover for most dabblers, and harbor insects that are of dietary importance to ducklings (Chura 1961).

Chura (1961) compared the diets of mallard ducklings by age class, and found that Class I ducklings (1 to 6 days) fed primarily on terrestrial insects, whereas Class II ducklings (7 to 12 days) fed on aquatic invertebrates and Class III ducklings (13 to 18 days) shifted their diets to vegetation. Insects of the orders Diptera, Ephemeroptera, Orthoptera, Odonata, Coleoptera and Hemiptera and crustaceans of orders Amphipoda and Cladocera are reported as the major anthropods eaten by a variety of duckling species (Chura 1961, Perret 1962, Sugden 1969, Rogers and Korschsen 1966, Swanson and Nelson 1970). These authors do

not present availability of invertebrates as numbers, weights or volumes per unit area; therefore, the data collected during my study can be compared with those from prime waterfowl production areas, only, in terms of relative abundance of species encountered.

All the animal forms that were important foods of ducklings, except Orthopterans, were especially abundant in samples from Class A and B ponds, as compared to other ponds sampled. Orthopterans did not appear in samples, because of the sampling technique. Limitations for Class B ponds are presumably the lack of emergent and shoreline insect habitat. Class A ponds lack the shoreline habitat.

Aquatic plant material is available in ponds of Classes A and B. *Scirpus* sp. nutlets were reported as significant dietary components of mallard (Chura 1961), gadwall (*Anas strepera*), pintail, widgeon (*Mareca americana*) and lesser scaup (*Aythya affinis*) ducklings (Sugden 1969), and *Scirpus* sp. is scarce in Class B ponds.

Class C ponds lack all important components of waterfowl production habitat. They are of potential importance, however, because (1) they would probably respond to the same management that will be recommended for Classes A and B ponds, and develop suitable plant communities that will reduce turbidity and support invertebrate populations, and (2) they comprise 35 percent of all ponds sampled. Because of their small size, however, they will not be as valuable as ponds of Classes A or B.

Classes D and E ponds are considered of low potential, because (1) the two classes combined comprise only 15 percent of the total sampled, (2) their plant and invertebrate productivity are relatively

low, and (3) no literature was found that reported ravine type impoundments as beneficial habitat for duck production.

Use of Impoundments by Wintering Waterfowl

Relationships Between Use by Waterfowl, Pond Size and Food Availability

During his statewide studies of migratory birds in Oklahoma Dodson (1953:2) observed "large numbers" of diving and surface feeding ducks frequenting small ponds and lakes "containing aquatic food such as pondweed and coontail". He indicated that ponds were used heaviest during spring migration and were used seldom during fall and winter because of their small size and hunting pressure. During the same period, however, he observed waterfowl feeding and resting throughout the fall and winter on large playa lakes of the Oklahoma panhandle. He suggested that both food and pond size, which assured protection, were key factors resulting in their use by waterfowl.

My findings agree with those of Dodson (1953). During this study, 2545 ducks, coots and grebes of 14 species (Appendix B) were observed 21 November 1973 to 2 April 1974 during aerial inventories of study lakes. Waterfowl use was significantly correlated with pond size ($r=+0.846$, $P<0.01$) and food index ($r=+0.938$, $P<0.01$). No significant correlation was observed between waterfowl use and food index per hectare ($r=+0.490$). This is interpreted to mean that although the smaller ponds produce more food per hectare, wintering waterfowl prefer to feed and rest on larger ponds. As noted earlier, a significant correlation was observed between food index and hectares ($r=+0.885$,

$P<0.01$). Therefore, it appears that larger ponds provide a large supply of food as well as the security of open water.

Relationships Between Waterfowl Use and Impoundment Classes

Classes A and B impoundments were used for feeding and/or resting by 71.8 and 23.4 percent, respectively, of all wintering waterfowl (Tables XIV and XV). Class A impoundments were occupied in an average of 92 percent of the inventory periods, and occupancy of Class B impoundments was 52 percent. Numbers and frequency of use by waterfowl were insignificant for other impoundment classes. Classes A and B impoundments were generally larger and had higher food indexes than did other classes (Tables VII and IX).

Correlations between waterfowl use, available food and pond size. have already been discussed, and the data shown above further support these conclusions.

The preference for larger ponds and higher food indexes was also observed among ponds of Class B. The largest pond, Number 8, (1.4 ha) supported the highest food index (726.6) and was frequented by more birds (392) a greater percentage of the time (100 percent) than was any other pond in the class. A higher food index apparently influenced greater use of Number 13 (140 birds) compared to Number 1 (47 birds). Number 13 (0.5 ha) was smaller than Number 1 (0.8 ha), but had a higher food index, 227.0 compared to 165.7.

One additional factor was observed that may have discouraged the use of another Class B impoundment. Number 19 was of similar size and food index to Number 13, but was encircled almost entirely by Populus

TABLE XIV

POPULATIONS OF DABBLERS AND DIVERS OBSERVED ON SAMPLE IMPOUNDMENTS AND THE PERCENTAGE OF INVENTORIES DURING WHICH EACH IMPOUNDMENT WAS OCCUPIED, 21 NOVEMBER 1973 TO 2 APRIL 1974

	Total Ducks Pond Number - Dabblers:Divers - Percent Occupancy														
	Classes														
	A			B			C			D			E	
2	354 349:5	100.0	1	47 32:15	40.0	3	14 10:4	40.0	15	0 0:0	0.0	7	80 0:80	20.0
6	406 120:286	80.0	8	392 334:58	100.0	4	2 0:2	20.0				11	0 0:0	0.0
17	161 0:161	100.0	13	140 139:1	60.0	5	25 25:0	60.0						
18	359 90:269	80.0	14	1 0:1	20.0	9	0 0:0	0.0						
20	548 366:182	100.0	19	16 10:6	40.0	12	0 0:0	0.0						
						16	0 0:0	0.0						
						21	0 0:0	0.0						
Ave.	365.6 51:47	92.0		119.2 86:14	52.0		5.9 85:15	17.1		0.0 0:0	0.0		40 0:100	10.0

TABLE XV

TOTAL AND AVERAGE NUMBER OF DABBLERS AND DIVERS INVENTORIED ON CLASS A THROUGH E IMPOUNDMENTS, BIRDS PER AREA AND PERCENT OCCUPANCY, 21 NOVEMBER 1973 TO 2 APRIL 1974

	Classes					
	A	B	C	D	E	Totals
Total Birds Observed	1828	596	41	0	80	2545
Percentage of Total	71.8	23.4	1.6	0	3.1	99.9
Dabblers:Divers	925:903	515:81	35:6	0:0	0:80	1475:1070
Percentage of Dabblers:Divers	51:49	86:14	85:15	0:0	0:100	58:42
Birds Observed per Hectare	86.2	181.0	8.6	0.0	44.5	
Birds Observed per Impoundment	365.6	191.2	5.86	0.0	40.0	
Percent Occupancy	92.0	52.0	17.1	0.0	10.0	

deltoides and Salix nigra. Only 16 birds were observed on this pond.

Many of the authors who have already been cited discussed frequencies of various waterfowl breeding activities on a per area basis, and they generally reported greater activities per area on small wetlands than on large. Lokemoen (1973) studied brood production on northern prairie farm ponds and found that small ponds produced more broods per hectare, however, large ponds produced more broods on a per pond basis. Therefore, he concluded that larger farm ponds are more valuable to nesting waterfowl than small ponds. My findings indicate that this conclusion applies similarly to the use of farm ponds by wintering waterfowl.

Class B ponds averaged 0.7 ha and were frequented by an average of 181 birds per hectare compared to Class A ponds (4.2 ha) where only 86 birds per hectare were observed. Barstow (1957) reported similar use of farm ponds in Payne County, eastern Oklahoma. Considering, however, that 71.8 percent of all waterfowl were inventoried on Class A ponds, and that these ponds averaged 366 birds per pond compared to the next highest of 119 per Class B ponds (Table XV), bird use per hectare is not a valid measure of their value to wintering waterfowl.

Ponds of all classes where 100 or more waterfowl were observed averaged 3.3 ha (0.5 to 7.4 ha) and supported total plant indexes that averaged 1313 (227 to 2803) (Table XVI). Ponds where 1 to 99 waterfowl were observed averaged 0.9 ha (0.2 to 3.6 ha) and had an average plant index of 172 (0 to 329). These data indicate that wintering waterfowl prefer and use farm ponds of large size and high plant indexes.

TABLE XVI

SIZE AND PLANT INDEX OF IMPOUNDMENTS ON WHICH
> 100, < 100, OR ZERO WATERFOWL WERE
INVENTORIED, 21 NOVEMBER 1973
TO 2 APRIL 1974

	Total Waterfowl Per Pond	Size of Pond (ha)	Total Plant Index
> 100 Birds	140 to 543 Average 336.4	0.47 to 7.37 Average 3.30	227.0 to 2803.0 Average 1313.0
< 100 Birds	1 to 80 Average 26.4	0.16 to 3.60 Average 0.92	0.0 to 328.5 Average 171.9
No Use	0	0.03 to 0.31 Average 0.15	0.0 to 121.5 Average 29.2

Major Waterfowl Species Observed on Study Impoundments

Dabbler species (Kortright 1942) comprised 58 percent of all waterfowl inventoried, and American widgeons and ring-necked ducks (*Aythya collaris*) were the dominant dabbler and diver species. The five most commonly occurring species were American widgeon, ring-necked duck, American coot (*Fulica americana*), redhead, and mallard; their percent relative occurrences were 49.2, 25.8, 8.7, 6.7, and 4.9, respectively.

Eighty-four percent of the divers were observed on Class A ponds. The ratio of dabblers to divers was 51:49 on Class A ponds and 86:14 on Class B ponds (Table XV). These data indicate diver species seemed to prefer larger lakes. These findings could be expected because divers feed in deeper waters than dabblers (Green et al. 1964), and depend on open water and diving for escape (Smith 1971).

One factor was observed on three Class A ponds that seemed to discourage use by dabblers. Numbers 17, 18 and 6 had extensive *Typha* sp. communities that dominated the vegetation occurring in their shallow water. Linde (1969) reported that shallow waters less than 71 cm deep are important areas for feeding of dabblers, and dense emergent communities will discourage use of these shallow areas by dabblers. This apparently accounts for the low dabbler to diver ratio (23:77) on ponds 6, 17 and 18.

Potential for Management of Existing Impoundments To Improve Their Value as Winter Waterfowl Habitat

Highly significant differences ($P<0.01$) occurred between impoundment classes in both the numbers of waterfowl observed and the percentage of inventory periods that ponds were occupied. Of all waterfowl observed, 71.8 percent were on Class A impoundments, 23.4 percent on Class B impoundments and the remaining 4.8 percent were on ponds of Classes C, D and E. Based on use by waterfowl, Class A and B impoundments appear to qualify as high and moderate quality winter habitat, respectively, for waterfowl. These two classes represent 50 percent of the total sampled (Class A=25 percent and Class B=25 percent), which means that the remaining 50 percent of the ponds sampled were of insignificant value to wintering waterfowl. Two Class B impoundments (Number 8 and 13) received much greater use than any other ponds of that class (Table XI). If the value of these two ponds is considered comparable with those of Class A, it may be concluded that 25 to 35 percent of the ponds existing in the study area are winter habitat of high quality for waterfowl.

Benefits of management to improve the value of existing ponds as winter habitat for waterfowl would probably be limited, because pond size appears to be the major factor influencing use by wintering waterfowl. Fencing of Class C and less productive Class B ponds should result in improved water clarity and allow plant communities of greater density and species numbers to establish (Nelson 1972), but use of these smaller ponds by wintering waterfowl probably would be only

occasional and by low numbers of birds. This applies similarly to Class D ponds; and the shorelines of Class E ponds are already naturally protected in their canyon sites. Fencing, however, would also result in establishment of potential nesting habitat for waterfowl, because prairie and riparian plant species would be protected from grazing along shorelines. Therefore, benefits other than use by wintering waterfowl would be realized from management of these smaller ponds.

Management Recommendations

The following recommendations, with the exception of those pertaining to impoundment construction, are relevant to both existing ponds and those ponds that will be constructed in the future.

1. Management practices should be tested on a sample of existing impoundments, and, contingent on test results, should be implemented as management plans in conjunction with construction of all new impoundments.

2. Only Class A and Class B ponds should be constructed, and, where possible, Class A ponds are preferable. Greater areas of grassland per pond can be protected around Class A ponds, as compared to the smaller Class B ponds, resulting in greater total area being deferred. The greater area of water and deferred grassland should benefit both wintering and nesting waterfowl.

3. Class A ponds should be constructed larger than 2.02 ha (5.0 a), and 25 to 50 percent of their surface acreage should be no more than 0.9 m deep. Class B ponds should be constructed larger than 0.4 ha. Their depths will not be critical, because they will

automatically be predominantly shallow.

4. All ponds should be constructed in rolling terrain instead of ravines. Some Class D ponds will, obviously, need to be built for control of flooding and erosion, but not for the benefit of waterfowl.

5. All ponds should be fenced at the time of construction to protect shoreline vegetation from disturbance. It is desirable to fence entire ponds, either leaving travel lanes in which livestock can go to water or construct gravity fill watering tanks below the pond dam. This, probably, will be economically and socially feasible only for Class B ponds. Data are not available to support a definite recommendation on the percentage of a pond that should be fenced when the entire pond cannot be fenced. This must be determined by trial and error or by further research. A reasonable percentage of the pond to fence for research purposes might be 35 to 50 percent of the upper ends of ponds, the percentage depending on the size of the pond.

6. Nelson (1972) recommends that as much of the deferred area as possible be situated in a continuous block. This discourages use of the areas as travel lanes for predators and thereby reduces nest predation. This distribution of cover can be created if the majority of the protected hectares are on one side of a pond, rather than distributed around the entire pond. Ponds that are split by two or more drainage systems (Y shaped) may be fenced to protect the uplands that lie between their drainages.

7. Class B and, if built, Class C impoundments as well, should be constructed in close proximity to Class A ponds, when possible, or in groups; this may encourage use of the entire complex of ponds.

These management recommendations should benefit both wintering and breeding waterfowl. However, it should be emphasized that there is a factual basis for recommendations concerning habitat for wintering waterfowl, but only hypothetical basis for recommendations concerning habitat for breeding and nesting.

CHAPTER IV

SUMMARY

The objectives of this study were, in general, to develop a classification system for small impoundments based, primarily, on their aquatic plant communities and to identify the relationships that exist among aquatic plant communities, invertebrate populations, water chemistry, and pond size and depth. In addition, use of impoundments by waterfowl was observed, and those factors which influenced their use by waterfowl were identified.

Three major pond classes (A, B and C) and two minor classes (D and E) were identified from a random sample of 20 impoundments. The three major classes of ponds represented 85 percent of the ponds sampled, and were generally ponds larger than 2.0 ha which contained a diverse aquatic plant community of both emergent and submergent species (Class A), ponds smaller than 2.0 ha that usually contained only submergent species and no more than a sparse emergent community (Class B) and ponds smaller than 0.2 ha that were usually turbid and devoid of aquatic vegetation.

Impoundment size in conjunction with cattle grazing appeared to be the combination of factors that influenced the species composition and abundance of the aquatic plant community observed in each pond. All watersheds of sample ponds were generally, heavily grazed by cattle, and the sample impoundments were also used for watering by cattle.

When cattle watered at smaller ponds they typically trampled the entire shallow water zone of the pond, and the trampling and resulting turbidity prevented the growth of vegetation. The ratio of length of shoreline to numbers of cattle increased with larger impoundments and, although cattle watered and grazed emergent species at all ponds, they had less of an effect on the aquatic plant community at ponds of larger sizes.

The water in impoundments that contained aquatic plant communities was generally clearer, and the larger ponds usually contained a greater density and more species of aquatic plants. Greater densities and more species of invertebrates were also observed in samples from larger impoundments.

Waterfowl nesting was not observed around sample impoundments; however, vegetation suitable for nesting was not present.

Fourteen species of wintering waterfowl were observed on the sample impoundments, and 87 percent of the 2545 birds observed were on 30 percent of the sample impoundments that were 1.4 ha or larger. Winter waterfowl use was correlated with food available (food index) ($r=+0.938$, $P<0.01$) and pond size ($r=+0.846$, $P<0.01$). It appears that wintering waterfowl used larger impoundments because these impoundments provided both adequate food and security from disturbance by humans.

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APPENDIXES

APPENDIX A

LEGAL DESCRIPTION OF SAMPLE IMPOUNDMENTS

Pond Number	Legal Description
1	SW ¼ of Section 24, T-18-N, R-17-W, Dewey County
2	N ½ of Section 31, T-14-N, R-18-W, Custer County
3	S ½ of Section 2, T-14-N, R-21-W, Roger Mills County
4	SW ¼ of Section 2, T-15-N, R-17-W, Custer County
5	SW ¼ of Section 36, T-16-N, R-21-W, Roger Mills County
6	NW ¼ of Section 2, T-15-N, R-21-W, Roger Mills County
7	SW ¼ of Section 14, T-16-N, R-22-W, Roger Mills County
8	SE ¼ of Section 23, T-14-N, R-19-W, Custer County
9	NW ¼ of Section 14, T-14-N, R-20-W, Custer County
11	NE ¼ of Section 18, T-17-N, R-20-W, Dewey County
12	SE ¼ of Section 33, T-16-N, R-18-W, Dewey County
13	NE ¼ of Section 5, T-14-N, R-19-W, Custer County
14	NW ¼ of Section 16, T-15-N, R-18-W, Custer County
15	SE ¼ of Section 3, T-16-N, R-17-W, Dewey County
16	SE ¼ of Section 7, T-15-N, R-20-W, Custer County
17	N ¼ of Section 11, T-14-N, R-20-W, Custer County
18	NW ¼ of Section 7, T-15-N, R-20-W, Custer County
19	NE ¼ of Section 21, T-16-N, R-19-W, Dewey County
20	SW ¼ of Section 19, T-16-N, R-19-W, Dewey County
21	SE ¼ of Section 28, T-16-N, R-18-W, Dewey County

APPENDIX B

SPECIES OF WATERFOWL CENSUSED ON THE STUDY IMPOUNDMENTS DURING FIVE AERIAL INVENTORIES, 21 NOVEMBER 1973 THROUGH 2 APRIL 1974

Specific Name	Common Name	Number Observed	Percent Relative Abundance
Anas acuta	pintail	30	1.2
Anas platyrhynchos	mallard	125	4.9
Anas strepera	gadwall	69	2.7
Aythya americana	redhead	170	6.7
Aythya collaris	ring-neck duck	653	25.8
Aythya valisineria	canvasback	3	0.1
Bucephala albeola	buffelhead	9	0.4
Bucephala clangula	common goldeneye	10	0.4
Fulica americana	American coot	221	8.7
Mareca americana	American widgeon	1251	49.2
Oxyura jamaicensis	ruddy	2	0.1
Podilymbus podiceps	pied-billed grebe	2	0.1
Totals		2545	100.3

VITA

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Candidate for the Degree of

Master of Science

Thesis: CHARACTERISTICS OF SMALL IMPOUNDMENTS IN WESTERN OKLAHOMA, THEIR VALUE AS WATERFOWL HABITAT AND POTENTIAL FOR MANAGEMENT

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