A VEGETATIVE STUDY OF TWO MALLARD RELEASE SITES IN EAST-CENTRAL OKLAHOMA

By

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A VEGETATIVE STUDY OF TWO MALLARD RELEASE SITES

IN EAST-CENTRAL OKLAHOMA

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CHAPTER I

INTRODUCTION

In the summers of 1969, 1970, and 1971, mallard ducklings (Anas platyrhnchos), provided by the Max McGraw Wildlife Foundation, Dundee, Illinois, were released at several aquatic sites in Oklahoma to study their potentiality for establishing nesting populations of wild birds. The study was sponsored by the Max McGraw Wildlife Foundation and the Oklahoma Cooperative Wildlife Research Unit.

Analysis of species composition, relative abundance, distribution phenology, and value to waterfowl of plant species occupying release sites is necessary for evaluating the success with which ducklings adapt to experimental sites. Such analysis enables us to predict potential success of adaptation to other sites in Oklahoma. Once the vegetative characteristics of a successful waterfowl release site are known, management procedures can be designed to identify other sites or to increase the acreage of suitable habitat. The present study was undertaken to develop simple procedures that could be employed to evaluate the vegetation of potential waterfowl areas in Oklahoma. Two experimental areas were analyzed in this study. These two areas are representative of east-central Oklahoma waterfowl habitat and they are protected, as part of the U. S. Naval Ammunition Depot, from all but minimal human use.

Location

The U. S. Naval Ammunition Depot constitutes 44,959 acres in southwest Pittsburg County. McAlester, the county seat, is 9 miles northeast of the main entrance to the Depot. The two areas under investigation, Rocket Lake and Duck Marsh, are 5.5 miles apart. Rocket Lake is 4.5 miles west of the Depot's main entrance gate. It consists of 22 surface acres situated in the Bull Creek drainage system. A major tributary of Bull Creek drains from the north end of Rocket Lake. Duck Marsh is west-southwest of Rocket Lake and 10 miles west of the entrance gate. It is composed of four contiguous impoundments totaling 155 surface acres. Figure 1 shows the location of these two lakes and the Naval Ammunition Depot in greater detail.

Topography and Geology

The U. S. Naval Ammunition Depot is located in the Cherokee Prairie soil resource area and borders the Ouachita highlands (Gray and Galloway, 1959). Gentle slopes make up 75 percent of the area. The remaining area is rolling sandstone. The average elevation is 750 ft above mean sea level. The highest and lowest points on the Depot are 908 and 695 ft above mean sea level, respectively. Ninety percent of the Naval Ammunition Depot drains northerly into Coal Creek, a major tributary to the Canadian River. The southern 10 percent of the Depot drains into North Boggy Creek (Stidham, 1966). Both of the study lakes are in the Canadian River drainage. The surface of Rocket Lake is 744 ft above mean sea level at normal level. Duck Marsh is 969 ft above mean sea level at normal surface level.

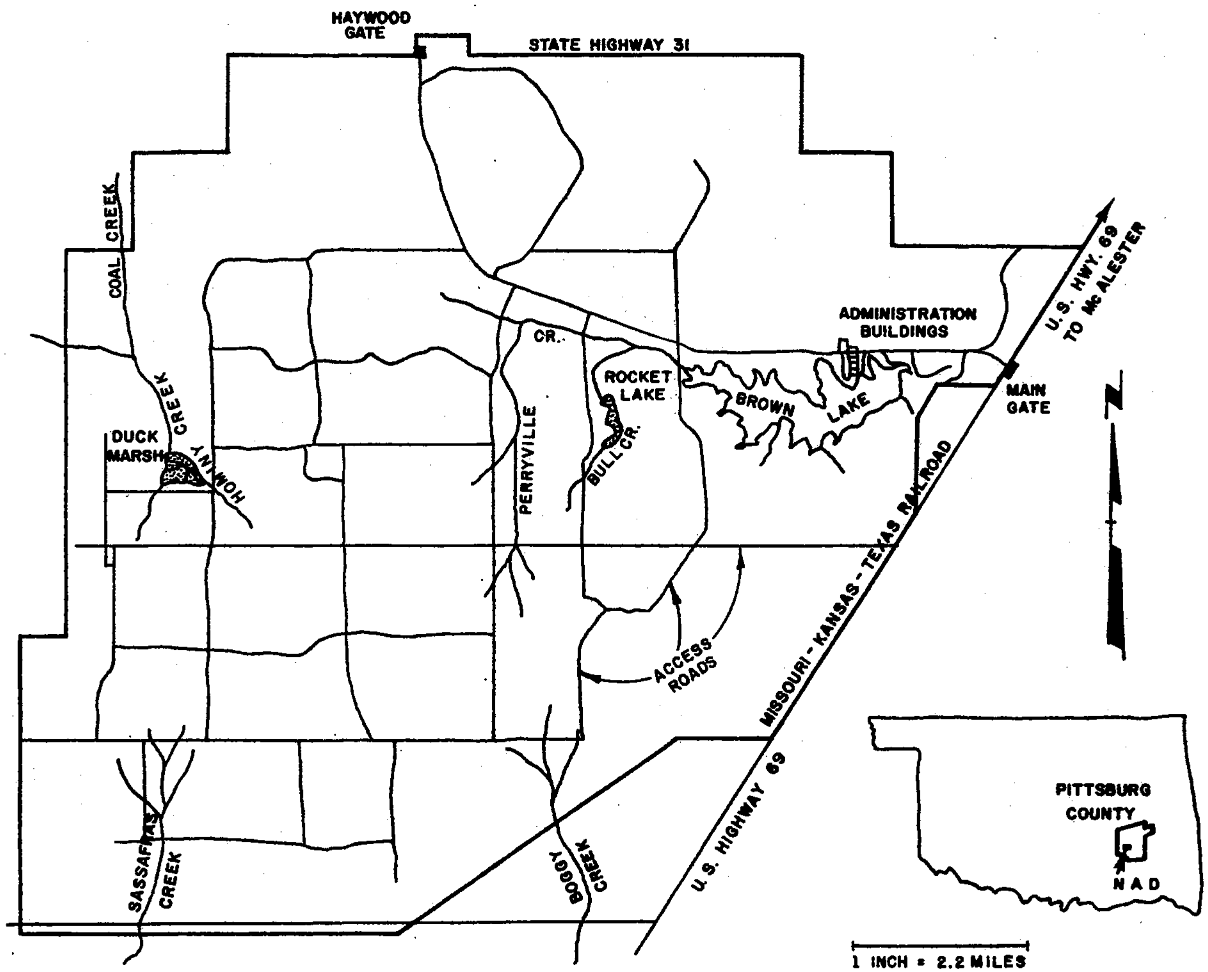


Figure 1. Major Features of the U. S. Naval Ammunition Depot, McAlester, Oklahoma

The Ouachita highlands were formed during the Pennsylvanian era. Prior to that time the area was covered by sea. Sedimentary sandstone and shales of considerable thickness were deposited. During early Pennsylvanian times an alteration of swamps and seas caused the formation of coal characteristic of this region. At the close of the Pennsylvanian period there was a great shifting in the earth's crust. Sandstones and shales of great thickness were thrown up in folds running from northeast to southwest, forming ledges and hills. Since this great Pennsylvanian shift, the area has remained relatively quiescent. Surface formation of Pennsylvanian Boggs Shale are common (Snider, 1917).

Gross Description of Vegetation on the Study Area

The vegetation of the Naval Ammunition Depot belongs to three major communities. The first is the Oak-Hickory Association of deciduous forest. It includes two intermingling habitat types, the upland and lowland forests (Bruner, 1931). A second major community, tallgrass prairie, penetrates the lowland forest to some extent. Shallow fresh water marsh forms the third community (Bruner, 1931), and is the community involved in this study.

Upland forests are restricted to the higher elevation and steeper slopes of the Ouachita highlands. Lowland forests occur contiguously to upland types on lower slopes and bottomland sites. The major species composing the upland forests are black oak*, black jack oak, post oak, Spanish oak, bitternut, hickory, black hickory, winged elm, and short-leaf pine. Subdominant species in the upland forests are Ohio buckeye, deerberry, St. Johnswort, deciduous holly, and wing-rib sumac.

*Scientific names appear in Appendix A.

Dominant species of the lowland forest are red oak, water oak, Spanish oak, black oak, water pecan, bitternut and black hickory. Less dominant lowland forest species include common alder, river birch, ironwood, beauty berry, witch hazel, false indigo and paw paw. Lowland forest is more common on the Naval Ammunition Depot, and it contains Rocket Lake and Duck Marsh.

Tallgrass prairie makes up a large part of the vegetation of the Naval Ammunition Depot. Duck Marsh and Rocket Lake are both partially surrounded to some degree by tallgrass prairie. Important plant species of the tallgrass prairie community are big bluestem, little bluestem, indian grass and switch grass. Less dominant species of the tallgrass prairie are Indian paintbrush, prairie mimosa, Japanese bromegrass, old man's beard, foxtail grass, prairie threeawn, little barley, blue-eyed grass, white false indigo, early buttercup, prairie foxglove, wild carrot, wild phlox, purple prairie clover, rose vervain, and scurff pea.

Some of the more common plants of the aquatic community are yellow lotus, coontail, muskgrass, common smartweed, annual sedge, soft rush, and primrose willow.

Climate

The climate of this area is the continental type (Walgreen, 1941). Characteristically this type of climate includes dramatic contrasts between seasons and a high proportion of the annual precipitation occurring during the warmer months of the year. The average annual temperature at McAlester is 62 F; the average temperature in January is 41 F and 83 F in July. Temperature extremes range from 116 F to -10 F.

The frost-free growing season of Pittsburg County includes the 233 days between 27 March and 5 November (Walgreen, 1941). Table I contains a summary of temperature and precipitation data for 1970. Most of the annual precipitation, 60-75 percent, occurs during the six warmer months of April through September. The 36-year-average annual precipitation at McAlester is 43 inches. Average annual evaporation is 36 inches (Walgreen, 1941). Since 1959 there have been 6 years of below-average precipitation and 5 years of above-average precipitation. The highest annual precipitation during this 10-year period was 61 inches in 1968, and the lowest was 21 inches in 1963 (U. S. Dept. of Commerce 1960-1970).

Annual variations in precipitation, insolation, and temperature, in conjunction with characteristics of soil, determine the phenology and productivity of plants. The aquatic species under investigation in this study are especially influenced by temperature in the commencement of spring growth and by precipitation for sustaining water levels.

Soils

Soils of the Naval Ammunition Depot in general, and Rocket Lake and Duck Marsh in particular, are shallow, light colored, acid, low fertility sandy loam. They developed as red-yellow podzolic soils over shale and sandstone substrates. Surface soils were formed under oak-hickory-pine forests and are strongly susceptible to leaching (Gray and Galloway, 1959).

At the Rocket Lake site, predominant soils in the lower watershed areas are Ennis Verdigris. These are loamy bottomland soils subject to frequent flooding. Flooding and concurrent scouring and deposition

TABLE I

AVERAGE MONTHLY TEMPERATURE AND PRECIPITATION IN 1970, AND 36-YEAR MONTHLY AVERAGES OF TEMPERATURE AND PRECIPITATION PRECEDING 1970, MCALESTER, OKLAHOMA

Month	1970 Average Temperature (F)	36-Year Average	1970 Total (Inches) Precipitation	36-Year Average
January	33.2	41.4	.78	2.05
February	43.5	44.6	2.19	2.16
March	47.0	51.8	4.07	2.84
April	63.4	61.4	6.92	4.48
May	70.0	65.5	.81	5.07
June	75.8	78.4	6.59	5.59
July	80.6	82.7	.83	3.55
August	83.7	84.5	1.52	3.67
September	76.1	76.9	11.69	4.78
October	60.1	64.6	11.16	3.94
November	49.4	50.8	1.37	2.72
December	46.3	43.3	1.46	1.93
Total/Average	60.8	62.2	49.39	42.78

1/ U. S. Department of Commerce. Annual Summary. F.A.A. Airport, McAlester, Oklahoma. (5 miles northeast of main entrance gate to U. S. Naval Ammunition Depot.)

make them unsuitable for cultivation. Soils predominating on upland prairie sites are Bates fine-sandy-loam and Dennis loam. Bates soils occur on gentle slopes and are deep, dark-colored and permeable. They are, however, susceptible to moderately severe erosion. Dennis loams are severely eroded soils found on lands formerly under cultivation. Productivity on this soil is low. Another soil of the upland, Eram clay loam, is shallow, dark-colored and slowly permeable; it is very easily eroded and useable only as native pastures. A soil of the wooded uplands surrounding Rocket Lake, the Hector-Hartsell complex, is a leach-prone soil formed under oak timber and tall prairie grasses. Due to its clay subsoil, low waterholding capacity, and stoniness, this soil is unsuitable for cultivation (Shingleton, 1971). Figure 2 is a soil map of the Rocket Lake vicinity showing the locations of the soil types discussed previously.

Soils at Duck Marsh (Figure 3) differ from those at Rocket Lake. Ennis-Verdigris soils predominate at bottomland drainage areas. Chastain silty clay loam also occurs in the bottomlands. It is a deep clay alluvial soil having poor drainage. The poor drainage accounts for the heavy growth of sedges and rushes. Dougherty loamy fine sand soil underlies the upland forest surrounding Duck Marsh. It is light colored, deep, and moderately permeable. This soil is relatively productive and has a large capacity to retain moisture. The shallow prairie soils of the Duck Marsh are made up of the Talihina-Collinsville complex. These are very shallow soils of the open prairie. They tend to be droughty and low in productivity. A small area of Eram clay loam also occurs near Duck Marsh (Shingleton, 1971).

Soils of higher elevations surrounding Rocket Lake and Duck Marsh,

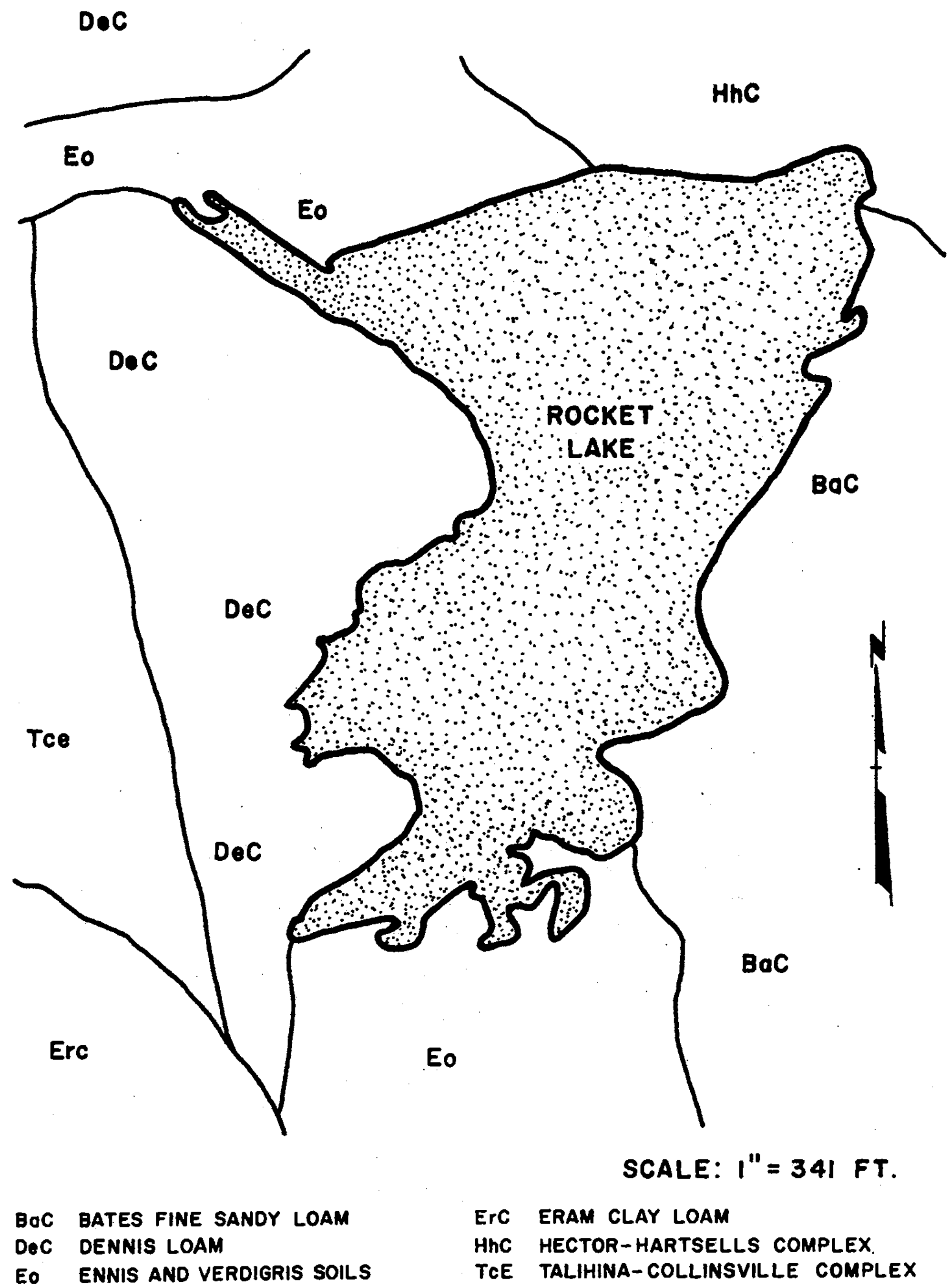
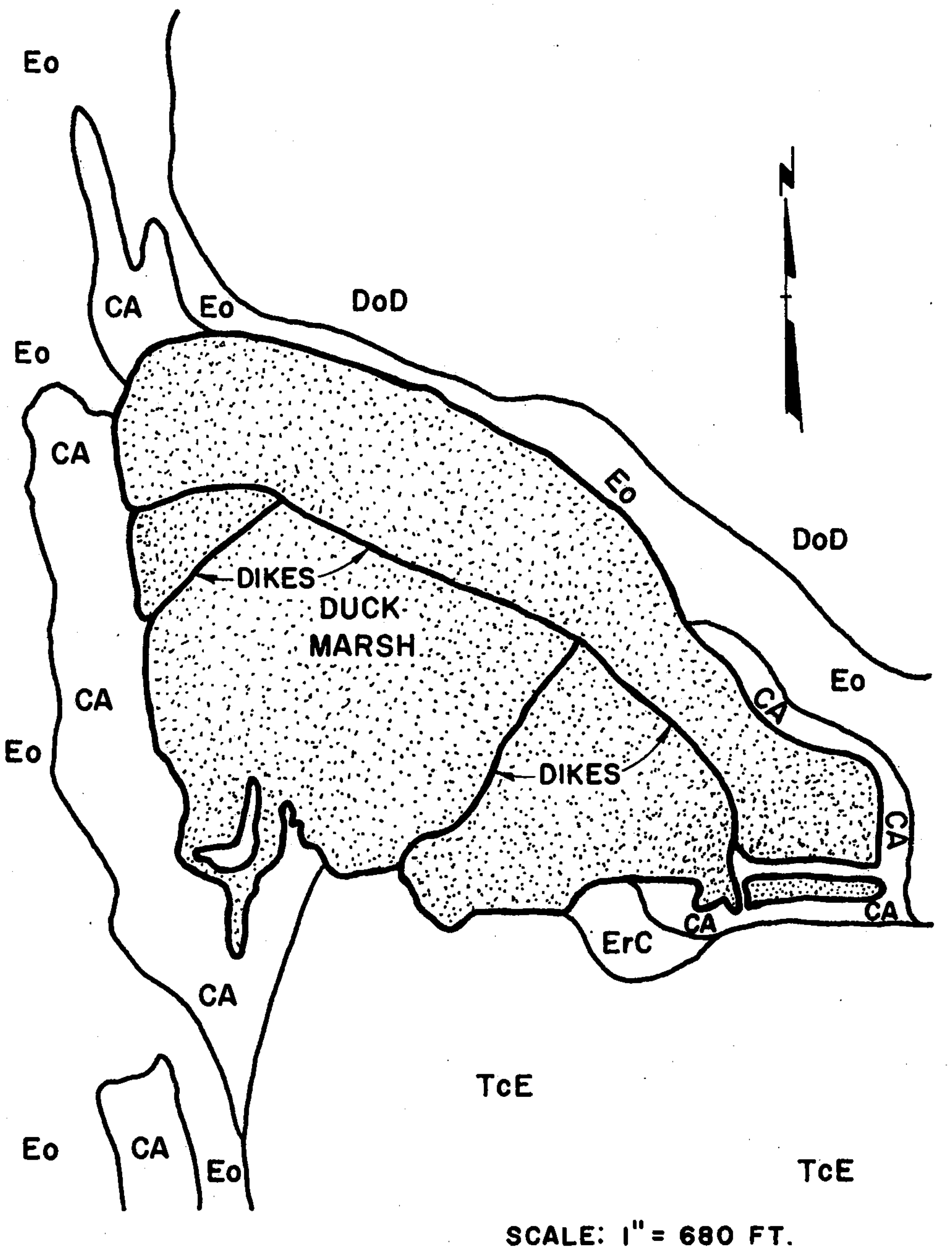


Figure 2. Map of Soils Adjacent to Rocket Lake,
U. S. Naval Ammunition Depot,
McAlester, Oklahoma



SCALE: 1" = 680 FT.

CA CHASTAIN SILTY CLAY LOAM
DoD DOUGHERTY LOAMY FINE SAND
Eo ENNIS AND VERDIGRIS SOILS
ErC ERAM CLAY LOAM
TcE TALIHINA–COLLINSVILLE COMPLEX

Figure 3. Map of Soils Adjacent to Duck Marsh, U. S. Naval Ammunition Depot, McAlester, Oklahoma

some of which have not been discussed previously, are important to these areas because they contribute to the bottom deposits of these water areas during times of runoff. These bottom deposits form the substrate upon which the aquatic vegetation grows. Bates and Dennis loams are prominent upland soils of Rocket Lake. Choteau very fine sand is the main soil type of the upland surrounding Duck Marsh. This soil formation is fairly productive but tends to erode easily.

Past Land Use

Prior to 1943, tillable lands surrounding the two lakes under investigation were planted to cotton or corn. Soil sites not suitable for cultivation were used as pastures. Due to the nature of the soils and their general susceptibility to depletion under poor management, the cultivated land became eroded and depleted of nutrients before the Navy took control in 1943. To facilitate land and resource management, the Navy divided the entire 45,000 acres into pasture, meadow, and other management units. Some of these pastures and meadows are leased to private bidders for grazing and haying. Since 1966, some 10,850 acres have been leased annually for haying and 10,350 acres for grazing (Hodge, 1966-1970). Neither Duck Marsh nor Rocket Lake is located in a pasture or meadow management unit. However, the unit directly west of Duck Marsh is open to grazing and the unit southwest of Rocket Lake is mowed for hay. Both of the areas studied are open to public recreational use, which at times is moderately heavy. Fishing is the primary activity, but 19,464 acres are open to deer hunting in the fall. Duck Marsh is included in this hunting area.

Rocket Lake, the older of the two areas, was constructed in 1919 as a stock watering tank. In 1947 the retaining dam broke and the lake was dry for 3 months until the dam could be reconstructed. Presently the lake is used as an emergency water source for combating prairie fires. Rocket Lake receives an effluent of TNT wash water from the production of explosives nearby. This pollutant, introduced into the incoming water supply, contains varying concentrations of salts of nitric acid, especially sodium nitrate ($N_a NO_2$). These salts slightly fertilize and salify the lake.

Duck Marsh, which is actually a lake with a marshy border, is a more recent impoundment, having been constructed in 1953. It also serves as an emergency water supply. There are no known pollutants entering the water supply of Duck Marsh.

Current land-use practices apparently have little effect on the plants of the two study areas. However, if any new land-use practice led to abnormally high runoff of rainfall, turbidity would increase and curtail production of submergent vegetation.

CHAPTER II

MATERIALS AND METHODS

Procedure for Sampling

Specimens were collected of all species of aquatic and riparian plants available. The specimens were pressed and later mounted using standard herbarium techniques. Waterfall (1969) was the primary reference for the identification and scientific nomenclature of specimens. I referred to Fernald (1950) for common names of plants.

Water depths were measured randomly throughout each plant community and in locations where plants were absent to correlate water depth and plant growth. An 8-foot pole marked off in 6-inch increments was used to measure depth. Generally, measurements were taken by wading; but when necessary a small aluminum boat was used. Phenology of plant species was observed in the area and obtained from literature review to estimate the time of availability of plant parts consumable by waterfowl, as shown in Table II.

The procedure employed to sample species composition, abundance, distribution, and association of vegetation was based on a line-plot technique described by Daubenmire (1959). In the line-plot technique, a plot is established at intervals along a line or transect of definite bearings (Cain and Castro, 1959). Each plot is then "read" either by counting individual stems or, as in this study, by estimating the

TABLE II

FOOD VALUE AND GENERAL TIME OF AVAILABILITY OF
MAJOR PLANT SPECIES FOR RELEASED MALLARDS
AT DUCK MARSH AND ROCKET LAKE

Species	Value for Mallards[a]	Part Consumed or Reason for Significance[b]	Zone of Occurrence[c]	Time of Availability
Ammannia coccinea	0	---	R	---
Alisma plantago-aquatica	1	I(a)	E	May-September
Carex Frankii	2	S	R	May-June
Carex lupuliformis	2	S	R	June-September
Carex Muhlenbergii	2	S	R	April-June
Cephalanthus occidentalis	3	I(t), S	R	June-September
Ceratophyllum demersum	3	F,I(a)	S	June-July
Chara Sp.	3	F, T, I(a)	S	May-September
Cyperus erythrorhizos	2	S, T	R	August-October
Cyperus globulosus	0	---	R	---
Echinochloa crusgalli	4	S	R	July-October
Eleocharis obtusa	2	F	R	June-October
Eleocharis parvula	2	F	R	June-October
Eleocharis quadrangulata	4	S	E	May-October
Fimbristylis vahlii	0	---	R	---
Hibiscus militaris	2	I(t)	R	May-October
Hydrolea ovata	0	---	R	---
Juncus diffusissimus	0	---	R	---
Juncus effusus	3	I(a)	E	May-September
Jussiaea peploides	2	S	E	June-August
Leersia oryzoides	3	S	R	August-October
Lemna minor	4	F, I(a)	S	---
Lobelia cardinalis	0	---	R	---
Ludwigia palustris	0	---	E	---

TABLE II (Continued)

Species	Value for Mallards[a]	Part Consumed or Reason for Significance[b]	Zone of Occurrence[c]	Time of Availability
Lythrum alatum	0	---	R	---
Mimulus alatus	0	---	R	---
Myriophyllum pinnatum	3	I(a)	S	May-June
Najas guadalupensis	2	S, F, I(a)	S	May-September
Nelumbo lutea	2	I(a)	S	June-September
Nuphar advena	1	S, I(a)	S	July-September
Nymphaea odorata	1	I(a)	S	June-September
Panicum agrostoides	0	---	R	---
Panicum anceps	0	---	R	---
Polygonum hydropiperoides	4	S	E	June-October
Potamogeton diversifolius	1	F	S	June-August
Potamogeton foliosus	2	S, F	S	July-September
Potamogeton nodosus	1	I(a)	S	July-September
Rhyncospora macrostachya	3	S	E	June-September
Sagittaria latifolia	2	S, F, T	E	May-October
Sambucus canadensis	0	---	R	---
Setaria lutescens	0	---	R	---
Setaria viridis	0	---	R	---
Tridens strictus	0	---	R	---
Typha latifolia	1	2(a)	E	May-September
Uniola latifolia	0	---	R	---
Utricularia gibba	4	I(a)	S	July-September

[a]
4 = Excellent
3 = Good
2 = Fair
1 = Poor
0 = No food value

[b]
S = Seed
F = Foliage
T = Tuber or roots
I(t) = Invertebrate (terrestrial)
I(a) = Invertebrate (aquatic)

[c]
R = Riparian
E = Emergent aquatic
S = Submergent aquatic

amount of ground covered by each plant species occurring within it. Stem counts are time consuming when results are compared to time spent in the field (Leasure, 1949). When measuring the amount of vegetation useful to wildlife, the stem count technique yields data of dubious quality (Daubenmire, 1959).

My plots were established with a frame of welding rod having inner dimensions of 12 inches by 26.2 inches (1/20,000 acre). A rectangular shape was used to de-emphasize bias favoring clumped species (Daubenmire, 1959). The number of plots per acre of habitat was based on number of plant species estimated to occur in each area and on the homogeny of the vegetation of each area.

A rating system based on canopy coverage was used to characterize the proportion of each plot occupied by each species of vegetation occurring within the plot. A rating of one indicated that ± 10 percent of the area within a given plot was covered by the canopy of the plant species given this rating, a rating of two indicated 30 percent, three indicated ± 50 percent, four indicated ± 70 percent, and five indicated ± 90 percent. In this application, canopy refers to the area included within an imaginary line, usually circular, connecting the tips of the lateral spread of leaves and branches of an individual plant or homogeneous clump of plants. Because plant communities are composed of superimposed layers of vegetation, various parts of the plot may be covered by more than one species of plant. Therefore, the coverage of each plot may total more than 100 percent (Daubenmire, 1959).

Because the plants encountered in this study occur at a relatively similar level above ground or near the water surface, one reading at or near the ground or water surface at each plot location rates the areas covered by all plant species occurring in each plot. Because the plants are compared simultaneously, this canopy-coverage-estimation technique also produces indices of association among plant species within each plot, depicting the community as a whole. By evaluating the number of plots in which two or more species occur jointly, the results also show a degree of association.

To my knowledge, this canopy-coverage technique has never been applied to an aquatic environment. However, it seems logical that if the technique works in a grassland community (Daubenmire, 1959) it is also applicable in an aquatic environment because both habitats tend to be relatively homogeneous in that all species occur at a similar height above the substrate.

A preliminary inspection of the Rocket Lake site revealed approximately 12 major plant species. Daubenmire (1959) stated that four plots per acre were adequate to sample 20 major plant species. In Rocket Lake, nine plots per acre were used to sample 12 major plant species. This large number of plots per acre yielded greater accuracy in sampling minor species. Minor species are important in this study since they could be beneficial to ducklings during a particular phase in their development. To place the nine plots per acre (200 total plots) systematically around Rocket Lake, 20 transect lines, each 50 feet long and containing 10 equidistant plots, were laid out at intervals of 330 feet.

Duck Marsh is considerably larger than Rocket Lake. A preliminary examination of it revealed about eight major species of aquatic vegetation. Based on this information, it was decided that six plots per acre would adequately sample the aquatic vegetation of Duck Marsh.

The six plots per acre (990 total plots) were placed systematically around Duck Marsh in 45 transect lines, each 88 feet long and containing 22 equidistant plots per line. Intervals between transect lines were 660 feet.

The transect lines for both Duck Marsh and Rocket Lake were first located on maps of each area, then established in conformance with the map as accurately as possible at the lake. Transect lines and plots were placed systematically along each line instead of randomly because systematic sampling yields equivalent results with a minimum amount of sampling (Daubenmire, 1959).

The transect lines ran from shore into deeper water at right angles to the shoreline. This insured a sampling of each stratum of vegetation from riparian to the submergent aquatic plants of the deepest water. It may seem that certain areas of deep water were neglected; however, based on the preliminary inspection, deep water vegetation of both areas was found to be quite homogeneous. As stated by Cain and Castro (1959), when vegetative homogeny increases, the necessary sample size decreases. In analyzing the sample results, this deep-water area is interpolated into the weighted coverage result described later.

In onsite application, the 12- by 26.2-inch rectangle was placed upon the substrate along each transect line at the interval prescribed for each area. Each species of vegetation occurring within the plot was rated according to the proportion of the plot covered by the canopy of that species, as described previously.

Water depth presented no problem in applying this technique to plots occurring at the offshore end of transect lines because the water was seldom deep enough, usually less than 4 ft, to impede reading the plot when the frame was placed on the substrate. In water that was too deep for reading the frame on the bottom, plant growth was limited by photopenetrant to a zone at or near the surface where a plot could be read as though the surface was equivalent (as far as benefits to mallards are concerned) to the substrate.

Procedure for Analyzing Data

Results from sample plots were analyzed for frequency of occurrence, relative abundance and association of plant species. To arrive at a relative abundance expressed as acres of coverage, the ratings of each species were totaled and this sum was then divided by the number of plots read at the study area. The resulting quotient was subsequently divided by the number of transect lines run in that lake. This yielded a value representing the percent of coverage. When the percent of coverage was multiplied by the acres in the lake, the unweighted acres of coverage were obtained. The formula for this operation is (R. Heath, personal communication, 1971): $\Sigma\bar{R}/P/L=C$, and $C \cdot A$ = unweighted acres of coverage when:

$\Sigma\bar{R}$ = mean rating for total plots of each species

P = total number of plots read at each study area

L = number of lines at each study area

C = percent of coverage

A = acres in each area

The unweighted results of this equation are limited to the sampled area and do not include the area beyond the transect line. Based on preliminary investigation, nonsampled areas were found to be vegetatively analogous to the offshore plots sampled on each transect line.

To obtain a weighted value incorporating these unsampled, but analogous, areas, a proportion was set up with unweighted results over total acreage of each study area and weighted results over areas actually sampled, which were obtained by using a planimeter and a map showing transect lines drawn to scale. The formula for this is (R. Heath, personal communication, 1971): $\frac{u}{A} \cdot \frac{X}{a}$ when:

u = unweighted results

A = acres in each study area

X = weighted results

a = acres sample

When this equation was solved for X the weighted result was obtained. This is a more accurate estimation of coverage of submergent species.

Another phase of the analysis of the data collected for this study involved the determination of percent of association or concurrence between two or more species. These associations may or may not be the result of a synergistic relationship. They may or may not be important in establishing the value of an area for released mallards. They are measured here to reveal potentially important relationships deserving further study. To arrive at a percent of concurrency for species A and B, the number of plots in which species A occurs concurrently with species B is divided by the total number of plots in which species A was found. The number of plots in which species B occurred with species A is divided by the total number of plots in which species B was found. These two resulting percentages were summed and then divided by two to arrive at a percent of concurrence for species A and B.

Another useful statistic for evaluating the vegetation of each area is frequency of occurrence. Frequency of occurrence is obtained by dividing the number of plots in which a species occurred by the total number of plots in which the species could have occurred in its overall zone of distribution. Zonation of fresh-water aquatic vegetation is characteristic of almost all fresh-water aquatic habitat (Odum, 1964). The aquatic plants encountered in this study fall into three distinct zones: riparian, plants occurring in the shoreline terrestrial community; emergent aquatic, plants occurring in water less than 12 inches deep and having most of their leaf growth extending above the surface; submergent, plants occupying water more than 12 inches deep and having most of their leaf growth occurring on or below the surface. Figure 4 illustrates this zonation of aquatic habitat. The width of these zones varied from line to line. The riparian zone averaged 10 ft in extent, the emergent aquatic zone varied from 16 to 20 ft, and the submergent aquatic zone ranged from 30 to 55 ft.

Plants for Waterfowl

To understand the value of each water area for waterfowl, we must know something of the value of plant species for waterfowl. Since detailed food habits and stomach content analysis were not within the scope of this study, a review of the literature to obtain a general value of each species for mallard ducks was conducted. For the purpose of this study, it was assumed that plant species of value to mallard ducks of all ages elsewhere would be of value to those released on the navy base. Reports by Bellrose (1941), Bellrose and Anderson (1943), Chura (1961), Collias and Collias (1958, 1965), Fasset (1940), Krecker (1939), Low and Bellrose (1944), Martin and Uhler (1939), McAtee (1918, 1939), and Wetmore (1921) were referred to. Each plant species

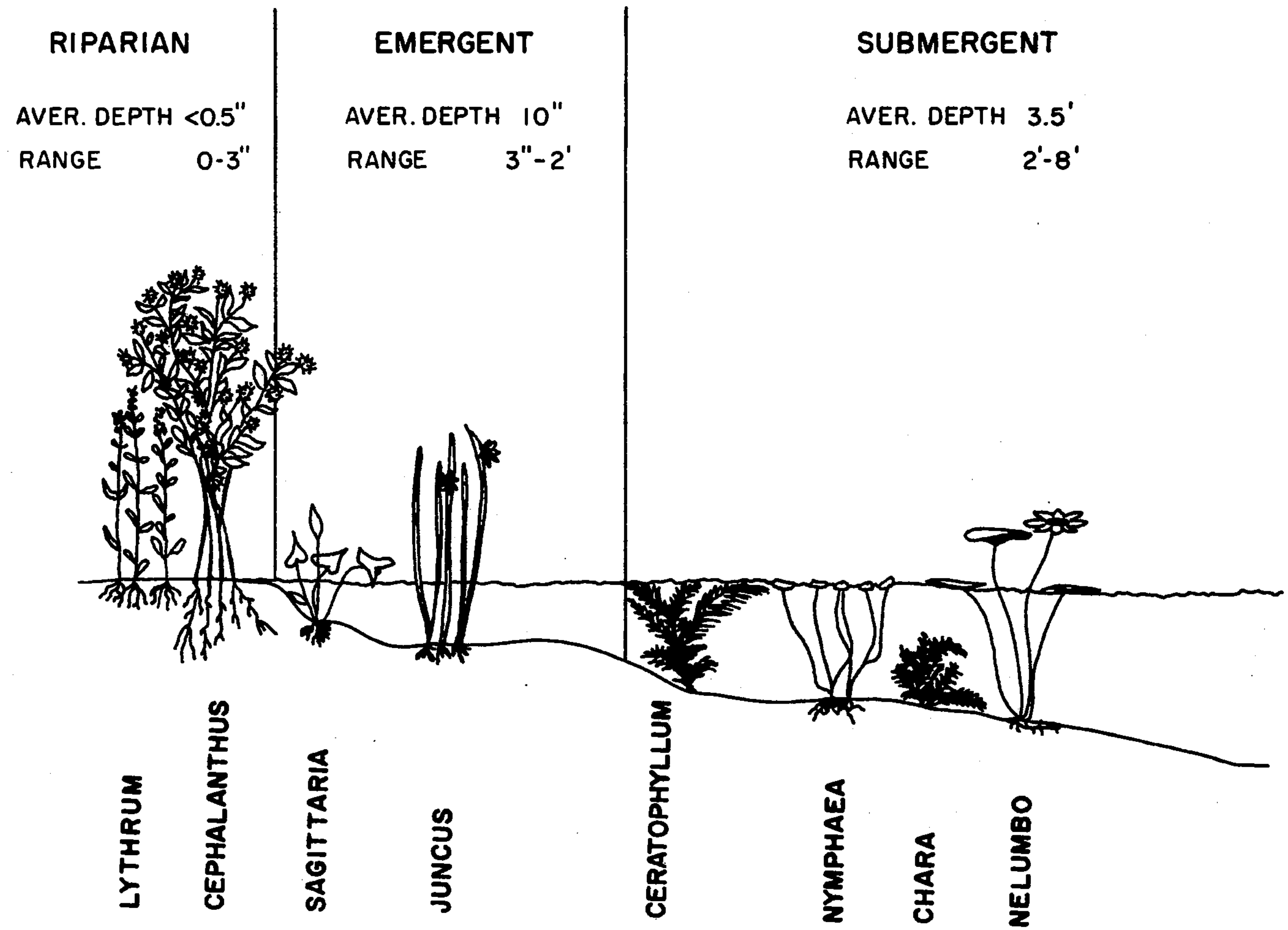


Figure 4. Stratification of Aquatic Plants in Rocket Lake and Duck Marsh

encountered during this study was given a subjective food value rating of none, poor, fair, good, or excellent based on its accounting in the above literature. These ratings were then converted into a numerical value of 0 to 4 for analytical purposes. With a value for weighted acres of coverage, frequency of occurrence, and value for waterfowl, a final value or waterfowl index could be obtained by multiplying these values. By summing the waterfowl indices for each lake a total value for the lake is obtained.

In mapping the vegetation on each area, another objective of this study was accomplished by using on-site visual observations in conjunction with data acquired from the line plot censuses, and to some extent from aerial photographs. Close-range photographic illustration of the study areas was prohibited by security regulations of the Navy base.

CHAPTER III

RESULTS AND DISCUSSION

Value of Plants for Waterfowl

Eighty-four plant species representing twenty-seven families were collected. They are listed aphabetically in Appendix B. Common names and authorities are included in this list.

Several plant species found on the study area are important foods for adult and immature mallards. The value of these plants for food may be in seed production, in vegetative parts, or in the entire plant. Table II contains the relative value of each species, portions of it usually consumed, and its general time of availability as food. If seed parts are an important food item, the time of availability refers to the time when seed production, ripening, or shattering occurs, whichever event is most significant to eventual ingestion by ducks.

Many plants having no food value for ducks are important for supporting a large number and variety of invertebrate animals as well as for providing escape and nesting cover. When evaluating plants having no intrinsic food value, such as Nelumbo lutea, it must be taken into account that many aquatic insects and other invertebrates exist in the habitat provided by their foliage. It is, therefore, difficult to say that a given species has no value for released mallards or their offspring. Prior to 2 or 3 weeks of age, the diet of ducklings consists mainly of terrestrial invertebrates. Beyond this age, the number of aquatic invertebrates in the diet exceeds that of terrestrial species. By the age of 7 weeks, the diet of the young has become identical to that of the adult, in which animal matter composes less than one percent of the diet (Chura, 1961).

Plants of Rocket Lake

Plot data from Rocket Lake appear in Table III, and values of the plants to waterfowl are shown in Table IV. The major riparian plants of Rocket Lake were Cephalanthus occidentalis, Cyperus erythrorhizos, Fimbristylis vahlii, Hydrolea ovata, and Panicum agrostoides. Prominent emergent species were Eleocharis quadrangulata, Eleocharis parvula, Juncus effusus, Jussiaea peploides, Polygonum hydropiperoides, Rhyncospora macrostachya, and Sagittaria latifolia. Submergent species of importance were Chara sp., Myriophyllum pinnatum, Najas guadalupensis, Potamogeton diversifolius and Potamogeton foliosus. In addition, the following were collected only at Rocket Lake: Eleocharis macrostachya, Hydrolea ovata, Myriophyllum pinnatum, Potamogeton foliosus and Sambucus canadensis.

Figure 5 is a map of the vegetation of Rocket Lake showing approximate locations of and areas covered by major plant species. Figure 6 shows approximate water depths as well as locations of transect lines used in sampling vegetation. The average water depth in Rocket Lake was 3.9 ft. However, depths up to 18 ft occurred in the north end of the Lake.

Several of the species listed as components of the flora of Rocket Lake appeared concurrently and were considered as associations. Table

TABLE III

RELATIVE ABUNDANCE OF PLANTS AT ROCKET LAKE

Species	No. of Lines of Occurrence	No. of Plots of Occurrence From Total 200 (Frequency)	Frequency Percent	Percent of Coverage	Unweighted Acres of Coverage	Weighted Acres of Coverage
Chara Sp.	15	67	84	25.5	5.04	12.5
Cyperus erythrorhizos	12	39	65	8.3	1.66	----
Polygonum hydropiperoides	16	37	62	5.7	1.44	----
Jussiaea peploides	12	31	52	7.5	1.56	----
Fimbristylis vahlii	9	25	42	6.5	1.30	----
Juncus effusus	11	20	33	7.5	1.50	----
Hydrolea ovata	11	18	30	2.9	0.58	----
Eleocharis parvula	8	17	28	4.5	0.92	----
Panicum agrostoides	9	13	22	1.9	0.38	----
Eleocharis quadrangulata	6	12	20	4.2	0.84	----
Najas quadalupensis	5	9	11	0.5	0.10	0.25
Panicum anceps	6	7	12	0.7	0.14	----
Cephalanthus occidentalis	6	6	10	0.6	0.12	----
Rhyncospora macrostachya	6	6	10	0.9	0.18	----
Potamogeton foliosus	5	6	7.5	0.4	0.08	0.20
Carex lupuliformis	2	5	8.0	1.6	0.52	----
Eleocharis obtusa	2	4	6.6	0.6	0.12	----
Ludwigia palustris	4	4	6.6	0.2	0.04	----
Juncus diffusissimus	3	3	5.0	0.2	0.04	----
Uniola latifolia	3	3	5.0	0.4	0.08	----
Myriophyllum pinnatum	1	3	4.0	0.5	0.10	0.25
Potamogeton diversifolius	1	2	2.5	0.1	0.02	0.05
Sagittaria latifolia	2	2	3.0	0.1	0.02	----
Ceratophyllum demersum	2	2	2.5	0.1	0.02	0.05

TABLE III (Continued)

Species	No. of Lines of Occurrence	No. of Plots of Occurrence From Total 200 (Frequency)	Frequency Percent	Percent of Coverage	Unweighted Acres of Coverage	Weighted Acres of Coverage
Sambucus canadensis	1	2	3	.2	.04	----
Setaria viridis	1	1	1.6	.2	.02	----
Carex Muhlenbergii	1	1	1.6	.1	.02	----
Echinochloa crusgalli	1	1	1.6	.1	.02	----
Nelumbo lutea	1	1	1.2	.5	.10	.25
Setaria lutescens	1	1	1.6	.2	.04	----

TABLE IV

SIGNIFICANCE AS WATERFOWL FOOD OF PLANTS AT ROCKET LAKE

Species	Value Rating for Waterfowl[a]	Relative Value to Waterfowl[b]
Chara Sp.	3	6652
Cyperus erythrorhizos	2	1040
Polygonum hydropiperoides	4	1488
Jussiaea peploides	2	780
Fimbristylis vahlii	0	0
Juncus effusus	3	743
Hydrolea ovata	0	0
Eleocharis parvula	2	258
Panicum agrostoides	0	0
Eleocharis quadrangulata	4	320
Najas guadalupensis	2	11
Panicum anceps	0	0
Cephalanthus occidentalis	3	18
Rhyncospora macrostachya	3	27
Potamogeton foliosus	2	6
Carex lupuliformis	2	26
Eleocharis obtusa	2	8
Ludwigia palustris	0	0
Juncus diffusissimus	0	0
Uniola latifolia	0	0
Myriophyllum pinnatum	3	6
Potamogeton diversifolius	1	0
Sagittaria latifolia	2	6
Ceratophyllum demersum	3	1
Sambucus canadensis	0	0
Setaria virdis	0	0
Carex Muhlenbergii	2	1
Echinochloa crusgalli	4	1
Nelumbo lutea	2	10
Setaria lutescens	0	0

[a]From Table II

[b]Frequency x Percent of Coverage x Rating = Relative Value to Waterfowl.

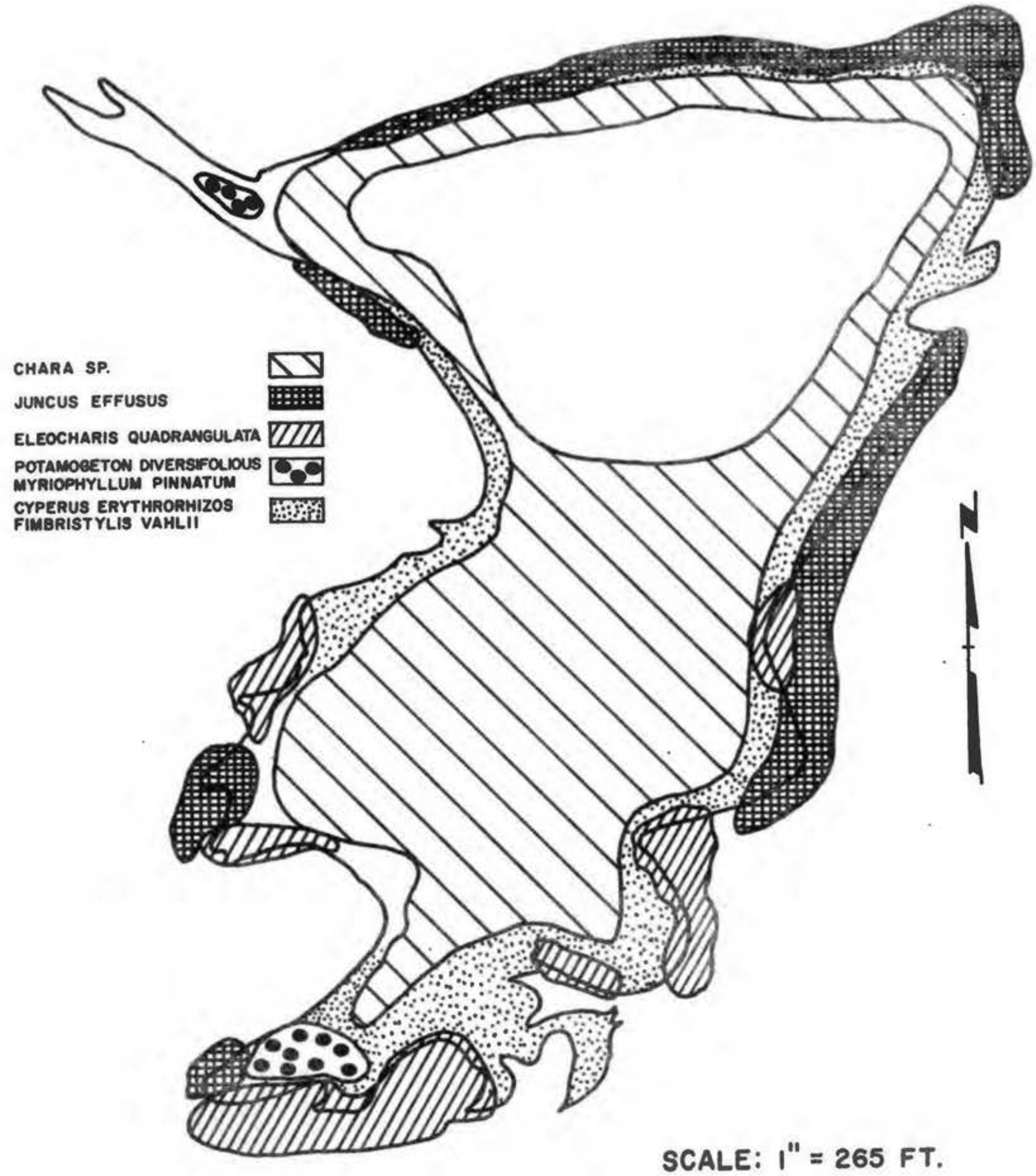


Figure 5. Distribution of Major Plant Species, Rocket Lake

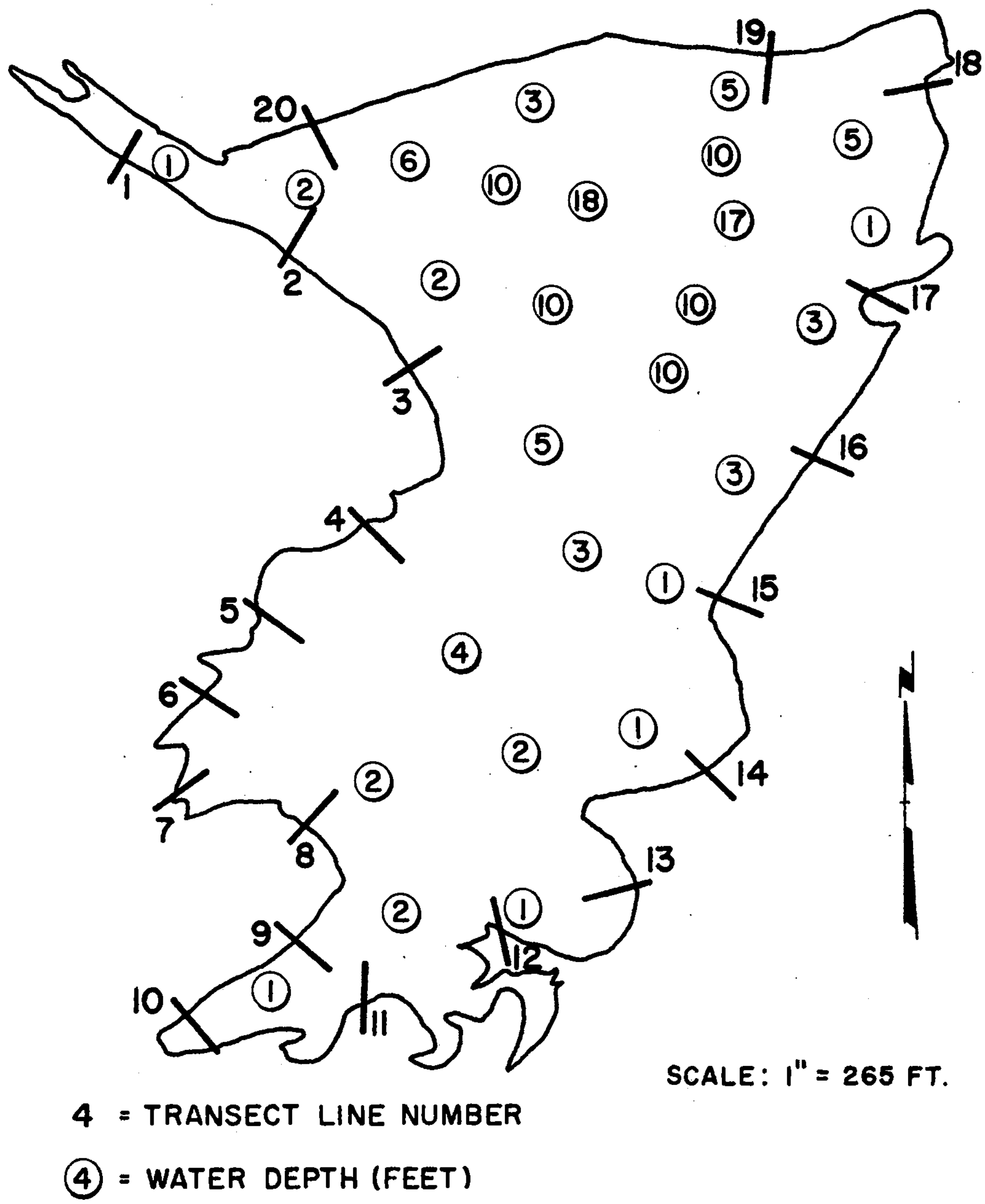


Figure 6. Location of Transect Lines (Not to Scale) and Water Depths of Rocket Lake

V shows these associations as percent of concurrence within one plot.

A riparian zone association was found to occur between two pioneering species. As water levels receded in late summer Cyperus erythrorhyzos and Fimbristylis vahlii constituted an invading association, occurring together in 52 percent of the area on newly exposed shoreline. Of these two species, only C. erythrorhyzos is of value to mallards, having a rating of fair. This association, therefore, contributes little to the value of Rocket Lake for McGraw Mallards.

Among emergent species, two associations appear: Polygonum hydropiperoides grows in concurrence with Juncus effusus in 46 percent of the area and with Eleocharis quadrangulata in 66 percent of the area. All three of these species (P. hydropiperoides, J. effusus, and E. quadrangulata) are of above average value to mallards. These associations are important to the overall suitability of Rocket Lake for the introduction of McGraw Mallards. Another emergent aquatic species, Jussiaea peploides occurs concurrently with several species at the ecotone between the riparian and emergent aquatic zones. Such species as Cyperus erythrorhizos (22 percent concurrence) and Panicum agrostoides (38.5 percent concurrence) are examples of this.

In deeper water having depths exceeding 1 ft, Chara sp. is the dominant submergent aquatic species. Najas guadalupensis, another submergent aquatic species occurs at a rate of 38.5 percent concurrently with Chara sp. These two species are rated as fair to good sources of food for mallards. This association could, therefore, be important to released mallards.

TABLE V

PERCENTAGE[a] OF CONCURRENCE OF SEVERAL PLANTS OF ROCKET LAKE

	Chara Sp. (S)	Cyperus erythrorhizos (R)	Polygonum hydropiperoides (R)	Jussiaea peploides (E)	Fimbristylis vahlii (R)	Juncus effusus (R)	Hydrolea ovata (R)	Eleocharis parvula (R)	Panicum agrostoides (R)	Eleocharis quadrangulata (R)	Najas Guadalupensis (S)
Chara Sp. (S)[b]	---	---	---	9	---	---	---	---	---	---	10
Cyperus erythrorhizos (R)	---	---	5	21	36	---	13	10	10	---	---
Polygonum hydropiperoides (R)	---	5	---	16	8	32	22	+	14	32	---
Jussiaea peploides (E)	19	23	19	---	13	10	6	6	23	6	---
Fimbristylis vahlii (R)	---	68	16	20	---	+	20	28	24	+	---
Juncus effusus (R)	---	---	60	15	+	---	15	---	10	+	---
Hydrolea ovata (R)	---	25	40	10	25	15	---	15	10	---	---
Eleocharis parvula (R)	---	24	+	12	41	---	24	---	+	---	12
Panicum agrostoides (R)	---	31	38	54	46	15	50	+	---	+	---
Eleocharis quadrangulata (E)	---	---	100	17	+	+	---	---	+	---	---
Najas Guadalupensis (S)	67	---	---	33	---	---	---	22	---	---	---

[a]If occurrence in one plot only, + is used.

[b]R = riparian
E = emergent aquatic
S = submergent aquatic

Plants of Duck Marsh

Due to low water and a resultant lack of aquatic vegetation, five transect lines, Numbers 23, 25, 26, 27, and 28 were not read. A total of 40 transect lines and 880 plots in Duck Marsh were read and the data analyzed.

Vegetation data collected from Duck Marsh are presented in Table VI. The value of plant species of Duck Marsh are given in Table VII. Major riparian plant species on Duck Marsh were Cephalanthus occidentalis, Echinochloa crusgalli, Hybiscus militanis, Leersia oryzoides, and Tridens strictus. Prominent emergent species of Duck Marsh are similar to those of Rocket Lake: Eleocharis quadrangulata, Juncus effusus, Jussiaea peploides, Polygonum hydropiperoides, Rhyncospora macrostachya and Sagittaria latifolia. The most obvious difference between the vegetation of Rocket lake and Duck Marsh was in the submergent aquatic species. Dominant submergent aquatic species on Duck Marsh were Ceratophyllum demersum, Potamogeton nodosus, Najas quadalupenis, Nelumbo lutea, Utricularia gibba and Nuphar advena. Fourteen species of plants found on Duck Marsh were not present on Rocket Lake: Ammannia coccinea, Echinodorus cordifolius, Hibiscus militaris, Jussiaea decurrens, Lemna minor, Ludwigia palustris, Nuphar advena, Nymphaea odorata, Polygonum bicorne, Polygonum coccinium, Polygonum lapathifolium, Potamogeton nodosus, Potamogeton pectinatus and Utricularа gibba.

Figure 7 depicts the approximate location and area of coverage of major plant species at Duck Marsh. Table VIII presents percent of concurrence of several species of plants at Duck Marsh. Some of the

TABLE VI

RELATIVE ABUNDANCE OF PLANTS AT DUCK MARSH

Species	No. of Lines of Occurrence	No. of Plots of Occurrence From Total 880 (Frequency)	Frequency of Occurrence Percent	Percent of Coverage	Unweighted Acres of Coverage	Weighted Acres of Coverage
Ceratophyllum demersum	36	425	82	39.2	54.8	97
Nelumbo lutea	30	421	81	33.6	47.1	85
Polygonum hydropiperoides	18	190	78	16.0	22.4	-----
Jussiaea peploides	21	98	40	5.9	8.3	-----
Eleocharis quadrangulata	11	53	22	3.6	5.0	-----
Juncus effusus	10	38	16	2.9	4.0	-----
Najas guadalupensis	6	37	7	2.5	3.4	6
Cephalanthus occidentalis	20	34	28	1.7	2.4	-----
Nymphaea odorata	3	14	3	1.0	2.1	2.1
Echinochloa crusgalli	10	13	11	0.6	0.9	-----
Potamogeton nodosus	7	12	2	0.8	1.1	1.9
Leersia oryzoides	3	10	8	0.5	0.7	-----
Cyperus erythrorhizos	8	9	4	0.6	0.8	-----
Utricularia gibba	2	5	2	0.27	0.2	-----
Tridens strictus	2	5	4	0.2	0.2	-----
Ammannia coccinea	3	4	3	0.1	0.1	-----
Chara Sp.	1	4	0.7	0.1	0.1	0.2
Rhynchospora macrostachya	4	4	3	0.3	0.4	-----
Typha latifolia	1	3	1	0.1	0.1	-----
Alisma plantago-aquatica	2	2	2	0.03	0.04	-----
Cyperus globulosus	1	2	2	0.02	0.03	-----
Eleocharis parvula	1	2	2	0.1	0.2	-----
Lobelia cardinalis	1	2	2	0.03	0.04	-----
Mimulus alatus	2	2	2	.1	.2	-----

TABLE VI (Continued)

Species	No. of Lines of Occurrence	No. of Plots of Occurrence From Total 880 (Frequency)	Frequency of Occurrence Percent	Percent of Coverage	Unweighted Acres of Coverage	Weighted Acres of Coverage
Carex Frankii	1	1	0.8	.03	.05	-----
Hibiscus militaris	1	1	0.8	.03	.04	-----
Lemna Sp.	1	1	0.2	.01	.02	-----
Lythrum alatum	1	1	0.8	.06	.1	-----
Setaria viridis	1	1	0.8	.01	.02	-----
Setaria lutescens	1	1	0.8	.01	.02	-----
Uniola latifolia	1	1	0.8	.01	.02	-----
Nuphar advena	1	2	2	.1	.2	.35

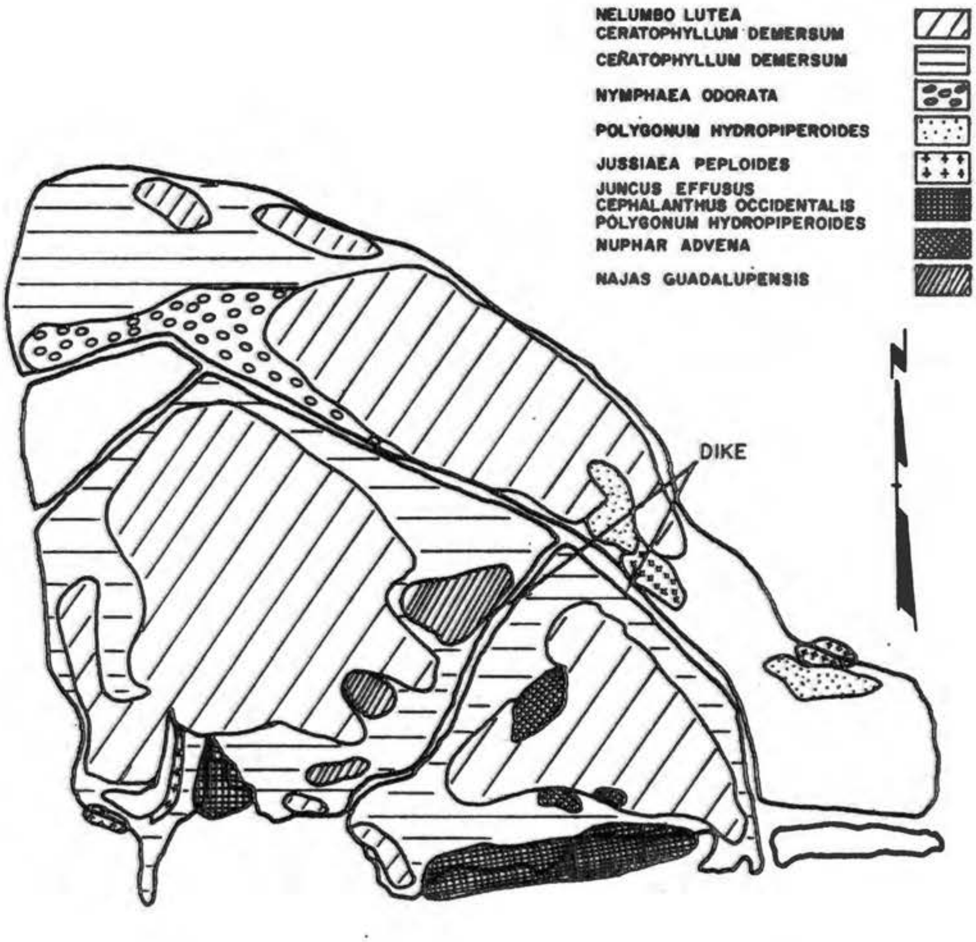
TABLE VII

SIGNIFICANCE AS WATERFOWL FOOD OF PLANTS AT DUCK MARSH

Species	Rating for Waterfowl[a]	Relative Value to Waterfowl[b]
Ceratophyllum demersum	3	9594
Nelumbo lutea	2	5443
Polygonum hydropiperoides	4	4992
Jussiaea peploides	2	480
Eleocharis quadrangulata	4	357
Juncus effusus	3	144
Najas guadalupensis	2	35
Cephalanthus occidentalis	3	168
Sagittaria latifolia	2	42
Nymphaea odorata	1	3
Echinochloa crusgalli	4	26
Potamogeton nodosus	1	2
Leersia oryzoides	3	12
Cyperus erythrorhizos	2	5
Utricularia gibba	4	2
Tridens strictus	0	0
Ammannia coccinea	0	0
Chara Sp.	3	0
Rhynchospora macrostachya	3	3
Typha latifolia	1	0
Alisma plantago-aquatica	1	0
Cyperus globulosus	0	0
Eleocharis parvula	2	8
Lobelia cardinalis	0	0
Mimulus alatus	0	0
Carex Frankii	2	2
Hibiscus militaris	2	1
Lemna minor	4	1
Lythrum alatum	0	0
Setaria viridis	0	0
Setaria lutescens	0	0
Uniola latifolia	0	0
Nuphar advena	1	4

[a]From Table II

[b]Frequency x Percent of Coverage x Rating = Relative Value to Waterfowl.



SCALE: 1" = 600 FT.

Figure 7. Distribution of Major Plant Species, Duck Marsh

TABLE VIII

PERCENTAGE[a] OF CONCURRENCE OF SEVERAL PLANTS AT DUCK MARSH

	Ceratophyllum demersum (S)	Nelumbo lutea (S)	Polygonum hydropiperoides (E)	Jussiaea peploides (E)	Eleocharis quadrangulata (E)	Juncus effusus (E)	Najas guadalupensis (S)	Cephalanthus occidentalis (R)	Sagittaria latifolia (E)	Echinochloa crusgalli (R)	Nymphaea odorata (S)	Potamogeton nodosus (S)	Leersia oryzoides (R)	Cyperus erythrorizos (R)	Utricularia gibba (S)
Ceratophyllum demersum (S)[b]	---	61	7	9	2	1	5	2	1	---	3	1	---	---	+
Nelumbo lutea (S)	61	---	28	10	4	3	4	3	3	+	---	1	1	+	1
Polygonum hydropiperoides (E)	16	52	---	10	11	7	2	7	7	4	+	---	4	---	1
Jussiaea peploides (E)	37	41	6	---	17	7	3	13	19	5	---	+	2	3	+
Eleocharis quadrangulata (E)	17	34	40	32	---	25	+	13	10	---	---	---	---	---	---
Juncus effusus (E)	8	34	37	18	11	---	---	+	+	+	---	---	+	---	5
Najas guadalupensis (S)	54	41	8	8	+	---	---	---	5	---	+	+	---	---	+
Cephalanthus occidentalis (R)	21	38	35	38	21	+	---	---	6	+	---	---	+	+	---
Sagittaria latifolia (E)	9	33	36	58	15	+	6	6	---	6	---	---	---	+	---
Echinochloa crusgalli (R)	---	+	61	38	---	+	---	+	15	---	---	---	+	46	---
Nymphaea odorata (S)	71	---	+	---	---	---	+	---	---	---	---	21	---	---	---
Potamogeton nodosus (S)	50	33	---	+	---	---	+	---	---	---	25	---	---	---	---
Leersia oryzoides (R)	---	30	70	20	---	+	---	+	---	+	---	---	---	---	---
Cyperus erythrorizos (R)	---	+	---	44	---	---	---	+	+	56	---	---	---	---	+
Utricularia gibba (S)	40	60	60	80	---	40	+	---	---	---	---	---	---	+	---

[a] If occurrence in one plot only, + is used.

[b] R = riparian zone; E = emergent aquatic zone; S = submergent aquatic zone

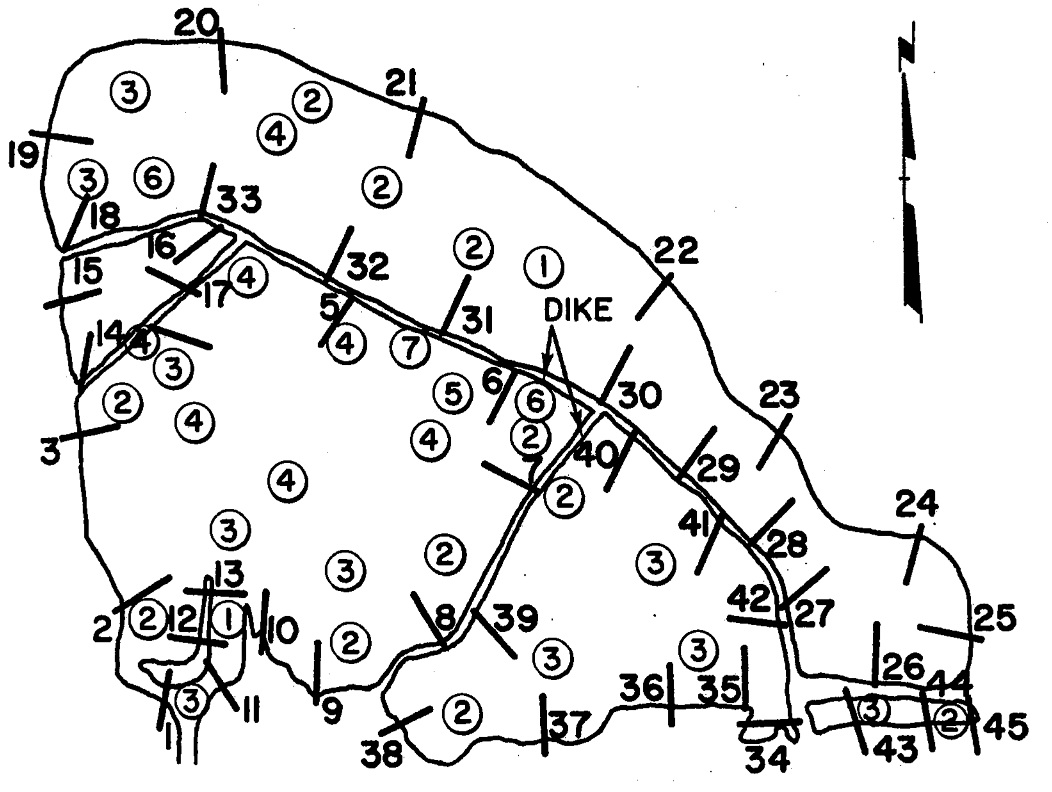
same plant associations occurring on Rocket Lake were found also on Duck Marsh. Emergent species Polygonum hydropiperoides, Juncus effusus and Eleocharis quadrangulata occur together at a lesser rate. P. hydropiperoides occurs jointly with J. effusus 18.5 percent of the time and with E. quadrangulata 25.5 percent of the time. Ceratophyllum demersum and Nelumbo lutea formed a dominant association among submergent species occurring jointly 61 percent of the time. It was observed that as the percent of coverage of Nelumbo lutea increased the percent of Ceratophyllum demersum decreased. This reduced growth of C. demersum probably results from a decrease in photopenetration due to a dense canopy of N. lutea. A completed or nearly complete canopy of N. lutea, according to Low and Bellrose (1944), can reduce the vegetative yield of C. demersum by as much as one-fourth. This same effect would probably occur with other submergent species such as Potamogeton pectinatus and Najas guadalupensis growing under a canopy of N. lutea. On Duck Marsh, as in Rocket Lake, a high percent of concurrence among species occurred at the ecotone. For example, Nelumbo lutea and Polygonum hydropiperoides occurred at a rate of 40 percent at the ecotone between emergent and submergent aquatic vegetation. Jussiaea peploides, another emergent aquatic, occurred with N. lutea at a rate of 25.5 percent at the emergent-submergent ecotone. Since P. hydropiperoides has good value as a food source for ducklings, the association of P. hydropiperoides and N. lutea could be important, especially if the presence of N. lutea reduces the production of P. hydropiperoides. The other ecotone association, J. peploides, N. lutea, offers little benefit of food to ducklings.

Water depths and transect line locations for Duck Marsh are shown in Figure 8. The average depth of water in Duck Marsh was 2.96 ft. The deepest water in Duck Marsh was 8 ft and occurred where excavation ditches remain after dike construction.

The value of plants as food for mallard ducks and ducklings at Duck Marsh and Rocket Lake is quite different. This can be visualized by adding the figures for "Relative Value to Waterfowl" from Table IV and VII. The total for Rocket Lake is 11,393 and for Duck Marsh is 21,314. These figures are independent of lake size since only percent is used. However, these data show the contrast between the two lakes. If "Relative Values to Waterfowl" of those plant species that are important sources of invertebrate food (Table II) are added, the total for Rocket Lake is 7,432 and for Duck Marsh is 15,393. Because ducklings up to 5 weeks of age depend to a large extent on aquatic invertebrates for food, the difference between Duck Marsh and Rocket Lake becomes important. Duck Marsh, therefore, is a more suitable habitat in which to rear ducklings, and this fact could also influence acceptance of Duck Marsh and rejection of Rocket Lake as nesting areas by adult females.

Evaluation of Sampling Technique

The technique used to analyze the vegetation in this study proved suitable and efficient. One of the major difficulties reported in other techniques for describing vegetatively an aquatic area was the amount of time involved in field application. For example, Wood (1963), using scuba equipment, spent 4 hr in preparation for 1 hr of data collection. The type and amount of data collected in the present study were equivalent to that obtained by Wood (1963), but much less time was



SCALE: 1" = 600 FT.

4 = TRANSECT LINE NUMBER

(4) = WATER DEPTH (FEET)

Figure 8. Location of Transect Lines (Not to Scale) and Water Depths of Duck Marsh

necessary for collection. A modified canopy-coverage method such as the one used in this study requires very little preparation and yields good quantities of data per hour of collecting. Between 50 and 60 plots can be read in 1 hr by an experienced observer. The author noticed that as the number of completed plots increased, the amount of time it took to read subsequent plots declined. This is due mainly to familiarity with the equipment and techniques and a resultant decrease in the time necessary to judge the percent of canopy coverage of a particular species. After this point of proficiency was reached, most of the field time was spent in recording data.

Differences Between Vegetation of Duck Marsh and Rocket Lake

The vegetative differences between Rocket Lake and Duck Marsh, as seen in Table III and VI, could result from several causes. Soils of Rocket Lake and Duck Marsh are grossly similar, but minor differences could contribute to differences in species composition. The TNT wash water added to Rocket Lake may also explain the difference between these two areas. The effect of this pollutant, in the form of nitrogen fertilizers, may increase the growth potential of early-season species. This pollutant also increases the salt concentration and might explain why salt-tolerant species such as *Chara sp.* and *Eleocharis parvula* are abundant at Rocket Lake but rare at Duck Marsh.

Duck Marsh and Rocket Lake are in separate drainage systems (Figure 1), having no direct water linkage, and it may be presumed that their flora have developed independently. The relative ages of both areas could influence species dominance; Rocket Lake is 34 years older than Duck Marsh. Several periods of interrupted successional development have occurred in Rocket Lake, such as the 1947 dam break and subsequent drying up. (N.A.D. personal communication, 1970).

The presence of carp *Cyprinus carpio*, in Duck Marsh could affect the plants occurring there. Where carp are present, their grazing activities reduce the growth rate of many aquatic plant species (Theinen and Helm, 1954). Carp have been shown to have a marked effect on the abundance of *Chara sp.* and *Potamogeton pectinatus* in particular (Anderson, 1950). The abundance of carp in Duck Marsh may account for the lack of or reduced abundance of certain submergent species, such as *Chara sp.* and *Potamogeton sp.*, in comparison to Rocket Lake where few or no carp are present (Hodge, personal communication, 1970).

Water levels in Rocket Lake and Duck Marsh are directly related to precipitation. The section on climate (Table I) identifies an annual period of low precipitation beginning in December and continuing through March. This low winter-spring water level will retard the initiation of spring growth of species of emergent and submergent aquatics with growing seasons normally commencing in early spring. However, the boost in growth of early-developing species due to the presence of the TNT wash water pollutant in Rocket Lake may offset the repression of spring growth induced by low water level. This could affect species of *Sagittaria*, *Typha*, *Alisma*, *Eleocharis*, *Chara*, *Potamogeton*, *Myriophyllum* and *Najas*. This boosting of plant growth in Rocket Lake could be a partial explanation for the differences encountered in the emergent and submergent aquatic species making up the flora of Rocket Lake and Duck Marsh.

Management Suggestions

Several methods can be employed to influence the production of desirable and undesirable species of aquatic plants. High and low fluctuation of water levels has been used to effect positive or negative changes in plant production (Robel, 1962). Without another source of water to augment rainfall, the use of water levels as a management tool can be ruled out for Rocket Lake and Duck Marsh.

In Duck Marsh a reduction of the stands of Nelumbo lutea would be advantageous to mallards. This would encourage the growth of submergent plants with greater food value for mallard ducks and ducklings, especially those over 7 weeks of age. Production of submergent aquatics such as Ceratophyllum demersum and Potamogeton pectinatus would increase. A reduction of N. lutea could be accomplished by mowing or applying herbicides early in the growing seasons (Uhler, 1944). The removal of carp from Duck Marsh would also be advantageous to many submergent aquatics in Duck Marsh.

The ideal situation for releasing mallards and having them survive and reproduce should incorporate several elements. First it would be necessary to have controllable water levels. Levels could then be raised or lowered as necessary to maximize production of those species most desirable as food and cover for mallard ducks and ducklings. The deepest water, supporting submergent aquatics need not be over 4 ft deep. Submergent aquatic plants are particularly important as a major source of late summer and fall food. It would be advantageous to have a large proportion, perhaps one-fourth, of the water area less than 2 ft deep to support emergent aquatics. These species produce much seed and provide habitat for invertebrate animals, a major source of food for mallard ducklings and ducks during the late spring and early summer. Also, emergent aquatics are used as escape and loafing cover. Riparian species are also necessary for seed production used as a source of food in fall, winter and early spring. These shoreline species may in some instances supply nesting cover for mallard hens, which is important to the long-term suitability of an area for mallards (Dwyer, 1970). Riparian species do provide escape cover for ducklings and serve as a source of terrestrial invertebrates, another major food of young ducklings. The growth of riparian species can be increased by an increased area of gentle, sloping shores and the avoidance of or modification of steep, high banks, which are occupied by upland terrestrial species.

Additional studies are needed to determine procedures for benefitting the more desirable submergent, emergent and riparian species. Submergent aquatics which should be managed for optimum environment would include: Ceratophyllum demersum, Chara sp., Myriophyllum pinnatum, Najas guadalupensis, Potamogeton foliosus, P. pectinatus, Lemna minor, and Utricularia gibba. Emergent aquatic species which should be managed would include: Eleocharis parvula, E. quadrangulata, Juncus effusus, Polygonum hydropiperoides, Rhyncospora macrostacyha and Sagittaria latifolia. Riparian species to be managed should include: Cephalanthus occidentalis, Echinochloa crusgalli, and Leersia oryzoides.

The population of released mallard ducks and ducklings is affected by the quality and quantity of the aquatic plants making up their habitat. The vegetation of Rocket Lake and Duck Marsh includes several species, mentioned earlier, that are valuable as a food source. Duck Marsh appears to be more suited for nesting and brooding habitat for released mallards because it contains a relatively higher volume of plant species that supply duckling food than does Rocket Lake. Therefore, mallards would probably be more successful when released at Duck Marsh than at Rocket Lake.

CHAPTER IV

SUMMARY AND CONCLUSIONS

In the present study a frame-plot and transect-line technique was employed to describe the aquatic vegetation of two water areas in east-central Oklahoma into which McGraw mallards had been released. Difference in the aquatic vegetation composition and the effect of these differences on the released ducks were studied. Rocket Lake contains one major species of submergent aquatic plant, *Chara sp*. The major emergent aquatic plants of Rocket Lake are; *Polygonum hydropiperoides*, *Jussieae peploides* and *Juncus effusus*. Major riparian species are; *Cyperus erythrorhizos* and *Fimbristylis vahlii*.

The major submergent aquatic species on Duck Marsh are; *Ceratophyllum demersum* and *Nelumbo lutea*. The emergent aquatics predominating on Duck Marsh are *Polygonum hydropiperoides*, and *Jussiaea peploides*. The predominant riparian species on Duck Marsh is *Cephalanthus occidentalis*.

Reasons for the differences in dominant species on these two areas might be: relative age of impoundment nitrogen (N_aNO_2) pollutant in Rocket Lake; the abundance of carp and the extensive cover of *Nelumbo lutea* in Duck Marsh. Both areas have value as waterfowl areas and both might support a breeding population of released McGraw Mallards. Duck Marsh does appear to be superior for ducklings due to a superior cover of plants that provide food for young mallards.

The technique used to analyze the vegetation on these areas was successful in view of the objectives set forth to compare and contrast the vegetation of the two areas accurately and efficiently. A more detailed study or the food habits and stomach contents of released mallards and their offspring on both areas would enhance understanding the value of vegetation for released mallards on both areas. Studies for and the implementation of management techniques to manipulate the vegetation to favor those species most suitable as food and cover for mallards would also be advantageous to the eventual success of releasing mallards onto impoundments in Oklahoma.

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APPENDIX A

PLANTS LISTED BY COMMON NAME ONLY IN TEXT

Annual sedge	*Cyperus erythrorhizos* Muhl.
Beauty berry	*Callicarpa americana* L.
Big bluestem	*Andropogon Gerardi* Vitman
Bitternut hickory	*Carya cordiformis* (Wang) K. Koch
Black hickory	*Carya texana* Buckl.
Black oak	*Quercus velutina* Lam.
Black jack oak	*Quercus marilandica* Muenchh.
Blue-eyed grass	*Sisyrinchium campestre* Bickn.
Common alder	*Alnus serrulata* (Ait) Wildl.
Common smartweed	*Polygonum hydropiperoides* Michx.
Coontail	*Ceratophyllum demersum* L.
Deciduous holly	*Ilex decidua* Walt.
Deerberry	*Vaccinium stamineum* L.
Early buttercup	*Ranunculus fascicularis* Muhl.
False indigo	*Amorpha fruticosa* L.
Foxtail grass	*Setaria geniculata* (Lam.) Beauv.
Illinois bundle flower	*Desmanthus illinoensis* (Michx.) MacM.
Indian grass	*Sorghastrum nutans* (L.) Nash
Indian paint brush	*Castilleja indivisa* Engelm.
Iron wood	*Carpinum caroliniana* Walt.
Japanese bromegrass	*Bromus japonicus* Thumb.

Little barley	*Hordeum pusillum* L.
Little bluestem	*Andropogon scoparius* Michx.
Muskgrass	*Chara* sp.
Ohio buckeye	*Aesculus glabra* Willd.
Old man's beard	*Andropogon saccharoides* Sw.
Paw paw	*Asimina triloba* (L.) Duna
Post oak	*Quercus stellata* Wang
Prairie foxglove	*Penstemon arkansanus* Pennel
Prairie threeawn	*Aristida oligantha* Michx.
Primrose willow	*Jussiaea peploides* (HBK) Raven
Purple prairie clover	*Petalostemum purpureum* (Vent.) Rydb.
Red oak	*Quercus shumardii* Buckl.
River Birch	*Betula nigra* L.
Rose vervain	*Verbena canadensis*
St. John's wort	*Hypericum spathulatum* (Spach)
Scurff pea	*Psoralea psoralioides* (Walt.) Cory
Short-leaf pine	*Pinus echinata* Mill.
Soft rush	*Juncus effusus* L.
Spanish oak	*Quercus palustris* Muenchh.
Switch grass	*Panicum virgatum* L.
Water oak	*Quercus nigra* L.
Water pecan	*Carya aquatica* (Michx. F) Nutt.
White false indigo	*Baptisia leucophaea* Nutt.
Wild carrot	*Daucus pusillus* Michx.
Wild phlox	*Phlox pilosa* L.
Wing-rib sumac	*Rhus copallina* L.
Winged elm	*Ulmus alata* Michx.

Witch hazel	*Hamamelis vernalis* Sarg.
Yellow lotus	*Nelumbo lutea* (Willd.) Pers.

APPENDIX B

PLANTS COLLECTED FROM ROCKET LAKE AND DUCK MARSH

Alisma plantago-aquatica L., var. *parviflorum* (Pursh.) Torr.	water-plantain
Ammannia coccinea Rothb.	no common name
Bromus japonicus Thumb.	Japanese brome
Carex Frankii Kunth.	Frank's sedge
Carex lupuliformis Sartwell	large sedge
Carex Muhlenbergii Schkuhr., var. *Muhlenbergii*	Muhlenberg's sedge
Carex vulpinoidea Michx.	sedge
Castilleja coccinea (L.) Spreng., forma *coccinea*	scarlet painted-cup
Cephalanthus occidentalis L., var. *occidentalis*	button bush
Ceratophyllum demersum L.	coontail
Chara Sp.	
Cicuta maculata L.	spotted waterhemlock
Cyperus erythrorhizos Muhl.	annual sedge
Cyperus globulosus Aubl.	globular umbrella-sedge
Cyperus strigosus L.	umbrella-sedge
Desmanthus illinoensis (Michx.) MacM.	Illinois bundleflower
Echinodorus cordifolius (L.) Griseb.	burhead
Echinochloa crusgalli (L.) Beauv.	barnyardgrass
Eleocharis macrostachya Britt.	spike-rush

Eleocharis obtusa (Willd.) Schultes	spike-rush
Eleocharis parvula (R. & S.) Link, var. *anachaeta* (Torr.) Svens.	small spike-rush
Eleocharis quadrangulata (Michx.) R. & S.	four-angled spike-rush
Elymus villosus Muhl., *forma*. *arkansanus* (Scribn. & Ball) Fern.	hairy wildrye or soft wildrye
Erigeron tenuis T. & G.	annual fleabane
Fimbristylis vahlii (Lam.) Link	no common name
Hibiscus militaris Cav.	rose-mallow or marsh-mallow
Hydrolea ovata Nutt.	no common name
Juncus acuminatus Michx.	tapered rush
Juncus diffusissimus Buckl.	diffuse rush
Juncus marginatus Rostk.	rush
Juncus scirpoides Lam.	rush
Juncus effusus L.	Torrey's rush or soft rush
Jussiaea decurrens (Walt.) DC.	annual water primrose
Jussiaea peploides (HBK.) Raven, var. *glabrescens* (Ktze.) Shinners	primrose-willow
Leersia oryzoides (L.) Sw.	rice cutgrass
Lemna minor L.	duck weed
Lobelia cardinalis L.	cardinal flower
Ludwigia palustris (L.) Ell., var. americana (DC.) Fern. & Grisc.	water-purslane or false loosestrife
Lythrum alatum Pursh., var. *lanceolatum* (Ell.) T. & G.	winged-loosestrife
Mimulus alatus Ait.	monkey flower
Myriophyllum pinnatum (Walt.) BSP.	Pinnate-leaved water-milfoil

Najas guadalupensis (Spreng.) Magnus.	naiad
Nelumbo lutea (Willd.) Pers.	yellow lotus, water-chinquapin or wonkapin
Nuphar advena (Ait.) Ait. f., var. *advena*	spatterdock or cow lily
Nymphae odorata Ait.	fragrant water-lily
Nymphae odorata Ait., forma. *rubra* Guillon	red fragrant water-lily
Panicum agrostoides Spreng.	redtop panicum
Panicum anceps Michx.	beaked panicum
Panicum dichotomum L.	fall panicum
Panicum scoparium Lam.	broom panicum
Panicum virgatum L.	switchgrass
Paspalum dilatatum Poiret	dallisgrass
Paspalum setaceum Michs., var. *ciliatifolium* (Michx.) Vasey	no common name
Petalostemum purpureum (Vent.) Rydberg.	purple prairie clover
Polygonum bicorne Raf.	pinkweed
Polygonum coccinium Muhl.	swamp smartweed
Polygonum hydropiperoides Michx., var. *Bushianum* Stanford	mile water-pepper or common smartweed
Polygonum hydropiperoides Michx., var. *hydropiperoides*	mile water-pepper
Polygonum lapathifolium L.	curltop smartweed
Polygonum punctatum Ell.	dotted smartweed
Potamogeton diversifolius Raf.	diverse-leaved pondweed
Potamogeton foliosus Raf., var. *macellus* Fern.	leafy pondweed
Potamogeton nodosus Poiret	longlead pondweed

Potamogeton pectinatus L.	fennelleaf pondweed or or sago pondweed
Prunella vulgaris L., var. *lanceolata* (Bart.) Fern.	common selfheal
Rumex crispus L.	curled dock
Rhynchospora macrostachya Torrey	horned-rush
Sagittaria calycina Engelm.	arrowhead-lily or swamp potato
Sagittaria graminea Michx.	grassy arrowhead
Sagittaria latifolia Willd., var. *latifolia* forma. *hastata* (Pursh) Robins	duck potato or wapato
Sagittaria latifolia Willd., var. *latifolia*, forma. *latifolia*	arrowhead or duck potato
Sambucus canadensis L., var. *submollis* Rehd.	common elderberry
Scirpus californicus (C. Meyer) Steud.	hard-stem bulrush
Setaria lutescens (Wiegel) Hubb.	yellow foxtail
Setaria viridis (L.) Beauv.	green foxtail
Solanum elaeagnifolium Cav.	silverleaf nightshade
Specularia lamprosperma (McVaugh) Fern.	venus's looking glass
Spiranthes vernalis Engelm. & Gray	ladies' tresses or pearl twist
Sphenopholis obtusata (Michx.) Schribn.	prairie wedgegrass
Sporobolus pyramidatus (Lam.) Hitchc.	pyramidal dropseed
Teucrium canadense L., var. *canadense*	American germander
Tridens strictus (Nutt.) Nash	longspike tridens
Typha latifolia L., forma. *ambigua* (Sonder) Kronf.	broadleaved cattail or reed mace
Typha latifolia L., forma. *latifolia*	broadleaved cattail or reed mace

Uniola latifolia Michx.	broadleaf uniola
Utricularia gibba L.	humped bladderwort

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