April 1970. In June 1970, fingerling Roanoke bass and fingerling rock bass—again the spawn of the originally stocked fish—were quite abundant, but by the end of July, none could be collected by seining, and when the pond was drained in December 1970, only one rock bass was recovered—Roanoke bass fingerlings being entirely absent from the population.

The fingerling disappearances, both in 1969 and in 1970, occurred despite an abundance of forage-size golden shiners being available in the pond.

RELOCATION EXPERIMENTS

Attempts have been initiated to relocate Roanoke bass into three Piedmont streams which seemingly possess ideal habitat for this species although it is not known to be in these watersheds. Relocation experiments also have been initiated in two Piedmont and in one Coastal Plain reservoirs and into one Coastal Plain farm pond.

Results of these introductions, thus far, are not known.

SUMMARY

It has been concluded from this study that the Roanoke bass is a highly desirable panfish that is present in moderate numbers in several streams of the Tar River and the Neuse River Watersheds. The Roanoke bass grows both faster and to a larger size than its nearest relative the rock bass, as well as its closest associate, the redbreast sunfish, and does, in fact, attain trophy size for a panfish. It is an extremely game fish when taken on rod-and-reel, and is most delectable when placed upon the table. Further attempts at relocating this species in other suitable waters of the State will be pursued.

HYDROPHYTIC CHANGES RELATED TO LAKE FLUCTUATION AS MEASURED BY POINT TRANSECTS

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ABSTRACT

In the spring of 1970 and 1971, vegetation transects were run on 22,700 acre Lake Tohopekaliga in Osceola County, Florida. The objective of this study was to monitor the response of various plant types to a 7 foot drawdown and compare results with those from a study done in 1956.

As a result of dewatering, littoral vegetation advanced lakeward, expanding from an area of approximately 9,000 acres to 10,500 acres, a 16% increase. The significance of this plant response, relative to standing crop of fish and invertebrate fish-food organisms, is discussed.

Five of 16 dominant plant types occurred most frequently or had widest distribution during a high water period (1970). The remaining 11 occurred most frequently or had widest distribution during low water periods (1956 and 1971).

In the 1956 study it was assumed that water stage duration determined the distribution of annual and perennial plants. Data from the present study indicate distribution of vegetation within Tohopekaliga's basin is determined mainly by prevailing water levels during the growing season. The lakeward limit of perennial emergents is related to historically low water elevations.

INTRODUCTION

Tohopekaliga is a 22,700 acre lake located in western Osceola County, Florida. It is one of the larger lakes in the Kissimmee chain of lakes, a major source of water for Lake Okeechobee and southern Florida. The lake currently supports a productive and dynamic sport fishery which can be maintained provided effective fishery management techniques are developed and implemented.

Prior to 1964 the lake's level and surface area was determined principally by annual rainfall in the drainage basin. For the period of record between January 1942-64, the lake periodically fluctuated between 59.40 MSL (feet, mean sea level) and 48.93 MSL, a range of 10.47 feet (United States Geological Survey, unpublished).

The Central and South Florida Flood Control District completed construction of a concrete lock and spillway at the lake outlet in January, 1964, stabilizing the lake level and reducing by approximately 55 percent the historic natural range of water fluctuation. Between 1964-70, Tohopekaliga's level was controlled between 56.09-51.35 MSL, a difference of only 4.74 vertical feet. The present water regulation schedule is designed to permit only a 3 foot fluctuation between 55.0 MSL (high pool) and 52.0 MSL (low pool).

The immediate result of water level regulation was the elimination of a considerable portion of the natural flood plain and a permanent reduction in lake surface area. Encroachment of the flood plain by agriculture and urban development quickly followed.

Experienced field biologists have observed many insidious effects associated with stabilized lake levels in Florida, which contribute to accelerated eutrophication. The rapid accumulation of organic detritus and unconsolidated muds, loss of important rooted aquatic vegetation and concentration of nutrient-laden wastes finally culminates in continuous blue green algal blooms and essentially complete loss of desirable sport fisheries.

In an effort to maintain desirable aquatic habitat presently showing signs of degradation, an extreme drawdown was initiated on Tohopekaliga in 1971. Response to the drawdown by fishes, macro-invertebrates, algal communities, aquatic macrophytes, water quality and lake substrate is under study.

The purpose of this paper is to describe the response of aquatic macrophytes in Lake Tohopekaliga to a 7 foot artificial drawdown. Data collected during 1970 under controlled water regulation are compared with data gathered in 1971, three months after dewatering. Both are compared with results of a study done in 1956 during a natural low water period.

MATERIALS AND METHODS

The point transect method of measuring the vegetation was selected because it is rapid, reasonably accurate and amendable to statistical treatment. It has been used successfully in Florida by Sincock and Powell (1956), a study which included Lake Tohopekaliga, and more recently by Ager and Kerce (1970) on Lake Okeechobee.

Sincock and Powell (1956) established 17 transects at approximate 2 mile intervals, circumventing the lake basin. For the present study, transects were run which approximated ten of those (Figure 1). Although fewer in number, these areas were representative of dominant plant communities in the lake basin where the greatest response to dewatering was anticipated.

A surveyor's level and stadia rod were used to establish transect lines for the 1970-71 study at a landward elevation of 55.5 MSL, one-half foot above regulated high pool stage. Proceeding lakeward on a compass bearing, stakes were set at 6 inch contour intervals to a point at or beyond the lakeward extent of emergent vegetation (48.5-48.0 MSL).

In Sincock and Powell's work, done prior to lake stabilization, the landward extent of transects was established at 58.3 MSL, which was the upper limit of water level fluctuation for the period of record prior to 1956. To compare their results with those obtained in 1970 and 1971, data between elevations 55.3 and 48.8 were recalculated.

The sampling tool consisted of a horizontal, ¾ inch steel tube, 5.5 feet long, to which five ¼ by 10 inch steel rods were attached on 16 inch centers. Detailed design of the tool is described further by Sincock and Powell (1956) and Ager and Kerce (1970).

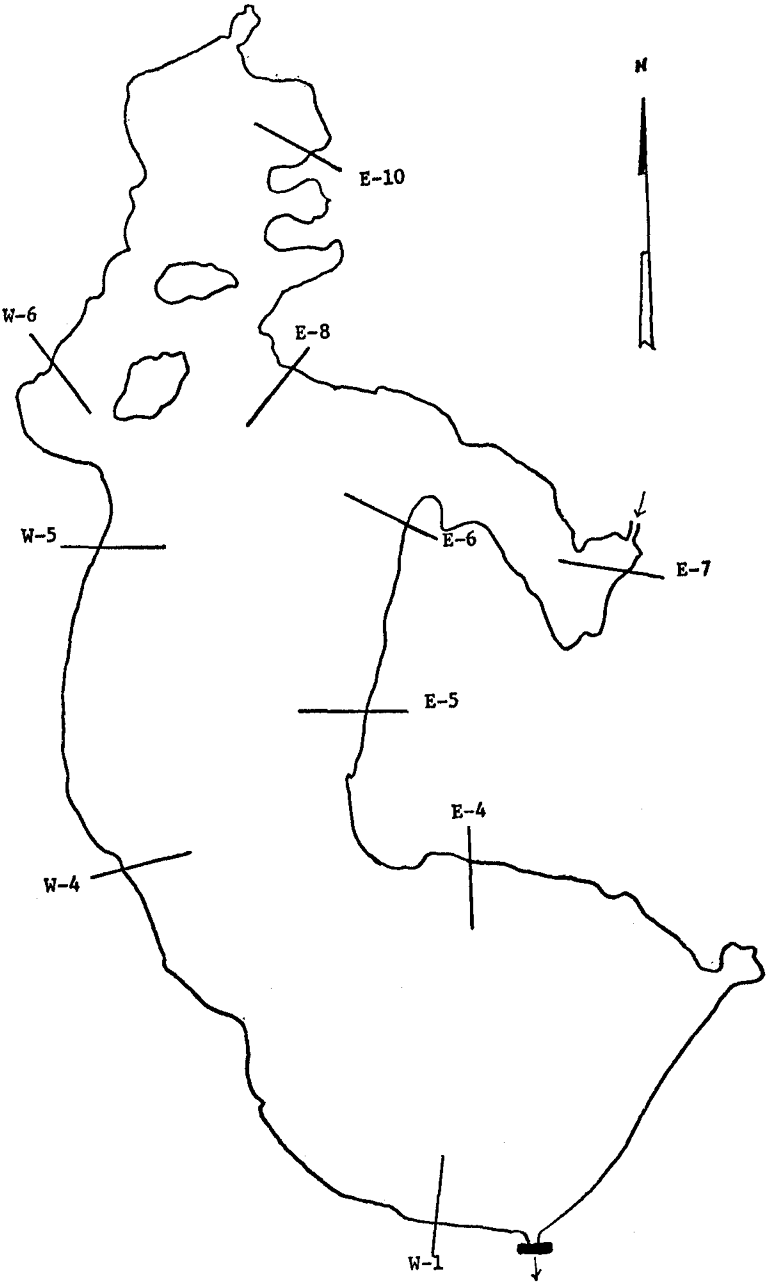

FIGURE 1. Outline map of Lake Tohopekaliga showing location of ten vegetation transects in 1956, 1970 and 1971. Numbers correspond to those established by Sincock and Powell (1956).

A "set" of the sampler was made every 15 feet along the transect by pacing. Vegetation touching each of the five points within 1 inch of the distal tip was recorded. If more than one plant species was touching, that nearest the tip was recorded. If no plant touched, bare ground was recorded. Vegetation unidentified in the field was collected and identified in the lab using taxonomic keys by Small (1933), Radford, Ahles, and Bell (1968) and Fassett (1960).

Field data were used to derive frequency of plant occurrence for total points taken, and distribution by contour elevation. Data were grouped by east or west shore as done in 1956.

The vegetation established lakeward of 49.0 MSL as a result of dewatering in 1971 was measured with a footage meter wheel at ¼ mile intervals around the entire shoreline to determine the acreage of expanded littoral vegetation.

RESULTS AND DISCUSSION

As mentioned, the point transect method is well adapted to large scale field studies because it is rapid and reasonably accurate. However, it has some obvious limitations. It does not sample different plant species with precise accuracy due to differences in growth forms. Plants like *Lindernia* or *Paspalum* which are repent or prostrate tend to be encountered more frequently than a plant like *Scirpus* which is erect and virgate. This also applies to single species having multiple growth forms. For example, mature *Panicum geminatum* is erect, but new seedlings are prostrate and sprawling. These limitations must be considered when evaluating the data. The method produced comparable results from transect to transect.

The natural drawdown of 1956 and the artificial one in 1971 were different in some respects. The principal difference was the length of time water levels were receding (Figure 2). From a peak of approximately 58 MSL in September 1953, the water gradually declined during a 36 month period, reaching approximately 50 MSL by August of 1956 when Sincock and Powell did their study. The artificial drawdown occurred in two phases over a 15 month period. From a normal high pool elevation of 55 MSL in March of 1970, the water receded on schedule to normal low pool elevation of 52 MSL by June. Due to drought conditions it did not rise again to high pool, usually occurring in November, but remained about 52 MSL until late winter of 1970. The scheduled drawdown begain February 1st and the lake level dropped from 52 to 49 MSL in a month, and to about 48 MSL by June, 1971.

The artificial drawdown of 1971 exposed approximately 50 percent of the lake basin, measured from high pool (55 MSL). Prior to drawdown the lakeward limit of rooted emergent vegetation was at 49 MSL. After dewatering, littoral vegetation advanced lakeward to 48 MSL, expanding from an area of approximately 9,000 acres to approximately 10,500 acres. This represents a 16 percent increase in area of littoral vegetation.

Table 1 presents plant types encountered during all study periods. A total of 89 different types were identified to genus or species. Fifty-three were present in 1956, 44 in 1970 and 44 in 1971. Only 12 types were present in all study years. Twenty-three different plant types occurred only in 1956, 15 only in 1970 and 11 only in 1971, demonstrating the dynamic character of the vegetation communities from year to year. The number of annuals and perennials present in each of the study years was similar. Most of the plants in Table 1 were encountered only a few times and only the dominant communities or those having particular importance to the fishery will be emphasized.

Table 2 lists plants occurring most frequently (expressed as percent of total points taken within all transects) during 1970. It also shows distribution of plants by contours occupied during each of the study periods. The last column shows differences in range of contours occupied by the plants, comparing 1956 and 1971 to 1970. With one exception, the vertical range in distribution of plants shown was greater in 1970.

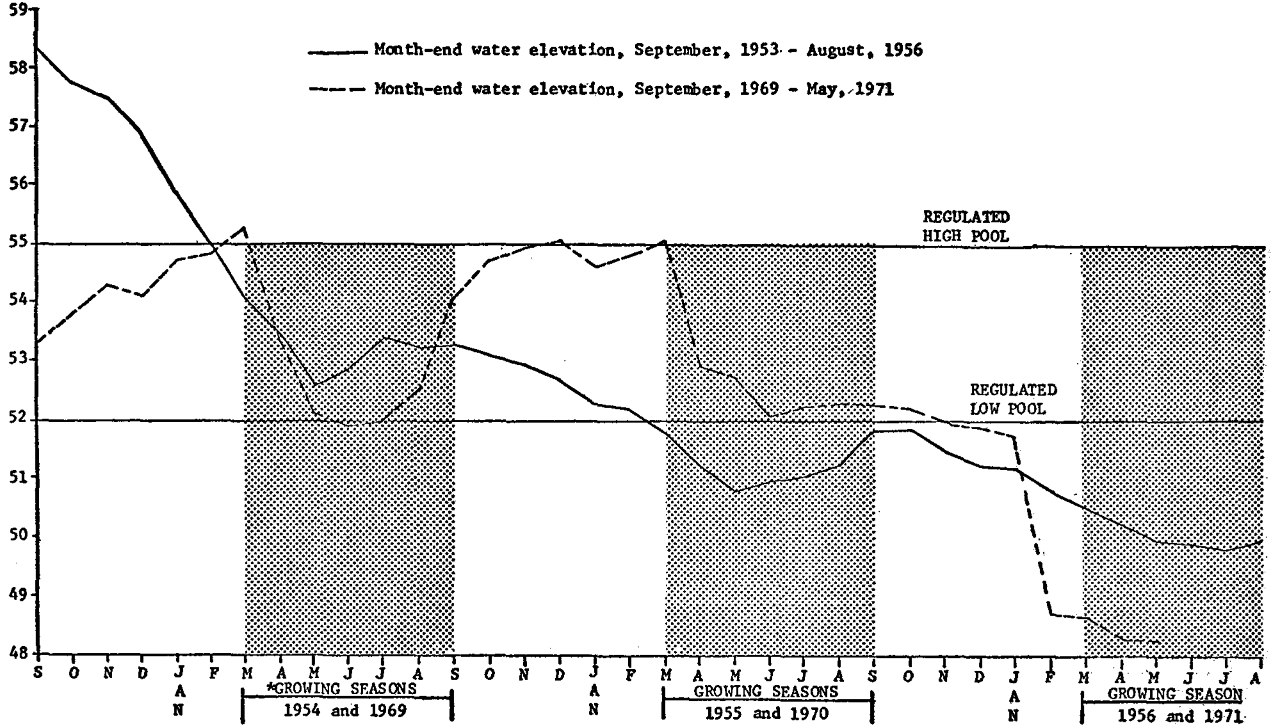

FIGURE 2. Water level fluctuations (feet, MSL) in Lake Tohopekaliga illustrating a period of natural (1953-56), and artificial (1970-present) drawdown using month-end elevations.
* March-September is considered the period of most active plant growth in Florida.

TABLE 1. Plant species encountered in vegetation transects run on Lake Tohopekaliga during 1956, 1970 and 1971

Plants Encountered	Recorded 56	70	71	A	P
Alternanthera philoxeroides		X	X		X
Andropogon spp.			X		X
Axonopus affinis		X	X		X
Axonopus furcatus			X		X
Axonopus spp.	X		X		X
Bacopa caroliniana	X			X	
Bulbostylis spp.	X		X	X	X
Centella repanda	X	X	X		X
Crotonopsis spp.	X			X	
Cynodon dactylon	X	X	X		X
Cyperus esculentus		X			X
Cyperus lecontei	X	X			X
Cyperus polystachyos		X		X	
Cyperus rivularis		X		X	
Cyperus spp.	X	X	X	X	X
Digitaria serotina	X	X	X	X	
Diodia virginiana			X		X
Diodia spp.	X	X	X	X	X
Echinochloa walteri	X		X	X	
Eclipta alba		X		X	
Eichhornia crassipes	X	X	X		X
Eleocharis acicularis		X	X		X
Eleocharis baldwinii	X			X	
Eleocharis caribaea		X		X	
Eleocharis obtusa		X		X	X
Eleocharis melanocarpa		X			X
Eleocharis parvula		X			X
Eleocharis spp.	X			X	X
Epilobium spp.		X			X
Erechtites hieracifolia	X			X	
Eriocaulon spp.	X				X
Eryngium prostratum	X		X		X
Eupatorium spp.	X		X	X	X
Fimbristylis autumnalis		X		X	
Fimbristylis spp.	X			X	X
Fuirena scirpoidea	X				X
Glottidium vesicarium	X		X	X	
Hydrochloa caroliniensis	X	X	X		X
Hydrocotyle umbellata		X	X		X
Hydrocotyle spp.	X				X
Hypericum fasciculatum	X				X
Hypericum spp.	X		X	X	X
Juncus marginatus			X		X
Juncus spp.			X	X	X
Lachnocaulon minus			X	X	
Lindernia anagallidea		X	X	X	
Lindernia grandiflora	X		X		X
Lindernia inequalis	X			X	
Lindernia spp.			X	X	X
Lippia nodiflora	X	X	X		X
Ludwigia arcuata	X	X	X		X
Ludwigia leptocarpa		X			X
Ludwigia spp.	X	X			X
Najas guadalupensis	X	X		X	
Najas minor		X		X	
Nuphar advena		X			X
Oldenlandia uniflora		X	X	X	

Plants Encountered	Recorded 56	70	71	A	P
Panicum dichotomiflorum			X	X	
Panicum geminatum		X	X		X
Panicum hemitomon	X	X	X		X
Panicum paludivagum	X		X		X
Panicum repens	X	X	X		X
Panicum spp.	X	X		X	X
Paspalum vaginatum		X	X		X
Paspalum dissectum			X	X	
Paspalum fluitans		X		X	
Paspalum spp.	X			X	X
Phytolacca americana			X		X
Pluchea spp.	X			X	X
Polygonum hydropiperoides		X	X		X
Polygonum punctatum	X		X	X	X
Polypremum procumbens	X				X
Pontederia cordata		X	X		X
Potomogeton illinoensis	X				X
Psilocarya nitens	X			X	
Rhexia spp.	X				X
Rhynchospora chalarocephala		X			X
Rhynchospora microcarpa	X				X
Rhynchospora odorata			X		X
Sagittaria graminea	X	X			X
Salix amphibia	X		X		X
Scirpus americanus	X				X
Scirpus californicus	X	X	X		X
Solidago spp.	X				X
Spartina Bakeri	X	X			X
Teucrium spp.	X				X
Typha latifolia	X				X
Utricularia spp.	X				X
Vallisneria americana	X	X			X

A = Annual
P = Perennial

Table 3 is similar to Table 2, but lists those plants with higher frequency and wider distribution during the low water years of 1956 and 1971.

The response by plant communities to different water levels was evident. Among the plants listed in Table 2, *Eichhornia crassipes* (water hyacinth) was the only floating aquatic sampled, though others were present. In 1970 it was encountered from the organic drift line at regulation high pool to the edge of the water at 52 MSL. Although present lakeward, it was not recorded since the sampler rested on the bottom beneath the plants. Hyacinths entrapped in zones of emergent vegetation develop into large rafts, completely shading out more desirable rooted emergents. Dewatering during 1971 virtually eliminated the plant from vegetated zones, and distribution was limited to narrow bands at the water's edge. Distribution was similar in 1956.

Eleocharis (spike-rush) is presented as a genus because the predominant species recorded in 1956 was *E. baldwinii* and in 1970-71 *E. acicularis*. In 1956 one or more additional spike-rushes were present but scarce and not identified to species. In 1970, *E. caribaea*, *E. obtusa*, *E. melanocarpa* and *E. parvula* were encountered rarely and distribution was scattered.

E. acicularis was apparently well adapted to fluctuation within the established water regulation schedule. For approximatley 24 months prior to the 1970 transect, the water level remained between 52-55 MSL and the plant established densely between 51.0 and 53.5 MSL. Evidently, establishment at these elevations is due to low pool stages during the

TABLE 2. Plants occurring most frequently or having widest distribution by elevation during 1970

Plants Encountered	Percent Occurrence 1956	1970	1971	Contours Occupied (MSL) 1956	1970	1971	Vertical range difference (ft.) 1956–1970	1970–1971
EAST SHORE								
Eichhornia crassipes	.89	1.83	.17	49.8–51.3	52.0–55.5	48.5–49.5	+2.0	+2.5
Eleocharis spp.	3.48	4.16	.17	49.3–55.3	*49.0–55.5	*50.0–52.5	+ .5	+4.0
Hydrochloa caroliniensis	2.09	3.80	1.43	49.8–54.3	50.5–55.5	51.0–55.0	+ .5	+1.0
Najas guadalupensis	.28	1.21	..	48.3–49.3	49.5–51.5	....	+1.0	..
Vallisneria americana	.79	3.35	..	48.3–49.8	50.0–52.0	....	+ .5	..
WEST SHORE								
Eleocharis spp.	1.54	3.68	.14	*49.8–54.3	*51.5–55.5	52.0–53.0	− .5	+3.0
Hydrochloa caroliniensis	1.64	9.86	5.87	49.8–53.8	51.5–55.5	*49.0–53.5	0	[1] + .5

1 Disregarding a single seedling (out of 128 plants encountered) at the 49.0 contour in 1971 (dry year), the distribution range during 1970 (wet year) was 2.0 feet greater than in 1971.
. . . Not encountered.
* Discontinuous within contours indicated.

TABLE 3. Plants occurring most frequently or having widest distribution by elevation during 1956 and 1971

Plants Encountered	Percent Occurrence 1956	1970	1971	Contours Occupied (MSL) 1956	1970	1971	Vertical range difference (ft.) 1956–1970	1970–1971
EAST SHORE								
Alternanthera philoxeroides	. .	.51	.43	. . . .	52.5–55.5	*50.5–55.5	. .	+2.0
Axonopus spp.	2.88	.30	.41	*50.8–55.3	*52.5–55.5	*51.0–55.5	+1.5	+1.5
Centella repanda	1.55	.06	.30	51.3–55.3	54.5–55.5	53.0–55.5	+3.0	+1.5
Cyperus spp.	1.48	1.00	8.74	*50.3–55.3	*52.0–54.5	48.5–55.0	+2.5	+4.0
Digitaria serotina	1.78	.34	5.51	*50.8–55.3	53.0–55.5	49.5–55.5	+2.0	+3.5
Ludwigia spp.	3.43	.14	.24	*49.8–55.3	*52.5–55.0	*49.0–54.0	+3.0	+2.5
Oldenlandia uniflora	. .	.06	4.99	. . . .	54.5–55.0	*48.5–55.0	. .	+6.0
Panicum geminatum	. .	1.27	3.02	. . . .	48.5–51.5	48.5–52.0	. .	+ .5
Panicum repens	6.85	3.30	5.63	50.3–55.3	*49.5–55.5	49.5–55.5	+1.0	.0
Paspalum spp.	5.70	4.38	9.57	49.8–55.3	52.0–54.5	48.5–55.0	+3.0	+4.0
Polygonum hydropiperoides	. .	.02	.88	. . . .	53.0–53.5	*48.5–53.5	. .	+4.5
WEST SHORE								
Alternanthera philoxeroides	. .	.24	.32	. . . .	52.5–54.0	*49.0–53.5	. .	+3.0
Axonopus spp.	1.23	1.05	1.93	*50.8–55.3	52.5–55.5	52.5–55.5	+1.5	0
Centella repanda	.70	.43	.60	*50.8–55.3	54.0–55.5	*52.5–55.5	+3.0	+1.5
Cyperus spp.	3.28	.48	16.15	50.3–54.8	52.5–53.5	*48.5–55.0	+3.5	+5.5
Digitaria serotina	3.05	1.82	6.24	50.3–55.3	53.0–55.5	*49.0–55.5	+2.5	+4.0
Ludwigia spp.[1]	2.07	.10	.28	*49.3–54.3	*51.0–55.5	48.5–53.0	− .5	−1.0
Panicum geminatum	. .	2.39	4.95	. . . .	49.0–51.0	48.5–51.5	. .	+1.0
Panicum repens	7.61	7.94	8.17	50.3–55.3	51.0–55.5	49.0–55.5	+ .5	+2.0
Paspalum spp.	6.78	1.87	8.43	49.8–54.8	52.0–54.0	*49.0–54.5	+3.0	+3.5
Polygonum hydropiperoides	. .	.05	.23	. . . .	55.0–55.5	49.0–52.5	. .	+3.0

[1] In 1970, only one plant occurred at each of the contours indicated. In fact, distribution in dry years was greater.
* Discontinuous within contours indicated.
. . . Not encountered.

major growing season. This conclusion is further supported by a scarcity of the plant on similar substrate at higher elevations which are dry or drying during the growing season. The data of 1971 clearly demonstrates the response of this plant to dewatering during the growing season.

Prior to the 1956 transect, the water level remained between 50-53 MSL, for 22 months, and *E. baldwinii* established densely between 49.3 and 51.8 MSL (Figure 2). *E. baldwinii* and *E. acicularis* developed under virtually identical conditions of shallow water and wet soil during one or more growing seasons. *E. acicularis* may have been misidentified as *E. baldwinii* in the 1956 study. The high frequency of occurrence in 1956 may be explained by the time of year when transects were run (August) and the gradual water recession, allowing ample time for the plant to migrate lakeward. Penfound (1953), observed similar movement by *E. macrostachya* for six fluctuating reservoirs in Oklahoma.

Hydrochloa caroliniensis (southern watergrass) is one of the dominant semi-aquatic grasses in the lake basin. It is well adapted to the established water regulation schedule, occurring most frequently above low pool stage in the zone of fluctuation. It exhibited a significant reduction in abundance and general distribution during 1971. Compared to 1970 data, a similar response is indicated for 1956.

Najas guadalupensis (southern naiad) occurred frequently in only one transect (E-7) during 1970, and was eliminated by dewatering in 1971.

Vallisneria americana (eelgrass) occurred frequently in 1970, in two transects on the east shore (E-6, 7). The plant was eliminated when exposed during drawdown in 1971. Eelgrass was encountered infrequently in 1956. It may have been abundant at higher elevations and eliminated by the receding water as occurred in 1971. The narrow band existing at the contours indicated was not exposed.

Table 3 lists eleven plant types which occurred most frequently and had widest distribution during the low water years 1956 and 1971. *Alternanthera philoxeroides* (alligatorweed) did not occur in the 1956 transects, and may be a recent invader of the lake basin. Frequency data for 1970-71 conflict somewhat, but expansion lakeward as a result of dewatering is evident.

Axonopus (carpetgrass) and *Centella repanda* (centella) were encountered in all three study periods. Response to changes in water level were similar. Generally, frequency and range distribution were limited during the higher water of 1970, compared to the low water years of 1956 and 1971.

The genus *Cyperus* (nutgrass) showed an immediate and dramatic response to dewatering. It spread throughout the exposed areas and was the most numerous plant group encountered in 1971. Many of the plants encountered were immature and not identified to species because transects were run earlier than in 1970.

Digitaria serotina (crabgrass) was the only annual plant encountered in all three study periods in significant numbers. Like nutgrass, it responded dramatically to dewatering, increasing in frequency and extent.

The genus *Ludwigia* (false loosestrife) represented mainly by *L. arcuata* responded slowly, but data from 1956 indicate that increases in abundance and distribution are related to the length of time the water is down.

Oldenlandia uniflora (oldenlandia), an annual, was not encountered in 1956, and occupied only three transect points in 1970. After dewatering, it spread rapidly on the east shore of the lake, increasing in frequency almost 5 percent and expanding 6 vertical feet in contour distribution.

Panicum geminatum (panicgrass) was not recorded in 1956 and may be another species only recently established. In 1956, one or more panicums were present and not identified. They occurred approximately 3 feet above the water level. Had *P. geminatum* been present, it would have been at or near the water's edge as demonstrated in 1971. It is now an important aquatic grass in Tohopekaliga and under the present fluctuation schedule is a dominant cover plant during low water periods. *P. geminatum* increased in abundance subsequent to dewatering, and advanced both landward and lakeward. The lakeward expansion to elevations lower than 49 MSL, previously void of vegetation, was accomplished mainly by new seedlings. Relative density also increased in the areas where *P. geminatum* was previously established by seedlings and rooting at the nodes of repent stems. While submerged, this species does not appear to propagate either by seedling or rhizomatous growth. However, vegetative portions become significantly denser, during the growing season, by branching.

Panicum repens (torpedograss) is another important semi-aquatic grass adapted to the zone of fluctuation, and is important as a cover plant during high pool stages. Torpedograss increased after the drawdown, but expansion was due to rhizomatous growth; no seedlings were observed. This accounts for its slow movement toward the water.

Paspalum (knotgrass) is presented in Table 3 as a genus because it was not identified further in the 1956 study. In 1970-71 *P. vaginatum*, was the dominant species. Like *Digitaria* and *Cyperus*, knotgrass responded well to drawdown, increasing in abundance and expanding lakeward.

Polygonum hydropiperoides (smartweed) was not recorded in 1956. It was found rarely in 1970, just above low pool on the east shore and high pool on the west shore. Smartweed develops in dense, narrow bands at the high and low pool drift lines. Table 3 indicates a response to dewatering, but the greatest response came after transect measurement when smartweed became a prevalent species throughout exposed areas.

A few plant species present in Tohopekaliga, although important, were not adequately sampled by point transect. *Pontederia cordata* (pickerelweed), *Sagittaria* (arrowhead) and *Typha latifolia* (cattail), are types restricted to narrow bands or isolated patches at and near the waters edge. They become dense during the growing season when the lake level is static. As the water receded in 1971, these plants were virtually eliminated from established areas, but re-invasion occurred rapidly at the low water level.

Scirpus californicus (bulrush) occurs frequently throughout the lake between 48.7-51.5 MSL. Density ranges from a few scattered stems to colonies several acres in size. Although transect data did not adequately represent its status, a concurrent study measuring growth in single species plots revealed that bulrush produces new shoots from rhizomes throughout the year. *Scirpus* continued to produce rhizomatous growth after dewatering for approximately three months, then new growth stopped and mature plants began dying. Seedlings began developing in May between 48-49 MSL, at or near the water in areas previously void of vegetation.

Cynodon dactylon (Bermudagrass) is an upland pasture grass. It was recorded in all three studies, but frequency and distribution data were inconsistent and could not be adequately interpreted with respect to prevailing water levels.

Echinochoa walteri (millet) was not sampled adequately in May of 1971, but its subsequent response to dewatering was dramatic. It established throughout the exposed lake bottom, becoming especially rank in moist, organic areas where cattle could not graze.

Panicum hemitomon (maidencane) is another plant for which frequency data were difficult to interpret, however its range was most extensive in both low water years. Maidencane occurs most commonly in small, dense patches in the northern area of the lake basin. It appears to have an affinity for organic substrate.

Many plants which responded to the drawdown are significant to the fishery. Standing crop estimates of the fishery in Tohopekaliga, comparing littoral with limnetic data, demonstrate the value of rooted emergent aquatic vegetation. Littoral samples yielded an avearge of 184 pounds per acre, of which 82 percent or 151 pounds were sport-fish.

Limnetic samples produced an average of 54 pounds per acre, of which 63 percent or 34 pounds were sport-fish.

A similar relationship exists for fish-food organisms in the lake. Standing crops from littoral and limnetic areas are nearly alike for substrate-associated organisms (1532 and 1559 organisms/M^2, respectively). But, if one considers organisms in littoral vegetation above the substrate, the standing crop become significantly greater.

Scirpus serves as important spawning areas for centrarchids. Large numbers of nesting sites are found in and around colonies of bulrush throughout the lake basin, even though other rooted plants are present in abundance on all sides. *Scirpus* serves as a natural fish attractor in Tohopekaliga, as demonstrated by heavy fishing pressure in such areas.

During regulation low pool stage *Panicum geminatum* is the dominant aquatic plant providing littoral habitat, cover and spawning areas for major sport-fish present in the lake. Being dense at the lakeward limit, it produces an "edge effect" between open water and the remaining littoral zone. *P. hemitomon* is the only significant emergent species present in the northern end of the lake during regulation low pool.

Panicum repens and *Hydrochloa caroliniensis* are the dominant plant species in the zone of water fluctuation. During high pool in winter and early spring, these plant communities serve as spawning areas for *Pomoxis nigromaculatus* (black crappie), *Esox niger* (chain pickerel) and *Micropterus salmoides* (largemouth bass). *Pontederia cordata,* which exists in narrow bands, serves the same function.

Eichhornia crassipes, the water hyacinth, is considered a detrimental species relative to the fishery and other aquatic plants in Lake Tohopekaliga. The capacity of hyacinths for propagating to astronomical proportions and shading out beneficial rooted aquatics makes it undesirable. Normal die-off and chemical control operations produce large amounts of organic sediment ultimately detrimental to substrate-related activities of important fish and fish-food organisms.

Annual plant communities in the lake basin are maintained from year to year by new seed germination. At a given elevation, if water is present, terrestrial forms will not develop and aquatic forms may expand, decrease or remain unchanged. If water is absent, aquatic forms will disappear and many terrestrial forms will encroach to the water's edge.

Stage duration curves are used by hydrological engineers to depict graphically the percent of time water level is at or above a particular elevation. Sincock and Powell (1956) assumed that stage duration of the previous year determined distribution of annual plants in the lake basin, meaning annual plants were present at a particular elevation because water was at or above that elevation for some amount of time during some portion of the year. However, the data from all years indicate that development and distribution of annual communities, within the immediate lake basin, is determined by the water level prevailing during the growing season, regardless of stage duration above, at or below that level during other portions of the year.

It was also assumed in the 1956 study that stage duration of the previous five year period determined distribution of perennial vegetation. Knowing the range in elevation for each plant species which occurred in the transects, applying it to the five year stage duration curve was expected to provide the extremes of inundation for each species.

An illustration using data from 1970 and 1971 will demonstrate the error of this assumption. The distribution of *Eleocharis* on both shores in 1970, when applied to a stage duration curve of the previous 5 year period, indicates a percent range of inundation of 2-100. Doing the same for *Eleocharis* distribution in 1971, the percent range of inundation for the east shore is 70-95, and for the west shore 57-86. These are erroneous figures because the curve from which they are derived does not provide information on the time of year during which water level is at a particular elevation. There is no apparent relationship between the distribution of annual and perennial plants and percent of inundation for contours they occupy.

Stage hydrographs illustrate actual water level elevations relative to the time of year they occur and are most useful for interpreting the establishment and distribution of vegetation.

We believe that the lakeward limit of perennial plants has been determined to a great extent by the extreme lows of water level fluctuation during growing seasons. There is both direct and indirect evidence to support this hypothesis. First, there is the documented response of major plant communities to the 1971 drawdown. Most developed lakeward to or near the water's edge. After transect measurement, many established several inches below it. At this writing, the water level (approximately 48 MSL) is now the low for the entire period of record. Second, the water level during the 1956 study was at the historic low for the prior period of record (approximately 50 MSL). The data from that study indicates response by vegetation relative to the water level was the same as occurred in 1971. Third, the lakeward limit of emergent vegetation present in 1970 at 49 MSL may be explained by the historically low water level which occurred at that elevation in June, 1962. This evidence suggests that when Tohopekaliga is returned to regulation schedule, the lakeward limit of emergent vegetation will remain at approximately 48 MSL. There is, however, obviously a limit to this concept. At some depth other factors may begin to regulate permanent establishment of emergents.

A discussion of the relationship of higher water levels to the distribution of perennial vegetation in Tohopekaliga must await documentation after re-flooding.

CONCLUSIONS

As a result of the artificial drawdown in 1971, littoral vegetation established lakeward. It expanded from approximately 9,000 acres to 10,500 acres, a 16 percent increase.

Five of 16 plant types occurred most frequently and had greater distribution during higher water levels of 1970. These included the water hyacinth, spikerush, southern watergrass, southern naiad and eelgrass. Eleven others responded similarly during lower water levels of 1956 and 1971. They were: alligatorweed, carpetgrass, centella, nutgrass, crabgrass, false loosestrife, oldenlandia, panicgrass, torpedograss, knotgrass and smartweed. It appears that *Panicum geminatum* and alligatorweed have invaded the Tohopekaliga lake basin since 1956.

Many of the plants which increased due to the drawdown are dominant communities in the lake basin and satisfy requirements of major sportfish and fish-food organisms. The importance of these communities is demonstrated by associated high standing crops of sport-fish and invertebrates.

Only one plant, the water hyacinth, is considered to be detrimental to the fishery and other plant communities. Its marked decline after dewatering suggests that further study may develop methods of hyacinth control which are cheaper and less destruuctive than chemicals.

The development and distribution of vegetation within the basin of Lake Tohopekaliga is determined mainly by prevailing water levels during the growing season and not by water stage duration. The lakeward limit of emergent vegetation is largely determined by extreme lows of water fluctuation during the growing season. The relationship of high water levels to the distribution of emergents in Tohopekaliga requires further investigation after reflooding occurs.

The artificial drawdown of 1971 established a new historically low water level for the period of record (approximately 48 MSL). Evidence from previous historic lows in the lake suggests that *Panicum geminatum, P. hemitomon* and *Scirpus californicus* will remain established on an additional 1,500 acres of lake bottom.

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RECENT DEVELOPMENTS IN FROG CULTURE

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ABSTRACT

Effects of crowding were investigated with respect to growth, feeding, food conversion, mortality, and health of bullfrogs (*Rana catesbeiana*) up to 9 months of age. No statistically significant differences were found with regard to growth, food consumption, food conversion, mortality, or health.

The average food conversion (C) was less than 2.6 during the first two months of growth and values between 1.65 and 1.99 were obtained. By the third month most values approached 3.00. A high correlation was found between gain and food conversion.

Daily consumption as high as 35% was recorded. The fastest growing bullfrogs approached or exceeded 226 g (½ lb.) in 8 months from metamorphosis.

Analysis of 68 frogs for sexual maturity showed that males had motile sperm by 4 months of age and a weight of 32 g. Analysis of females indicated eggs approaching maturity may be produced as early as 6 months from metamorphosis.