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An Ecological Survey of the Vascular Aquatic Vegetation of the Cumberland Plateau in Tennessee

Franklin Delano Robinson
University of Tennessee - Knoxville

To the Graduate Council:

I am submitting herewith a thesis written by Franklin Delano Robinson entitled "An Ecological Survey of the Vascular Aquatic Vegetation of the Cumberland Plateau in Tennessee." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Botany.

Royal E. Shanks, Major Professor

We have read this thesis and recommend its acceptance:

Fred H. Norris, J. C. Howell

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

May 22, 1956

To the Graduate Council:

I am submitting herewith a thesis written by Franklin Delano Robinson entitled "An Ecological Survey of the Vascular Aquatic Vegetation of the Cumberland Plateau in Tennessee." I recommend that it be accepted for twelve quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Botany.

Royal E. Shanks
Major Professor

We have read this thesis
and recommend its acceptance:

Fred H. Norris

J. C. Howell

Accepted for the Council:

Dean of the Graduate School

AN ECOLOGICAL SURVEY OF THE VASCULAR AQUATIC VEGETATION OF THE CUMBERLAND PLATEAU IN TENNESSEE

A THESIS

Submitted to
The Graduate Council
of
The University of Tennessee
in
Partial Fulfillment of the Requirements
for the degree of
Master of Science

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by

Franklin Delano Robinson

June 1956

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INTRODUCTION

The role played by vascular aquatic plants in the water environment is an extremely variable one and also one of vast importance. Butcher (1933) listed the following as some of the ways in which the habitat and the organisms inhabiting the water environment are affected by the macrophytic vegetation present: (1) swiftness of current and depth of streams are influenced by the amount and type of vegetation; (2)shelter is afforded the smaller animals; (3) a habitat is created by the plants in which certain species of fish and amphibians lay their eggs; (4) the rooted aquatics serve as structures to which algae may be attached; (5) the plants are a source, both direct and indirect, of food used by animals; (6) the process of photosynthesis releases free oxygen which affects the oxygen content of the water; (7) fertility of the water is increased by the trapping of silt and by the decomposition of plant parts; and (8) the rooted plants tend to stabilize the stream bed. To these de Gruchy (1938) adds (1) the value of plants in the clarifying of water and (2) their aesthetic values. All of these are usually considered as desirable qualities with regard to growth of organisms, scenic beauty, and rate of erosion. There are, however, some effects of water plants which are undesirable. Among these are nuisance to boatmen and fishermen (Coker 1954), antagonistic action on algae and rotifers (Hasler and Jones 1949), too much sheltering of small fry of forage species of fish resulting in slow growth of carnivorous species of game fish, and depletion of oxygen associated with decay of plants

or due to respiration in the green plants during periods of reduced photosynthesis as a result of low light intensity (Toole 1943).

In order to determine the net value of aquatic plants it is necessary to balance the desirable features (with regard to the factors mentioned in the preceding paragraph) against those which are undesirable. The balance may be swayed in a particular area by choosing the species which possess the more desirable qualities to be used in planting of managed bodies of water and by eradication of the undesirable species. Information as to the relative value of various species is given by de Gruchy (1938). Toole (1943) discusses some of the management practices that may be used.

Once the importance of the role of aquatic vegetation was realized it became apparent that any information dealing with factors controlling plant growth or any distribution knowledge would be of value in fish management and conservation practices as well as being of academic interest.

A considerable amount of work has been done in an effort to determine the factors involved in the control of aquatic plants. R. W. Butcher (1933) has conducted a great deal of research on the biology of the rivers of England and has collected a considerable amount of information concerning the physical conditions affecting plant growth and distribution. Moyle (1945) has classified aquatic plants according to the range of water hardness and pH values which he measured. Pond (1930)

and de Gruchy (1938) have discussed some of the biological relationships between the aquatic plants and the substratum. Shoup (1950) conducted a field chemical examination of the waters in the major streams of Tennessee. Other studies have been made in various localities, but the above are indicative of the type of work that has been done in this field.

A thorough study of the vegetation of the Tennessee Valley Reservoirs was conducted by Isely in 1946. Eyles and Robertson (1944) prepared a key to the aquatic plants of the Southeastern United States and included some distributional information. With regard to local distribution and knowledge of the smaller bodies of water, however, there is a blank in the picture.

The aim of this study was to fill in some of this blank in a portion of the Cumberland Plateau of Tennessee. The area is underlain by sandstones and shales and the streams are clear natural waters at their sources with but little measurable alkalinity and total buffer. Since these streams have little or no alkali reserve they are very susceptible to acid mine water pollution from mines and slack heaps and some of the streams display varying degrees of pollution, depending on the amount of acid water entering them (Shoup 1950). The streams in this study are tributaries to the Tennessee River System. The work was done largely in Cumberland and Morgan counties with limited samples from parts of Fentress, Grundy, and Putnam counties. Treatment is based entirely on data collected during

the summer of 1955 by the author with the exception of the data from Grundy County which were collected by John Parsons of the Tennessee Game and Fish Commission.

It was intended to gather distributional data and at the same time try to learn the extent to which some of the environmental factors might affect the macroscopic herbaceous plants. Turbidity readings and analyses of water samples for carbon dioxide in parts per million, total acidity in parts per million $CaCO_3$ equivalent, total alkalinity in parts per million $CaCO_3$ equivalent, and pH were taken at each station for a species. These data were compiled and range and mean of each factor determined for each species. No effort was made to determine the threshold or limiting value of a factor for a species. This would entail a more complex study in which there would be some means of controlling some of the many variables involved.

It has been shown that the chemical and physical conditions in water change from day to day and from season to season. For this reason the measurements of the chemical factors chosen may differ somewhat from those that would be obtained from a series of measurements covering all the seasons and therefore cannot be interpreted as average values for the entire year. The major part of a growing season was included in the period of measurements, however, and it was hoped that the number of samples would be large enough to offset the small changes for short time intervals. Therefore the information should furnish a

fairly accurate basis for estimating the natural environmental conditions under which the plants were living.

METHODS

Collection and Classification of Distributional Information of Plants

To gather completely detailed distributional data for the entire extent of all the bodies of water considered in this study would have required observation of all their areas throughout the length of the growing season. Obviously this would have been an impossible task, and therefore some way of gathering valid information had to be designed.

A survey of a fifteen mile portion of Obed River revealed that observing about 100 yards of the stream at stations four or five miles apart gave the same list of species as was obtained by walking the entire distance. Further observations on other streams also indicated that representative information could be obtained about the plants by making a study of about 100 yard samples at intervals of about five miles on those streams. This was the study method adopted.

The lakes and ponds, however, presented a slightly different picture. Most of the vegetation was present in the shallow water around the margins and was sometimes present on one side but absent on others. Therefore in order to insure a complete species list for these bodies of water, the entire perimeter of each of them was observed.

Voucher collections were made and deposited in the herbarium of the University of Tennessee. Most of the work is based on field identifications, however.

Taxonomic keys by Isely (1946), Muenscher (1944), and Fassett (1940) were found to be very helpful in the identification of the plants. The final classification, however, is that used by Fernald in his Gray's Manual of Botany, Eighth Edition (1950).

Chemical Measurements

Water samples were taken at each station where a species was collected. In addition to these, a series of samples about three weeks apart was taken at stations on Obed River, Rock Creek, Clear Creek, Crab Orchard Creek, and at the mouth of Daddy's Creek. These samples were analyzed for carbon dioxide content, total acidity, total alkalinity, and pH using the methods given by Theroux, Eldridge, and Mallmann (1943). A brief outline of the methods used is given below.

Carbon Dioxide.

1. Place 100 ml. of sample in a container.
2. Add 10 drops of phenolphthalein indicator.
3. Add N/44 sodium hydroxide from a burette, stirring gently, until a slight pink color appears.
4. The ml. of sodium hydroxide used multiplied by 10 is equal to p.p.m. carbon dioxide.

Total Acidity.

1. Place 100 ml. of sample in a container.
2. Add 3 drops of phenolphthalein indicator.

3. Add 0.02 N sodium hydroxide from a burette until the first permanent pink color appears.

4. Number of ml. of sodium hydroxide used multiplied by 10 is equal to p.p.m. total acidity expressed in terms of $CaCO_3$.

Total Alkalinity.

1. Place 100 ml. of sample in one flask and 100 ml. of distilled water in another.

2. Add 3 drops of phenolphthalein indicator to each.

3. If the sample becomes pink, add 0.02N sulfuric acid from a burette until pink color just disappears and record the number of ml. of acid used.

4. Add 3 drops of methyl orange indicator to each flask.

5. If the sample becomes yellow, add 0.02N sulfuric acid until the first difference in color is noted when compared with the distilled water. The end point is orange. Record the number of ml. of acid used.

6. Number of ml. of acid used multiplied by 10 is equal to the total alkalinity as p.p.m. $CaCO_3$.

Hydrogen-ion Concentration (pH).

1. Fill 3 tubes with sample.

2. Add designated quantity of the indicator solution to one tube. (Standard indicator series)

3. Place the tubes in the comparator in such a manner that the color standards are opposite the tubes not containing the indicator.

4. Compare the colors, select and read the pH of the tube having a color nearest that of the sample.

Turbidity Readings

Turbidity readings were taken using a turbidity tape and scale calibrated to read in parts per million of silica equivalent. The scale consists of a weighted aluminum strip 8 inches long, calibrated from 50 to 3000. Attached to the upper end of the strip is a non-stretchable tape 4 feet long calibrated from 7 to 45, and at the lower end of the strip is a platinum needle. To determine turbidity, the strip is immersed vertically until the platinum needle just disappears when viewed from a fixed point near the upper end of the taut tape. The depth of immersion indicates the degree of turbidity by scale readings on the tape.

RESULTS AND DISCUSSION

The species list for the area studied was arranged in alphabetical order under five group headings according to the most frequently observed habit or position of growth. Relatively detailed distribution and the range and mean of each of the chemical factors considered is given under each species. County distribution is given in parentheses after detailed information. County locations of the bodies of water and a map showing the approximate location of the study area are given in the appendix.

With the exception of very brief periods following heavy rains, it was found that turbidity readings gave an indication of clear water. Therefore it was concluded that turbidity was not an important factor in the area studied and further treatment of this factor is omitted from this paper.

The first column of numbers gives the range of the factors and the second column indicates the mean. The number in parentheses after the figure for the mean indicates the number of samples from which the range and mean were determined. In a few cases there was only one collection and the values for the analysis of the water at these locations are given as originally determined.

Submersed

Najas flexilis (Willd.) R. & S.

Distribution: Grundy County State Park Pond #1. (Grundy County)

Carbon dioxide:	0
Total acidity:	0
Total alkalinity:	52
pH:	8.3

Najas minor Allioni.

Distribution: Grundy County State Park Pond #1 and #4. (Grundy County)

Carbon dioxide:	0-9	4.5(2)
Total acidity:	0-9	4.5
Total alkalinity:	52-54	53.0
pH:	6.9-8.3	7.6

Myriophyllum humile (Raf.) Morong.

Distribution: Clear Creek at mouth of Little Clear Creek and at Genesis-Lancing Road; Cumberland State Park Lake; Little Clear Creek at mouth; Otter Creek throughout; and Rock Creek between Annadel and mouth. (Cumberland and Morgan Counties)

Carbon dioxide:	1-10	3.2(21)
Total acidity:	1-10	3.2
Total alkalinity:	1-32	10.1
pH:	6.3-7.1	6.8

Utricularia gibba L.

Distribution: Clear Creek at mouth of Little Clear Creek and Little Clear Creek at mouth. (Morgan County)

Carbon dioxide:	1 at both locations	1.0(2)
Total acidity:	1 at both locations	1.0
Total alkalinity:	2-4	3.0
pH:	6.9-7.0	6.9

Either Submersed or Emersed

Callitriche heterophylla Pursh.

Distribution: Grassy Cove Creek; Panther Creek; Obed River at Highway 70S, at Adam's Bridge, and at Potter's Ford; and Rock Creek between Annadel and mouth. (Cumberland and Morgan Counties)

Carbon dioxide:	1-174	10.1(23)
Total acidity:	1-174	10.1
Total alkalinity:	5-162	22.2
pH:	5.9-7.8	6.8

Juncus debilis A. Gray

Distribution: Big Creek in Grundy County; Buck Stewart Pond, west of Crossville near Highway US 70N; Clear Creek at mouth of Panther Creek, and at mouth of Little Clear Creek; Clear Fork River, pond at head; Crab Orchard Creek at Flat Rock Ford and at Upper Bridge; Daddy's Creek at mill pond on Crossville-Pikeville Highway; Donelson Pond; Fall Creek at first bridge below Ozone; Firescald Creek in Grundy County; Grassy Cove Creek; Grundy County State Park Pond #3 and #4; Hugo

Gernt Pond at Allardt; Obed River at Highway 28; Panther Creek at mouth; Piney Creek in Cumberland County; and Waldensia Lake. (Cumberland, Fentress, Grundy, and Morgan Counties)

Carbon dioxide:	1-19	4.0(28)
Total acidity:	1-19	4.0
Total alkalinity:	5-94	21.9
pH:	4.3-7.8	6.8

Juncus repens Michx.

Distribution: Clear Creek at mouth of Little Clear Creek and Cumberland State Park Lake. (Cumberland and Morgan Counties)

Carbon dioxide:	1-3	2.0(2)
Total acidity:	1-3	2.0
Total alkalinity:	2-8	5.0
pH:	6.9 at both locations	6.9

Ludwigia palustris (L.) Ell.

Distribution: Allardt State Pond; Buck Stewart Pond, west of Crossville near Highway US 70N; Campbell Junction Lake; Caney Fork at Highway US 70S; Clear Creek at mouth of Panther Creek and at Genesis-Lancing Road; Crooked Creek about 5 miles below Allardt; Cumberland State Park Lake; Daddy's Creek at mill pond on Crossville-Pikeville Highway; Hugo Gernt Pond at Allardt; Obed River at Highway 28, Adam's Bridge, and Potter's Ford; Otter Creek, middle

section; Panther Creek at mouth; Piney Creek in Cumberland County; Rock Creek between Annadel and mouth; and Waldensia Lake. (Cumberland, Fentress, and Morgan Counties)

Carbon dioxide:	1-19	3.4(35)
Total acidity:	1-19	3.4
Total alkalinity:	5-41	15.4
pH:	5.9-7.4	6.9

Myriophyllum brasiliense Camb.

Distribution: Big Creek in Grundy County; Campbell Junction Lake; Caney Fork at Highway US 70S; Daddy's Creek at mill pond on Crossville-Pikeville Highway; Gernt Pond east of Allardt; Grundy County State Park Pond #1, #3, and #4; Piney Creek in Grundy County. (Cumberland, Fentress, and Grundy Counties)

Carbon dioxide:	0-9	3.6(10)
Total acidity:	0-9	3.6
Total alkalinity:	6-54	25.4
pH:	6.5-8.3	7.0

Nasturtium officinale R. Br.

Distribution: Grassy Cove Creek and a small creek north of Crab Orchard. (Cumberland County)

Carbon dioxide:	1-3	2.0(2)
Total acidity:	1-3	2.0
Total alkalinity:	94-136	115.0
pH:	7.8 at both locations	7.8

Podostemum ceratophyllum Michx.

Distribution: Daddy's Creek at mouth; Emory River at Montgomery Bridge; Obed River at Highway 28, Adam's Bridge, Potter's Ford, Henry's Ford, mouth of Otter Creek, and mouth of Daddy's Creek; Otter Creek in lower section. (Cumberland and Morgan Counties)

Carbon dioxide:	1-8	3.0(19)
Total acidity:	1-8	3.0
Total alkalinity:	8-41	15.9
pH:	6.6-7.3	7.0

Proserpinaca palustris L.

Distribution: Big Creek in Grundy County; Clear Creek at Genesis-Lancing Road; Daddy's Creek at mill pond on Crossville-Pikeville Highway; and Donelson Pond. (Cumberland, Grundy, and Morgan Counties)

Carbon dioxide:	1-6	3.7(4)
Total acidity:	1-6	3.7
Total alkalinity:	9-38	21.7
pH:	6.2-7.4	6.8

Proserpinaca pectinata Lam.

Distribution: Clear Fork, pond at head, and Obed River below Highway 28. (Cumberland and Fentress Counties)

Carbon dioxide:	2-8	3.8(5)
Total acidity:	2-8	3.8
Total alkalinity:	10-41	22.6

pH:	6.6-7.3	7.0

Vallisneria americana Michx.

Distribution: Caney Fork River at Highway US 70S; Clear Creek at Genesis-Lancing Road; Crab Orchard Creek at Flatrock Ford; Emory River at Montgomery Bridge; Little Clear Creek at mouth; and North Fork of Clear Creek at Twin Bridges. (Cumberland and Morgan Counties)

Carbon dioxide:	1-10	3.2(13)
Total acidity:	1-10	3.2
Total alkalinity:	4-34	13.1
pH:	6.3-7.0	6.8

Floating Leaves

Brasenia schreberi Gmel.

Distribution: Monterey Lake. (Putnam County)

Carbon dioxide:	3
Total acidity:	3
Total alkalinity:	8
pH:	6.9

Nuphar advena (Ait.) Ait. f.

Distribution: Cumberland State Park Lake and Obed River below and about 2 miles above Potter's Ford. (Cumberland County)

Carbon dioxide:	.5-3	2.0(11)
Total acidity:	.5-3	2.0

Total alkalinity:	6-22	12.1
pH:	6.8-7.2	7.0

Orontium aquaticum L.

Distribution: Clear Creek at mouth of Little Clear Creek and at Genesis-Lancing Road; Clear Fork River at Peters' Ford; Crab Orchard Creek at White Oak and at mouth; Crooked Creek about 5 miles below Allardt; Little Clear Creek at mouth; and North Fork of Clear Creek at Twin Bridges. (Fentress and Morgan Counties)

Carbon dioxide:	1-10	3.0(11)
Total acidity:	1-10	3.0
Total alkalinity:	2-18	8.4
pH:	6.3-7.0	6.8

Potamogeton bicupulatus Fern.

Distribution: Allardt State Pond; Clear Fork River, pond at head; Gernt Pond east of Allardt; Hugo Gernt Pond at Allardt; and Otter Creek throughout. (Cumberland and Fentress Counties)

Carbon dioxide:	1-5	3.3(10)
Total acidity:	1-5	3.3
Total alkalinity:	5-23	12.2
pH:	6.5-7.3	6.9

Potamogeton diversifolius Raf.

Distribution: Clear Creek at mouth of Little Clear Creek and Little Clear Creek at mouth. (Morgan County)

Carbon dioxide:	1 at both locations	1.0(2)
Total acidity:	1 at both locations	1.0
Total alkalinity:	2-4	3.0
pH:	6.9-7.0	7.0

Potamogeton foliosus Raf.

Distribution: Buck Stewart Pond, west of Crossville near Highway US 70N; Clear Creek at Genesis-Lancing Road; Crooked Creek at Allardt; Cumberland State Park Lake; Daddy's Creek at mill pond on Crossville-Pikeville Highway; Grundy County State Park Pond #4; Otter Creek in upper section; and Rock Creek between Annadel and mouth. (Cumberland, Fentress, Grundy, and Morgan Counties)

Carbon dioxide:	1-14	4.4(11)
Total acidity:	1-14	4.4
Total alkalinity:	4-54	15.3
pH:	6.3-6.9	6.8

Potamogeton pulcher Tuckerm.

Distribution: Crab Orchard Creek at Flatrock Ford; Emory River at Montgomery Bridge; and Obed River at Highway 28, Adam's Bridge, Potter's Ford, mouth of Otter Creek, Henry's Ford, and mouth of Daddy's Creek. (Cumberland and Morgan Counties)

Carbon dioxide:	.5-8	2.6(22)
Total acidity:	.5-8	2.6
Total alkalinity:	4-41	15.3

pH:	6.6-7.3	6.9

Potamogeton tennesseensis Fern.

Distribution: Caney Fork at Highway US 70S; Clear Fork River at Gatewood Ford; Crab Orchard Creek at Flatrock Ford; Little Clear Creek at mouth; Otter Creek throughout; and Rock Creek between Annadel and mouth. (Cumberland, Fentress, and Morgan Counties)

Carbon dioxide:	1-6	3.4(17)
Total acidity:	1-6	3.4
Total alkalinity:	2-32	12.0
pH:	6.4-7.1	6.8

Emergent

Alisma subcordatum Raf.

Distribution: Grassy Cove Creek and Grundy County State Park Pond #3 and #4. (Cumberland and Grundy Counties)

Carbon dioxide:	1-9	5.3(3)
Total acidity:	1-9	5.3
Total alkalinity:	49-94	65.7
pH:	6.9-7.8	7.3

Dulichium arundinaceum (L.) Britt.

Distribution: Big Creek in Grundy County; Clear Creek at mouth of Little Clear Creek; Clear Fork River, pond at head; Cumberland State Park Lake; Mayland Lake; Monterey Lake; and Otter Creek throughout. (Cumberland Fentress, Grundy, Morgan, and Putnam Counties)

Carbon dioxide:	.5-6	3.3(14)
Total acidity:	.5-6	3.3
Total alkalinity:	2-38	13.1
pH:	6.4-7.4	6.8

Eleocharis acicularis (L.) R. & S.

Distribution: Buck Stewart Pond, west of Crossville near Highway US 70N; Campbell Junction Lake; and Monterey Lake. (Cumberland and Putnam Counties)

Carbon dioxide:	3 at all locations	3.0(3)
Total acidity:	3 at all locations	3.0
Total alkalinity:	8-18	11.7
pH:	6.9 at all locations	6.9

Eleocharis equisetoides (Ell.) Torr.

Distribution: Hugo Gernt Pond at Allardt; and Monterey Lake. (Fentress and Putnam Counties)

Carbon dioxide:	1-3	2.0(2)
Total acidity:	1-3	2.0
Total alkalinity:	8-9	8.5
pH:	6.9-7.3	7.1

Eleocharis obtusa (Willd.) Schultes

Distribution: Allardt State Pond; Buck Stewart Pond, west of Crossville near Highway US 70N; Campbell Junction Lake; Clear Fork River, pond at head; Daddy's Creek at mill pond on Crossville-Pikeville Highway; Fall Creek at first bridge below Ozone; Gernt Pond east of Allardt; Grassy Cove Creek; Grundy County State Park Pond #3;

Hugo Gernt Pond at Allardt; Monterey Lake; Obed River at Highway 28 and Potter's Ford; and Waldensia Lake. (Cumberland, Fentress, Grundy, and Putnam Counties)

Carbon dioxide:	1-19	3.5(21)
Total acidity:	1-19	3.5
Total alkalinity:	8-94	21.8
pH:	6.6-7.8	7.0

Eleocharis quadrangulata (Michx.) R. & S.

Distribution: Buck Stewart Pond, west of Crossville near Highway US 70N; Gernt Pond, east of Allardt; Hugo Gernt Pond at Allardt; and Monterey Lake. (Cumberland, Fentress, and Putnam Counties)

Carbon dioxide:	1-4	2.8(4)
Total acidity:	1-4	2.8
Total alkalinity:	8-18	11.0
pH:	6.9-7.3	7.0

Gratiola virginiana L.

Distribution: Cumberland State Park Lake. (Cumberland County)

Carbon dioxide:	3
Total acidity:	3
Total alkalinity:	8
pH:	6.9

Isoetes engelmanni A. Br.

Distribution: Clear Creek at Genesis-Lancing Road and Obed River at Potter's Ford. (Cumberland and Morgan Counties)

Carbon dioxide:	1-10	2.7(8)
Total acidity:	1-10	2.7
Total alkalinity:	4-22	11.1
pH:	6.3-7.1	6.9

Justicia americana (L.) Vahl.

Distribution: Clear Creek at mouth of Little Clear Creek and at Genesis-Lancing Road; Clear Fork River at Gatewood Ford, Peters' Ford, and at Highway Tenn. 52; Crab Orchard Creek at mouth; Daddy's Creek at mouth; Emory River above US 27, at Montgomery Bridge, Camp Austin, Nemo, and at Oakdale; Little Clear Creek at mouth; Obed River at Potter's Ford, mouth of Otter Creek, Henry's Ford, and mouth of Daddy's Creek; Otter Creek in lower section; Rock Creek between Annadel and mouth; and White Oak Creek at Highway Tenn. 52. (Cumberland, Fentress, and Morgan Counties)

Carbon dioxide:	.5-10	2.8(35)
Total acidity:	.5-10	2.8
Total alkalinity:	4-32	12.2
pH:	6.3-7.3	6.9

Juncus effusus L.

Distribution: Allardt State Pond and Waldensia Lake. (Cumberland and Fentress Counties)

Carbon dioxide:	1-2	1.5(2)
Total acidity:	1-2	1.5
Total alkalinity:	10-23	16.5
pH:	6.9-7.3	7.1

Lindernia anagallidea (Michx.) Pennell

Distribution: Campbell Junction Lake; Obed River at Potter's Ford; and Pond #6 on UT Experiment Farm. (Cumberland County)

Carbon dioxide:	1-3	2.0(5)
Total acidity:	1-3	2.0
Total alkalinity:	9-22	13.0
pH:	6.9-7.1	7.0

Lindernia dubia (L.) Pennell

Distribution: Allardt State Pond; Clear Fork River, pond at head; Gernt Pond, east of Allardt; and Obed River below Adam's Bridge. (Cumberland and Fentress Counties)

Carbon dioxide:	1-4	2.8(7)
Total acidity:	1-4	2.8
Total alkalinity:	9-23	14.8
pH:	6.6-7.3	6.9

Penthorum sedoides L.

Distribution: Grundy County State Park Pond #3 and Obed River at Potter's Ford. (Cumberland and Grundy Counties)

Carbon dioxide:	1-6	2.6(5)
Total acidity:	1-6	2.6
Total alkalinity:	10-49	21.6
pH:	6.9-7.1	7.0

Pontederia cordata L.

Distribution: Cumberland State Park Lake. (Cumberland County)

Carbon dioxide:	3	
Total acidity:	3	
Total alkalinity:	8	
pH:	6.9	

Saururus cernuus L.

Distribution: Obed River below Potter's Ford and Rock Creek between Annadel and mouth. (Cumberland and Morgan Counties)

Carbon dioxide:	1-4	2.1(8)
Total acidity:	1-4	2.1
Total alkalinity:	10-32	17.6
pH:	6.7-7.1	6.9

Scirpus purshianus Fern.

Distribution: Campbell Junction Lake and Monterey Lake. (Cumberland and Putnam Counties)

Carbon dioxide:	3 at both locations	3.0(2)
Total acidity:	3 at both locations	3.0
Total alkalinity:	8-9	8.5
pH:	6.9 at both locations	6.9

Sparganium americanum Nutt.

Distribution: Allardt State Pond; Campbell Junction Lake; Clear Creek at mouth of Little Clear Creek; Clear Fork River 5 miles above Gatewood Ford and at Gatewood Ford; Crab Orchard Creek at Flatrock Ford, White Oak, and mouth; Crooked Creek at Allardt and about 5 miles below Allardt; Cumberland State Park Lake; Daddy's Creek at mill pond on

Crossville-Pikeville Highway; Emory River at Montgomery Bridge; Fall Creek at first bridge below Ozone; Grundy County State Park Pond #3; Little Clear Creek at mouth; Mayland Lake; Monterey Lake; North Fork of Clear Creek at Twin Bridges; Obed River at Highway US 70S, Highway 28, Adam's Bridge, Potter's Ford, mouth of Otter Creek, Henry's Ford, and mouth of Daddy's Creek; Otter Creek throughout; Piney Creek in Grundy County; and Rock Creek between Annadel and mouth. (Cumberland, Fentress, Grundy, Morgan, and Putnam Counties)

Carbon dioxide:	.5-174	5.9(58)
Total acidity:	.5-174	5.9
Total alkalinity:	2-162	16.4
pH:	5.9-7.4	6.8

Sparganium chlorocarpum Rydb.

Distribution: Cumberland State Park Lake. (Cumberland County)

Carbon dioxide:	3
Total acidity:	3
Total alkalinity:	8
pH:	6.9

Typha latifolia L.

Distribution: Campbell Junction Lake; Cumberland State Park Lake; Fall Creek at first bridge below Ozone; Gernt Pond, east of Allardt; Mayland Lake; Monterey Lake; and Waldensia Lake. (Cumberland and Fentress Counties)

Carbon dioxide:	0-4	2.0(8)
Total acidity:	0-4	2.0
Total alkalinity:	6-52	16.3
pH:	6.9-8.3	7.1

Xyris caroliniana Walt.

Distribution: Clear Creek at the mouth of Little Clear Creek and at Genesis-Lancing Road; Clear Fork River about 5 miles above Gatewood Ford and at Peters' Ford; Crab Orchard Creek at mouth; Little Clear Creek at mouth; North Fork of Clear Creek at Twin Bridges; and Otter Creek throughout. (Cumberland, Fentress and Morgan Counties)

Carbon dioxide:	1-10	3.7(18)
Total acidity:	1-10	3.7
Total alkalinity:	4-14	8.2
pH:	6.3-7.0	6.8

Riparian

Cyperus strigosus L.

Distribution: Donelson Pond and Grundy County State Park Pond #1 and #2. (Grundy County)

Carbon dioxide:	0-6	3.0(3)
Total acidity:	0-6	3.0
Total alkalinity:	9-52	26.7
pH:	6.2-8.3	7.1

Drosera intermedia Hayne

Distribution: Clear Creek at mouth of Little Clear Creek. (Morgan County)

Carbon dioxide:	1 at both measurements	1.0(2)
Total acidity:	1 at both measurements	1.0
Total alkalinity:	2-4	3.0
pH:	6.9-7.0	6.9

Hypericum boreale (Britt.) Bickn.

Distribution: Clear Creek at mouth of Panther Creek; Clear Fork River at pond at head, 5 miles above Gatewood Ford, at Gatewood Ford; Crooked Creek at Allardt; Grundy County State Park Pond #3; and Panther Creek at mouth. (Cumberland, Fentress, and Grundy County)

Carbon dioxide:	3-19	6.6(7)
Total acidity:	3-19	6.6
Total alkalinity:	5-49	17.8
pH:	5.9-7.1	6.7

Lobelia cardinalis L.

Distribution: Big Creek in Grundy County; Buck Stewart Pond, west of Crossville on Highway US 70N; Campbell Junction Lake; Caney Fork at Highway US 70S; Clear Creek at mouth of Panther Creek; Clear Fork River at Gatewood Ford and Peters' Ford; Crab Orchard Creek at Upper Bridge and at Flatrock Ford; Crooked Creek at Allardt; Daddy's Creek at mill pond on Crossville-Pikeville Highway; Emory River at Montgomery Bridge; Little Clear Creek at mouth;

Monterey Lake; North Fork of Clear Creek at Twin Bridges; Obed River at Highway 28, Adam's Bridge, Potter's Ford, mouth of Otter Creek, and mouth of Daddy's Creek; Otter Creek throughout; Panther Creek at mouth; Rock Creek between Annadel and mouth; Waldensia Lake; White Oak Creek at Highway Tenn. 52; and a small creek north of Crab Orchard. (Cumberland, Fentress, Grundy, Morgan, and Putnam Counties)

Carbon dioxide:	.5-19	3.1(58)
Total acidity:	.5-19	3.1
Total alkalinity:	4-136	16.0
pH:	5.9-7.8	7.0

Lobelia nuttallii R. & S.

Distribution: Clear Creek at mouth of Little Clear Creek and Obed River at Henry's Ford. (Cumberland and Morgan Counties)

Carbon dioxide:	.5-3	1.6(5)
Total acidity:	.5-3	1.6
Total alkalinity:	2-16	9.0
pH:	6.8-7.0	6.9

Lycopus virginicus L.

Distribution: Buck Stewart Pond, west of Crossville near Highway US 70N; Clear Creek at mouth of Panther Creek; Clear Fork River, pond at head, 5 miles above Gatewood Ford, and at Gatewood Ford; Crooked Creek at Allardt; Daddy's Creek at mill pond on Crossville-Pikeville Highway; Gernt Pond, east of Allardt; North Fork of Clear

Creek at Twin Bridges; and Rock Creek between Annadel and mouth. (Cumberland, Fentress, and Morgan Counties)

Carbon dioxide:	1-19	4.2(15)
Total acidity:	1-19	4.2
Total alkalinity:	6-32	14.7
pH:	5.9-7.1	6.8

Osmunda regalis L.

Distribution: Daddy's Creek at mouth; North Fork of Clear Creek at Twin Bridges; Obed River at mouth of Daddy's Creek; and Rock Creek between Annadel and mouth. (Morgan County)

Carbon dioxide:	.5-4	1.7(15)
Total acidity:	.5-4	1.7
Total alkalinity:	6-32	14.1
pH:	6.7-7.3	7.0

Panicum agrostoides Spreng.

Distribution: Grundy County State Park #4. (Grundy County)

Carbon dioxide:	9
Total acidity:	9
Total alkalinity:	54
pH:	6.9

Rhexia virginica L.

Distribution: Allardt State Pond; Buck Stewart Pond, west of Crossville near Highway US 70N; Campbell Junction Lake; Clear Fork, pond at head; and Gernt Pond east of

Allardt. (Cumberland and Fentress Counties)

Carbon dioxide:	2-4	3.2(5)
Total acidity:	2-4	3.2
Total alkalinity:	9-23	15.8
pH:	6.9-7.3	7.0

Rhynchospora corniculata (Cam.) Gray

Distribution: Big Creek in Grundy County. (Grundy County)

Carbon dioxide:	1
Total acidity:	1
Total alkalinity:	38
pH:	7.4

Sagittaria australis (J. G. Sm.) Small

Distribution: Campbell Junction Lake and Clear Fork River at pond at head. (Cumberland and Fentress Counties)

Carbon dioxide:	3-4	3.5(2)
Total acidity:	3-4	3.5
Total alkalinity:	9-20	14.5
pH:	6.9 at both locations	6.9

Sagittaria latifolia Willd.

Distribution: Clear Fork River at pond at head, about 5 miles above Gatewood Ford; Crab Orchard Creek at mouth; Cumberland State Park Lake; Daddy's Creek at pond on Crossville-Pikeville Highway; Gernt Pond, east of Allardt; Mayland Lake; Monterey Lake; North Fork of Clear Creek at Twin Bridges; and Waldensia Lake. (Cumberland, Fentress, Morgan, and Putnam Counties)

Carbon dioxide:	.5-8	2.9-(19)
Total acidity:	.5-8	2.9
Total alkalinity:	6-41	14.5
pH:	6.6-7.3	6.9

Sagittaria teres S. Wats.

Distribution: Hugo Gernt Pond at Allardt. (Fentress County)

Carbon dioxide:	1
Total acidity:	1
Total alkalinity:	9
pH:	7.3

Discussion

From the preceding list of results something may be seen of the range of conditions under which the various species grew. For cases in which measurements were taken for a species at less than five stations the information is probably not sufficient for drawing very safe conclusions. For cases in which there were over five measurements for a species, however, it is felt that the range gives a relatively good picture of the degree of tolerance for a factor which the species showed in the area studied. The means appear to be near to the values obtained in those locations in which there were medium to heavy growths of the species concerned.

The species observed in this study may be divided into two groups on the basis of the pH of the water in which they

were growing. The first group which consists of Alisma subcordatum, Najas flexilis, Najas minor, Nasturtium officinale, Rhynchospora corniculata, and Sagittaria teres grew in water which ranged from moderately to highly basic (pH 7.3 or greater). The other forty-nine species listed grew in water which ranged from slightly acid to slightly basic (pH 6.8-7.1). Observations of species in the first pH group are not adequate to support conclusions concerning their relative importance in the vegetation. In the second group dominance was sometimes observed, but variations in dominance or conspicuousness appear to be related to factors other than pH.

One factor that influences the abundance and dominance of a species in a given environment is the presence of other species. It is possible that some species retain dominance in certain places where this role would be assumed by another species if it were introduced. For example, Nuphar advena now appears to be the dominant species in the pools in Obed River below and for about two miles above Potter's Ford. According to elderly natives of the region, however, this plant was not in this particular stream until about twenty years ago. It is obvious that prior to the introduction of Nuphar the role of dominance must have been assumed by some other species if there was a dominant. It is also known that Myriophyllum brasiliense introduced as little as five years ago to fish ponds and small lakes has multiplied until the water is literally filled with the plants, making quite a problem for fishermen.

On the bases of these and other cases the author has concluded that almost all of the species in the second pH group if introduced would grow in bodies of water having the appropriate pH, provided that other conditions are suitable for any kind of plant growth and that the physical factors to be discussed in the following paragraph are as required for the species.

Depth of water, movement of water, and the kind of bottom were the other major factors that apparently affected the degree of abundance of the plants growing in water of a given pH range. In deep still water where the bottom was usually smooth and composed of silt and sand the floating leaf class of plants was regularly the most conspicuous type of vegetation, but in terms of abundance the submersed Callitriche, Ludwigia, or Myriophyllum probably excelled. In the shallower water around the margins of the pools, lakes, and ponds, certain of the emergent species such as Pontederia cordata and Typha latifolia were sometimes the plants that were most noticeable. Some species of Potamogeton was in most cases associated with each of the other species of plants mentioned as being conspicuous in deep still water. No two of the other floating leaf species were ever observed in the same place and it is therefore impossible to say what kind of relation they would have to one another if present in the same habitat.

On shoals where the water is flowing and is relatively shallow and the bottom consist of rock with sand and silt filled crevices, Justicia or Sparganium is usually dominant

with Juncus, Lobelia, Lycopus, Osmunda, Xyris, or some of the other riparian or emergent species as associated minor species.

Under similar conditions with the exception of little silt or sand between the rock on the bottom, Podostemum is often the dominant and sometimes the only species present in any abundance. This species was observed as a completely submersed species in the earlier part of the summer and at this time only vegetative growth was observed. Later in the season the water was somewhat shallower and the Podostemum grew up over the exposed sandstone rock and produced flowers.

The variation of the other chemical factors measured at the various stations for a species was so great that there are apparently no definite generalizations which can be made concerning the species characteristic for any range of a factor.

Although the recurring pattern is such that the vegetation of a stream can be adequately sampled along 100 yard stretches at five mile intervals, as pointed out earlier in this discussion, the aquatic vegetation of the Plateau shows a considerable amount of variability with regard to constituent species and their abundance. It would seem that this variation must be largely due to chance dispersal and lodging of seeds or plants, since most species are not restricted to a narrow range of habitat factors. Individual stands observed were composed of from one to about twenty species. There are few closed stands in which there may be actual dominance in the strict

sense of the word. These closed stands which do occur are generally small in area and may be in either lakes, ponds, or streams. The larger plants, Brasenia, Justicia, Nuphar, Orontium, Pontederia, Sparganium, and Typha, appear to be the only species exerting dominance. The smaller plants apparently exist in about equal proportions when growing together in a uniform habitat. Although there are few bodies of water having dense vegetation cover there are very few places completely bare of plants.

Of the fifty-five species listed about twenty are fairly widespread, and about ten others are abundant through parts of the area. The other twenty-five species are relatively sparse and unimportant as constituents in the vegetation of the area as a whole. The more common species are summarized in the following lists in their approximate order of abundance.

Widely Distributed

Juncus debilis
Justicia americana
Ludwigia palustris
Sparganium americanum
Lobelia cardinalis
Dulichium arundinaceum
Lycopus virginicus
Eleocharis obtusa
Potamogeton foliosus
Orontium aquaticum
Myriophyllum brasiliense
Hypericum boreale
Sagittaria latifolia
Myriophyllum humile
Callitriche heterophylla
Rhexia virginica
Vallesneria americana
Xyris caroliniana
Potamogeton tennesseensis
Potamogeton pulcher

Local, but Abundant in Part of the Area

Podostemum ceratophyllum
Nuphar advena
Brasenia schreberi
Pontederia cordata
Eleocharis quadrangulata
Potamogeton diversifolius
Lindernia dubia
Osmunda regalis
Sagittaria australis
Typha latifolia

SUMMARY

A study of the vascular aquatic plants in the Cumberland Plateau in Tennessee was made during the summer of 1955. The purpose of this study was to find out the distribution of species in this area and try to learn some of the conditions under which the species involved survive. The species list for the area was arranged in alphabetical order under group headings according to the most frequently observed habit or position of growth. Under each species name the range and mean values determined for the carbon dioxide content, total acidity, total alkalinity, and pH of the surrounding water were given. These values appear to be characteristic for the species if they were determined from measurements at five or more sites.

The species observed may be divided into two groups on the basis of the pH of the water in which they grew. These groups are from moderately to highly basic and from slightly acid to slightly alkaline. The first group is sparsely represented on the Cumberland Plateau. The second group is made up of approximately fifty species.

Within the pH group the factors that seem to influence the type and amount of vegetation are introduction of the species which are not native, depth of water, movement of water, and the closely related bottom condition and structure.

The vegetation varies greatly in density as well as in species composition and abundance. This is probably due largely to chance dispersal and lodging of seeds and other plant propagules. The few closed stands which occur may be in either lakes, ponds, or streams. There are few bodies of water or very large parts of bodies of water which are without some kind of vascular plant growth.

Of the fifty-five species listed about twenty are widely distributed and ten others are locally abundant in parts of the area. The other twenty-five species are relatively sparse and unimportant as constituents in the vegetation of the area as a whole.

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APPENDIX

COUNTY LOCATIONS FOR PARTS OF BODIES OF WATER SURVEYED

Allardt State Pond, Fentress County

Big Creek, Grundy County

Buck Stewart Pond, Cumberland County

Byrd Creek, Cumberland County

Campbell Junction Lake, Cumberland County

Caney Fork River, Cumberland County

Clear Creek, Cumberland-Morgan Counties

Clear Fork River, Fentress-Morgan Counties

Crab Orchard Creek, Morgan County

Crooked Creek, Fentress County

Cumberland State Park Lake, Cumberland County

Daddy's Creek, Cumberland-Morgan Counties

Emory River, Morgan County

Fall Creek, Cumberland County

Firescald Creek, Grundy County

Gernt Pond, east of Allardt, Fentress County

Grassy Cove Creek, Cumberland County

Grundy County State Park Ponds, Grundy County

Hugo Gernt Pond, Fentress County

Little Clear Creek, Morgan County

Mayland Lake, Cumberland County

Monterey Lake, Putnam County

North Fork of Clear Creek, Morgan County

Obed River, Cumberland-Morgan Counties

Otter Creek, Cumberland County

Panther Creek, Cumberland County

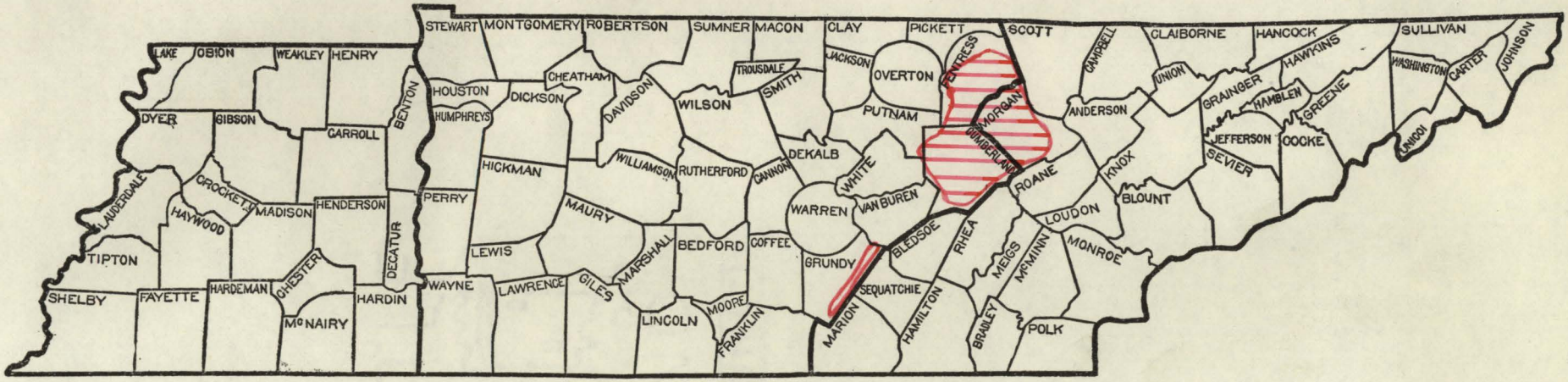
Piney Creek, Cumberland County

Piney Creek, Grundy County

Rock Creek, Morgan County

Waldensia Lake, Cumberland County

White Oak Creek, Morgan County



Area of Field Work in Summer of 1956