Calculations

The volume of water sampled in each case is calculated as follows:

1. The initial flowmeter reading is subtracted from the final reading to obtain the total number of counts.
2. The total number of counts is divided by the number of seconds elapsed during the retrieval of the net to obtain the number of counts per second.
3. By means of the graph supplied with each flowmeter, the number of counts per second is converted to centimeters per second to obtain the velocity at which the net was retrieved.
4. The velocity is multipled by the total number of seconds elapsed during retrieval of the net to obtain the total distance sampled.
5. The volume of water sampled can be calculated by using the formula for the volume of a cylinder, $V = \pi r^2 h$, where r is the radius of the orifice of the net and h is the distance sampled.

Discussion

The equipment and modifications described here have proved useful in TVA's work on zooplankton. The equipment is relatively inexpensive, is easy to operate and maintain, and when used in accordance with the described procedures provides a representative sample with limited variation caused by nonuniform vertical distribution or by avoidance of the sampling device by the zooplankton. The variation caused by nonuniform vertical distribution is minimized because the oblique, bottom-to-surface tow provides a quantitatively and qualitatively integrated sample of the water column. Variation attributable to avoidance is minimized by the relatively large diameter of the net.

Samples collected in surveys utilizing Modifications I, II, or III have shown that acceptable replication can be obtained with all three modifications. Numbers of organisms per cubic meter for the three principal zooplankton groups (Rotifera, Cladocera, and Copepoda) and for the total combination of these important groups [zooplankton assemblage] were analyzed statistically for sample mean (X), standard deviation (SD), and the coefficient of variation (CV, percentage ratio of the standard deviation to the mean). (Table 1). Average CV values were 3.9, 14.3, and 11.9% for Modification I; 21.1, 28.9, and 16.1% for Modification II; and 8.3, 12.6, and 8.5% for Modification III for Rotifera, Cladocera, and Copepoda respectively. CV values for the total zooplankton assemblage were 7.3%, 14.9%, and 9.8% for Modifications I, II, and III respectively. Only 2 of the 27 samples (both collected with Modification II) had CV values above 25%, the maximum level considered acceptable for our sampling regimes.

Acknowledgment

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References

Aron, W., E. H. Ahlstrom, B. McK. Bary, A.W.H. Bé, and W. D. Clarke. 1965. Towing characteristics of plankton sampling gear. Limnol. Oceanogr. 10:333-340.

Barkley, R. A. 1964. The theoretical effectiveness of towed net samplers as related to sampler size and swimming speed of organisms. J. Conseil, Conseil Perm. Intern. Exploration Mer. 29:146-157.

Barnes, H. 1953. A simple and inexpensive closing net. Mem. Ist. Ital. Idrobiol. 7:189-198.

Bary, B. M., J. G. DeStefano, M. Forsyth, and J. van den Kerkhof. 1958. A closing, high-speed plankton catcher for use in vertical and horizontal towing. Pacific Sci. 12:46-59.

Bé, A.W.H. 1962. Quantitative multiple opening-and-closing plankton samplers. Deep-Sea Res. 9:144-151.

Clarke, G. L., and D. F. Bumpus. 1940. The plankton sampler—an instrument for quantitative plankton investigations. Amer. Limnol. Soc. Spec. Pub. 5:1-8.

Cushing, D. H. 1962. Patchiness. Rappt. Proces-Verbaux Reunions, Conseil Perm. Intern. Exploration Mer. 153:152-163.

Fleminger, A., and R. I. Clutter. 1965. Avoidance of towed nets by zooplankton. Limnol. Oceanogr. 10:96-104.

Fraser, J. H. 1966. Zooplankton sampling. Nature 211(5052): 915-916.

McGowan, J. A., and V. J. Fraundorf. 1966. The relationship between size of net used and estimates of zooplankton diversity. Limnol. Oceanogr. 11:456-469.

Schwoerbel, Jurgen. 1970. Methods of Hydrobiology (Freshwater Biology). Pergamon Press, New York. 200 p.

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FLORISTIC SURVEY OF SPRING FLOWERING HERBS AT FROZEN HEAD STATE PARK, MORGAN COUNTY, TENNESSEE

Fred W. Holtzclaw, Jr.

Oak Ridge, Tennessee 37830

Abstract

An isolated, little-disturbed forest in Frozen Head State Park, located in the Cumberland Mountains, has been surveyed to determine the floristics of spring herbs. Forty-seven families and 123 species in 91 genera were reported from the study area. The largest family was

Liliaceae with 16 genera while the largest genus was *Viola* with 11 species. An annotated list of all specimens is included together with a discussion of several species whose range in Tennessee is limited, i.e., *Disporum maculatum, Panax trifolium* and *Hydrastis canadensis.*

INTRODUCTION

Frozen Head State Park, formerly Morgan State Forest, is in the southeastern section of Morgan County and very limitedly in adjacent Anderson County. State highway 116 passes through the southeastern portion of the park and federal highway 62 is approximately three miles south of the park (see Fig. 1).

Historically, the earliest white settlers entered this area in the late 1700's and early 1800's. Of Scotch-Irish stock, they gradually replaced the Chickasaw and Cherokee which once roamed this area. Later, in the mid-1800's, Swiss and German colonists joined the earlier settlers, drawn by reports of bountiful game and rich farming land (Crouch and Adams, Inc. 1972). The park area, roughly 8,000 acres, was purchased in the early 1900's for use as a State Forest; although managed for hardwood timber products, few trees were ever cut. In December of 1970, this acreage was transferred to the Division of State Parks to facilitate the development of Frozen Head State Park. Shortly after this transfer of land the closing of Brushy Mountain Prison, with its 4,000 acres of forested land and 1,800 acres of farm land associated with the State Honor Farm, came under the control of the Tennessee Department of Conservation (Crouch and Adams, Inc. 1972). The specimens collected were from the 12,000 acres of forested land and are not intended to reflect the species diversity of the Honor Farm, which lies west of the forested area.

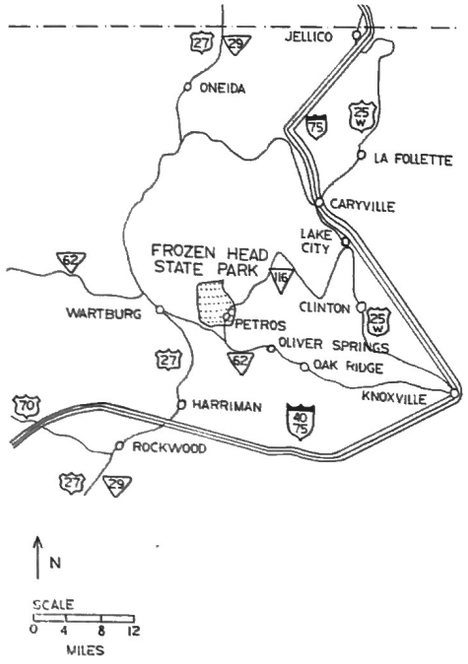

FIG. 1: *General Location Map, Frozen Head State Park*

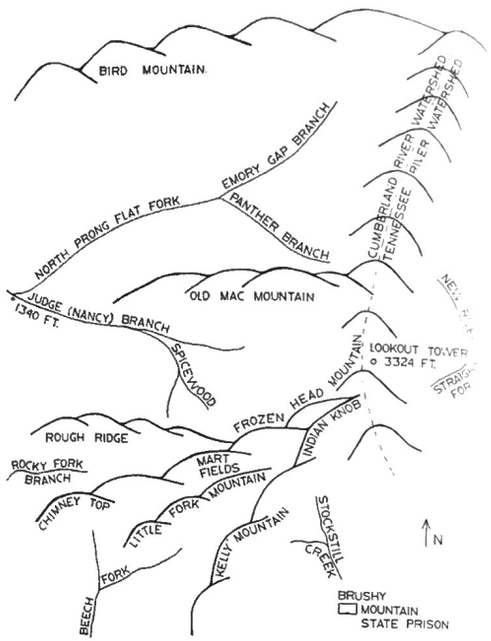

FIG. 2: *Map showing major surface features and drainage system within the park.*

Although the study area is generally considered to lie within the Appalachian Plateaus Province, which includes a tableland-type terrain with an average of 2,000 feet elevation, it is specifically a portion of the subprovince known as the Cumberland Mountains. This is a ruggedly dissected mountainous section where park terrain varies from 1,340 feet on North Prong Flat Fork to 3,324 feet at the observation tower on Frozen Head Mountain (Fig. 2). The striking surface features of this area are primarily attributed to the erosion-resistant Pennsylvanian sandstones and conglomerates which underlie the entire uplands (Floyd, 1965). Interbedded with these rocks are shales and two known coal seams, the Peewee seam at approximately 2,600 feet and the Walnut Mountain seam at about 2,900 feet.

The climate of the park can be generally described as humid but moderate with frost-free days extending from mid-April to mid-October. Tennessee Valley Authority rainfall station 167 at Petros indicates a 34 year mean annual precipitation of approximately 60 inches, including about 20 inches of snow. The park has never had a temperature station but the United States Weather Bureau station at Crossville with a corresponding elevation (1,810 feet) and location shows a ten-year average from 1961 to 1971 of 54.5 degrees Fahrenheit (Crouch and Adams, Inc. 1972).

The study area lies within the Cumberland Plateau Section of the Mixed Mesophytic Forest Region (Braun, 1950). This is conterminous here with the Cumberland Plateau physiographic-floristic regions of Shanks (1958). Within the park these taxa share dominance in the ravines: *Fagus grandifolia, Liriodendron tulipifera, Quercus rubra, Q. alba, Acer rubrum, Aesculus octandra, Prunus serotina* and *Tsuga canadensis.* Along the drier ridges these taxa share dominance: *Liquidambar styraciflua, Quercus rubra, Q. prinus* and *Pinus virginiana.*

MATERIALS AND METHODS

Specimens were collected during the spring months from March through May in 1974 and 1975 and deposited at Vanderbilt University Herbarium, Nashville. Nomenclature follows mainly that of Fernald (1950) and Gleason and Cronquist (1963).

The following terms, in decending order of importance, are used to denote distribution: abundant, common, frequent, infrequent, and rare. They relate to the area surveyed and are not intended to reflect distribution patterns of wide-ranging species.

The listing of taxa is first by class, then alphabetically by family and scientific name.

RESULTS

MONOCOTYLEDONEAE

Amaryllidaceae
Hypoxis hirsuta (L.) Coville Dry, sandy soils of open woods: infrequent but locally abundant.

Araceae
Arisaema triphyllum (L.) Schott Moist woods, marshes; common. Variety *stewardsonii* (Britt.) Stevens widely scattered.

Commelinaceae
Tradescantia subaspera Ker. Woodland roadsides to moist, deep woods; widely scattered to all elevations.

Cyperaceae
Carex careyana Torr. Rich woods; common throughout, abundant in Flat Fork drainage area.
C. nigromarginata Schw. Dry often steep sloped woods; primarily of Straight Fork drainage area.
C. oligocarpa Torr. Moist, rich woods; infrequent.

Dioscoreaceae
Dioscorea quaternata (Walt.) Gmel. Deciduous woods; throughout.

Gramineae
Poa cuspidata Nutt. Rocky, wooded slopes; infrequent.

Iridaceae
Iris cristata Ait. Common throughout.
Sisyrinchium angustifolium Mill. Open woods, old roads; scattered throughout.

Juncaceae
Luzula campestris (L.) DC. Open woods; infrequent.

Liliaceae
Clintonia umbellulata (Michx.) Morong Rich woods in sandy soils or sandstone ledges; Flat Fork and Straight Fork drainage areas.
Disporum lanuginosum (Michx.) Nicholson Rich woods; common.
D. maculatum (Buckl.) Britt. Mature mesophytic woods; found in deep coves of all major drainage areas.
Erythronium americanum (Ker.) Rich woods; throughout.
Medeola virginiana (L.) Deep, rich woods; Flat Fork and Straight Fork drainage areas.
Polygonatum biflorum (Walt.) Ell. Woods; throughout.
P. canaliculatum (Muhl.) Pursh Deciduous woods of all elevations. Also *P. commutatum* (R. and S.) Dietr. and considered tetraploid condition of *P. biflorum.*
P. pubescens (Willd.) Pursh Base of ravines along streams.
Simlax ecirrhata (Engelm.) Watson Woods; throughout.
Trillium cuneatum Raf. Deciduous woods; throughout.
T. erectum (L.) Rich wood at all altitudes; throughout. Variety *vaseyi* (Harbison) Ahles Moist woods especially slopes above 2,000 feet; widely scattered mostly along mountain tops.
T. grandiflorum (Michx.) Salisb. Rich woods; throughout.
T. luteum (Muhl) Harbison Rich woods; widely scattered.
Uvularia grandiflora Sm. Moist woods and thickets; widely scattered.
U. perfoliata (L.) Dry woods of both pine and deciduous types; widely scattered.

Orchidaceae
Cypripedium calceolus (L.) Moist, mesophytic woods; rare, total of seven plants reported from three widely scattered locations.
Orchis spectabilis L. Mature mesophytic woods; widely scattered.

DICOTYLEDONEAE

Araliaceae
Panax trifolium (L.) Mature mesophytic woods; rare, only one population of approximately 24 plants in Panther Branch area at 2,000 feet.

Aristolochiaceae
Aristolochia durior Hill Rich woods especially along streams; flowering vines confined to Flat Fork area.
Asarum arifolium Michx. Woodlands; throughout.
A. canadense (L.) Moist ravines especially along rocky banks; throughout.

Asclepiadaceae
Asclepias quadrifolia Jacq. Woodlands, especially along old roads; throughout.

Berberidaceae
Caulophyllum thalictroides (L.) Michx. Moist woodlands; throughout.
Podophyllum peltatum (L.) Woodlands; throughout.

Boraginaceae
Cynoglossum virginianum (L.) Woodlands; Flat Fork drainage area.

Campanulaceae
Specularia perfoliata (L.) A. DC. Roadsides, waste places.

Caprifoliaceae
Triosteum aurantiacum Bicknell Dry woods; rare, only one location along roadside at 3,000 feet.

Caryophyllaceae
Dianthus armeria (L.) Roadsides, waste places; rare, Flat Fork valley.
Silene virginica (Walt.) Open woods, shaded roadsides; throughout.
Stellaria pubera (Michx.) Woodlands; abundant.

Celastraceae
Euonymus americanus (L.) Rich woods, ravines and stream banks; throughout.

Compositae
Achillea millefolium L. Roadsides, waste places; infrequent.
Antennaria plantaginifolia (L.) Richard Dry, open woods, throughout.
A. solitaria Rydb. Dry, open woods; throughout.
Chrysanthemum leucanthemum L. Roadsides, old fields; widely scattered.
Erigeron pulchellus Michx. Dry woods; throughout.
Hieracium venosum L. Open, dry woodlands; throughout.
Kriga biflora (Walt.) Blake Second growth areas to moist woods; throughout.
Senecio smallii Britt. Open woods; widely scattered.

Convolvulaceae
Convolvulus sepium L. Roadsides; throughout.

Crassulaceae
Sedum ternatum Michx. Typically rich, often rocky ravines; throughout.

Cruciferae
Barbarea verna (Miller) Ascherson Moist roadsides; widely scattered.
Cardamine parviflora L. Open woods, old roadways. Beech Fork drainage area.
Dentaria diphylla Michx. Woodlands and moist ravines; throughout.
D. heterophylla Nutt. Woodlands and gentle slopes; Flat Fork drainage basin.
D. laciniata Muhl. Woodlands; throughout.

Ericaceae
Epigaea repens L. Dry, often mixed forests; infrequent usually along steep banks.

Euphorbiaceae
Euphorbia mercurialina Michx. Woodlands; throughout.

Fumariaceae
Dicentra cucullaria (L.) Bernh. Rich woods especially of north facing or protected coves; throughout.

Gentianaceae
Obolaria virginica L. Primarily moist woods; widespread.

Geraniaceae
Geranium maculatum L. Rich woods and coves; abundant and throughout.

Hydrophyliaceae
Hydrophyllum canadense L. Rich woods especially along rocky ravines by streams; widespread.
Phacelia bipinnatifida Michx. Rich woods, creek banks; throughout.

Labiatae
Salvia lyrata L. Roadsides, woodland borders; throughout.
Scutellaria elliptica Muhl. Woodland, shaded roadsides; widespread.
S. serrata Andr. Rich mesophytic woods; rare, found only in Straivht Fork by stream.

Leguminosae
Vicia caroliniana Walt. Woods, woodland borders and old roadsides; throughout.

Loganiaceae
Spigelia marilandica L. Rich woods, shaded roadbanks; throughout but most prevalant on slopes and old roadbanks above 2,200 feet.

Orbanchaceae
Conopholis americana (L.) Wallr. Oak woodlands; throughout.
Orobanche uniflora L. Rich woods; rare, found in Straight Fork and Rocky Fork Branch.

Oxalidaceae
Oxalis dillenii Jacq. Woodlands or boulders, old roadsides; infrequent.
O. grandis Small Rich woods, old roadsides; throughout.
O. violacea L. Dry alluvial sandy soils; throughout.

Papaveraceae
Sanguinaria canadensis L. Woodlands; abundant.

Polemoniaceae
Phlox divaricata L. Woodlands, stream banks; throughout.
P. glaberrima L. Stream or old road banks in lower woods; Flat Fork drainage basin.

Polygonaceae
Rumex acetosella L. Waste places, old fields; Flat Fork drainage basin.

Portulacaceae
Claytonia caroliniana Michx. Rich woods especially above 2,200 feet; frequent, various ingrades with *C. virginica especially* below 2,000 feet.
C. virginica L. Rich woods especially below 2,000 feet; throughout.

Primulaceae
Lysimachia quadrifolia L. Open woods, old roadbeds; infrequent and scattered.

Ranunculaceae
Anemone quinquefolia L. Rich woods, creek banks; throughout.
Anemonella thalictroides (L.) Spach Woodlands; abundant.
Hepatica acutiloba DC. Woodlands; abundant.
Hydrastis canadensis L. Rich, moist woods; rare.
Ranunculus fascicularis Muhl. Open, frequently moist woods; throughout.
R. recurvatus Poir. Moist woods especially along old roadsides; throughout.
Thalictrum clavatum DC. Moist, shaded sandstone cliff; rare, Panther Gap cliffs only known site where it was locally frequent.
T. dioicum L. Woodlands; throughout.

Rosaceae
Aruncus dioicus (Walt.) Fernald Moist woods; throughout.
Fragaria virginiana Duchesne Old fields and open roadsides; Flat Fork drainage area.
Gillenia trifoliata (L.) Moench Moist, rich woods; Flat Fork drainage area.
Potentilla canadensis L. Open, dry woods; throughout.
Rubus flagellaris Willd. Old fields; Flat Fork drainage basin.
Waldsteinia fragarioides (Michx.) Tratt. Moist woodlands; throughout all valleys.

Rubiaceae
Galium latifolium Michx. Deep, rich woods; widely scattered.
Houstonia caerulea L. Open woods; Beech Fork drainage area.
H. purpurea L. Open woods, roadsides; throughout.
Mitchella repens L. Rich woods especially along stream banks; throughout.

Saxifragaceae
Heuchera americana L. Rich woods; throughout.
Mitella diphylla L. Rich woods especially along creek banks; frequent in Flat Fork and Straight Fork drainage areas.
Tiarella cordifolia L. Rich woods; throughout.

Scrophulariaceae
Pedicularis canadensis L. Open woodlands; throughout.
Penstemon brevisepalus Pennell Woodland borders, open roadsides; infrequent but scattered.
Veronica officinalis L. Old roadsides; infrequent.

Solanaceae
Physalis virginiana Miller Deep woods on slope; rare, one station near headwaters of Beech Fork.

Violaceae
Hybanthus concolor (Forster) Sprengel Mountain slopes; infrequent and scattered.
Viola blanda Willd. Rich, moist woods and seeps; throughout.
V. canadensis L. Deep, often rocky woods; throughout.
V. cucullata Ait. Seeps, drainage areas; throughout.
V. hastata Michx. Woodlands; throughout.
V. palmata L. Mountain slopes; infrequent.
V. papilionacea Pursh Open woods, roadsides; throughout.
V. pensylvanica Michx. Moist woods; throughout.
V. rostrata Pursh Woodlands; abundant in valleys, infrequent on slopes.
V. rotundifolia Michx. Moist woods, coves; throughout.
V. striata Ait. Rich mesophytic woods; rare, Straight Fork drainage area only.
V. tripartita Ell. Woods; rare and local along Rocky Fork Branch and Flat Fork.

Umbelliferae
Osmorhiza longistylis (Torrey) DC. Moist woods; throughout.
Sanicula gregaria Bicknell Mountain slopes; throughout.
Thaspium barbinode (Mich.) Nuttall Woods, old roadsides; abundant.
T. trifoliatum (L.) Gray Woods, woodland borders; throughout.

Discussion

The foremost purpose of this survey was the careful observation and description of the spring flora of a portion of a physiographic area which, in Tennessee, has been largely ignored. In addition, it was the author's hope that this recently little-disturbed land would be recognized as an important ecological setting which is rapidly disappearing from the Cumberland Mountains, primarily because of the extensive damage brought to this region by strip mining. The edge of the northern park boundary marks the starting point for one of the most intensive coal mining operations in Tennessee, that of the New River drainage area. It is thus with some trepidation that one realizes the significance of the two previously mentioned coal seams found within the park. The development of these seams would uproot countless acres of forest and bury hundreds of other acres. Additionally, it would be a serious detriment to the processes of succession which are now returning the forest to a near pristine state.

Under the present conditions, with the forest of the park maturing, several plant families stand out in importance. The Liliaceae is the family with the largest number of species, 16. Of special interest within this family is *Disporum maculatum*. Listed as a rare plant of Tennessee (Sharp, 1974), it is fairly frequent within the park, found in deep coves of all major drainage areas. Perhaps it is the vanishing of its habitat, deep mesophytic woods, that determines its limited occurrence. Also of interest is *Clintonia umbellulata*, especially well suited to the rich sandstone-dominated area of Straight Fork, where several extensive populations occur. Finally, the four species and one subspecies of *Trillium* grow in profusion that rivals that of the Great Smoky Mountains. The later flowering time and tendency to dominate the higher elevations may mark the evolutionary factors necessary for *T. erectum vaseyi* to be more generally recognized as *T. vaseyi*.

Within the family Violacea the genus *Viola*, with its 11 species, is the most common genus encountered. Especially common are *V. blanda, V. canadensis, V. hastata* and *V. rostrata* which frequently cover the ground in profusion. Only *V. striata* and *V. tripartita* are rarely seen and then in deep, forested coves.

Three other species demand attention, each rare in Tennessee. *Carex careyana*, although considered rare in Tennessee, is found in all major drainage areas throughout the park. It is especially common in the Flat Fork drainage basin where the dark evergreen leaves are prominant during the winter months. Unfortunately one of these species, *Hydrastis canadensis*, may now be absent from the park due to the value of its rootstock. During the spring of 1974 a secluded cove at an elevation of 3,000 feet on the northern slope of Byrd Mountain contained a population of this rare species. The next spring when the same area was surveyed the entire population was gone, evidently destroyed by "herb diggers." The illegal removal of plants has seriously reduced the presence of *H. canadensis* as well as the more common *Panax quinquefolius*.

The remaining species, *Panax trifolium*, is evidently confined to a single station of 24 plants within the Panther Creek drainage area. This delicately beautiful plant grows in deep, mesophytic woods amidst what may be the heaviest population of flowering herbs within the park, including large numbers of *Viola canadensis* and *Tiarella cordifolia*.

Indeed, the entire upper reaches of the North Prong Flat Fork, including both Panther Branch and Emory Gap Branch, harbor extensive and diverse populations of spring flowering herbs. Fortunately, the present plans of the Conservation Department call for this entire area to be preserved as a protected watershed.

Acknowledgments

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Literature Cited

Braun, E. L. 1950. Deciduous forests of Eastern North America. Hafner Publishing Co., New York.

Crouch and Adams, Inc., Oak Ridge, Tennessee. 1972. Design study of the Morgan State Forest property conversion into Frozen Head State Park. Prepared for State of Tennessee, Department of Conservation, Division of Planning and Development.

Fernald, M. L. 1950. Gray's Manual of botany, 8th Ed. Amer. Book Co., New York.

Floyd, Robert J. 1965. Tennessee rock and mineral resources. Tennessee Department of Conservation, Division of Geology, Bulletin 66. Nashville, Tennessee.

Gleason, H. A. and Arthur Cronquist. 1963. Manual of vascular plants of Northeastern United States and adjacent Canada. D. Van Nostrand Co., Princeton, New Jersey.

Shanks, R. E. 1958. Floristic regions of Tennessee. J. Tenn. Acad. Sci. 33:195-210

Sharp, A J. 1974. Rare plants of Tennessee. The Tennessee Conservationist. 40:20-21.