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AVAILABLE SOIL MOISTURE AND PLANT COMMUNITY DIFFERENTIATION IN DAVIES ISLAND, MIDDLE TENNESSEE

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ABSTRACT

One of the dominating factors which determine community differentiation is available soil moisture, which is intimately coupled with soil types. The moisture contents of various soil types found at Davies Island located in the Center Hill Reservoir in Middle Tennessee are determined and correlated with the vegetational types supported by such soils. Species of plants found in four sites, namely a beech-maple complex, an oak-hickory complex, old fields and cedar woods are listed and their occurrence is discussed in relation to the available soil moisture.

INTRODUCTION

Intensive research on the subject of effect of ecological factors on specific communities has been carried out by many in the last few decades in Tennessee and elsewhere. One example of such a research was carried out by Shanks and Norris (1950), who studied the relation of variations in frost dates as correlated with vegetation in an East Tennessee valley. The critical differences in minimum temperatures between extreme ridge top and valley flat stations indicated a difference of at least twenty days in length in the fall portion of the potential growing season among plant habitats in a relatively small topographic unit. McDermott (1954) found differences in the distribution of hardwood tree seedlings due to the influence of different degrees of saturation of the soil. Red maple, river birch and sycamore seedlings were found to recover from sustained soil saturation and the relatively high degree of recovery was indicative of their successional relationship and the ultimate composition of stands in bottomlands.

Beals and Cope (1964) found that variations in soil types greatly influenced the distribution of plant communities within a 32.38 hectare woodland, and that the moisture regime was the dominant factor in the distribution of the herbaceous plants within the study area. Various other factors defining community composition have been studied (Stearns, 1960; Daubenmire, 1949); However, the effect of soil water alone on plant growth is expressed more commonly than any other soil factor (Oosting, 1956). Soil moisture is of fundamental importance to plants and no environmental study would be complete without the measurements of this factor (Platt and Griffiths, 1964). Beals and Cope (1964) and Caplenor (1968) reported the importance of soil moisture as a criterion for the differentiation of communities. Several ecological and taxonomic studies of diverse plant communities have been made in Tennessee (Sharp, 1939; Shaver, 1945; Quaterman, 1950; Braun, 1950; Williams, 1958; and Caplenor, 1965). The objective of the present investigation is to determine the correlations, if any, between soil moisture constants and types of plant communities found on different soil types on Davies Island, Center Hill Reservoir in Middle Tennessee.

STUDY AREA

The United States Army Corps of Engineers constructed the Center Hill dam in 1948 on the Caney Fork River in Middle Tennessee. Davies Island is located in the Center Hill Reservoir in DeKalb County; and since the completion of the dam, the island has been totally separated from the mainland, which makes it an ideal area for many kinds of ecological investigations. The reservoir is 103 KM in length, covers 7865.54 hectares at maximum elevation, and has a drainage area of 5685.16 SqKM. The study area covers approximately 2107.12 hectares and is 1.71 KM long and 1.00 KM wide at the north end (Fig. 1). Elevation varies from 201.17 at the water edge to 298.70 M at the crests of hills and ridges. Portions of the Davies Island had been extensively farmed before acquisition. Since the area has been uninhabited for the past twenty years, the numerous old field sites are in various stages of secondary succession. One of the study sites on the north-west section is covered predominantly with *Juniperus virginiana* L. almost to the exclusion of other arborescent species; and a two acre site on the north end of the island is completely dominated by *Pueraria lobata* (Willd.) Ohwi. A few old roads are still in evidence as well as some fence lines. The signs of severe burns that occurred at times in the forested areas are still noticeable.

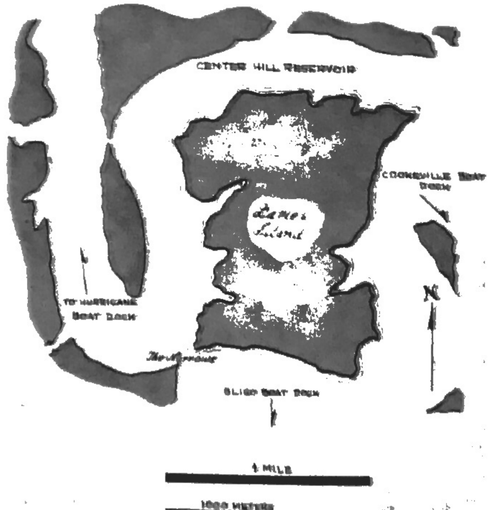

Figure 1. The Study Area

Soils predominant in the area are the Dellrose, Bodine, Mimosa, Rockland, and Etowah mapping units. They are mostly silt loams to cherty silt loams and are placed in capability classes IIIe to VIIs. The gentler slopes of Mimosa and Dellrose have been cultivated and eroded (II, III, IV, e above) but steeper slopes, especially on limestone Rockland and Bodine (IV, V, VI, VII, s) are rocky and steep. Brief descriptions of soils predominant in the area are given below. For detailed information on all these soil types, consult Jackson *et al.*, 1963.

Dellrose: The Dellrose soil series consists of deep, well drained cherty soils on hillsides extending from the physiographic unit Highland Rim into the Central Basin. The soils were formed in old cherty colluvium that was washed down-slope from the higher Bodine and Baxter soils. The creep was deposited in layers of variable thickness over the residuum derived from phosphatic limestone. The soils are medium to strongly acid and are commonly found on slopes of 12 to 45 per cent. They are, however, only moderately susceptible to erosion since their profile is loose, friable, and contains a large amount of chert. These soils are weakly to moderately developed, and they vary in depth from 0.61 M to 9.14 M. The surface layer is dark brown, friable, cherty silt loam while the subsoil is brown to dark brown, friable, cherty silty clay loam or silt loam. Water infiltrates the profile quickly and the cherty surface helps in the prevention of soil movement from rains. Most of the soils of this series have been cleared and used for agricultural purposes. The numerous old field sites on the study area are mostly on Dellrose soils.

Bodine: The soils of the Bodine series are moderately shallow to deep and contain a high amount of chert. They are found on ridge crests and steep hillsides and have formed in the residuum from very cherty limestone. The Bodine soils have a pale brown cherty silt loam surface. Slope of these soils usually is between 20 and 40 per cent in most areas, and are generally found above the Dellrose series. Bodine soils are strongly acid to very strongly acid, very low in organic matter and in natural fertility. The soils have very low moisture supplying capacity and are droughty. The predominant vegetation is made up of oak and hickory forest.

Mimosa: The Mimosa soil series is made up of well-drained soils that have formed on uplands in the clayey residuum of phosphatic limestone. Permeability is low, run-off is rapid, and little moisture is available to plants due to the steepness and a clay subsoil. Root penetration is also limited by the thin clay subsoil and closely underlying bedrock. The soils are medium to strongly acid, phosphatic in most places and droughty. The native vegetation consists generally of eastern red cedar, black walnut, hackberry, elm, hickory and honey and black locust thickets.

Rockland: The Rockland soils consist mainly of limestone outcrops and very shallow soils with ridges of clayey and cherty limestone occupying 50 per cent of the surface area. The soils are very high in clay content. The site of the plant communities designated as Cedar Woods on the study area are on Rockland limestone soils. Red cedar occupies the sites almost to the exclusion of other arborescent species.

Etowah: The Etowah soils are deep and well-drained. They have developed in old alluvium on stream terraces which do not flood. The alluvium has washed down from limestone and loess soils and the soils are found mainly on toe slopes and fans as the base of steep slopes in highly dissected parts of the Highland Rim. The Etowah soils usually have slopes ranging from 5 to 20 per cent. The soils generally have a 12.7 to 25.4 cm layer of dark brown cherty silt loam and a subsoil of yellowish-red or reddish-brown, friable cherty silty clay loam. The soils are strongly acid and moderate in fertility. The amount of chert in the soil and low pH interfere with cultivation, impairs productivity and reduces available water supply. Most of the acreage of this series was cleared at one time, and in such old field sites herbaceous specimens are common.

MATERIALS AND METHODS

Thorough preliminary exploration of the study area was begun in the early spring of 1967. The boundaries of the plant communities of the island were determined subjectively and points were established for purposes of collecting soil samples. Sampling points were located in four types of communities which are described as Beech-Maple, Oak-Hickory, Old Field Sites, and Cedar Woods. Soil samples (300 g) were taken weekly for three months from these plant communities at two depths, namely 7.6 and 30.5 cm. Portions of the samples were placed in aluminum drying pans, weighed, dried for 24 hours at 105° C, cooled in a desiccator and reweighed. The resulting weight loss was then calculated as the percentage of soil moisture at the 7.6 and 30.5 cm depths. Every week a total of eight samples were collected from each of the four communities mentioned above. The weekly moisture content was then determined as an average of the four points at each depth within each community.

Moisture measurements were made using the method suggested by the United States Department of Agriculture, Salinity Laboratory Staff (Richards, 1954). The permanent wilting percentage (P.W.P.) was obtained for each sample as follows: The air dry soil was passed through a 2 mm sieve, placed on a pressure membrane apparatus, soaked to saturation for 24 hours, subjected to 225 psi for 24 hours, weighed, dried for 24 hours at 105° C, cooled in a desiccator, and reweighed. The weight loss (per cent lost on basis of dry weight of soil) was then recorded as P.W.P. of the sample.

Field capacities of each soil sample were determined on a ceramic pressure membrane apparatus. The air dried samples were mortared to pass a 2 mm sieve, soaked to saturation for 24 hours, subjected to a pressure of 25 mm of mercury for 24 hours, weighed, dried for 24 hours at 105° C, cooled in a desiccator, and reweighed. The resulting weight loss was then recorded as the field capacity of the sample. Each of the soil moisture constant was determined from the formula:

$$\text{Constant} = \frac{\text{weight loss}}{\text{dry weight of soil}}$$

Specimens were collected from each type of community covering approximately two to four hectares of land at a time in spring and summer and all the plant taxa noted were collected. Plant specimens were collected from each type of community concurrently with the soil sampling, and were identified using standard keys (Radford, Ahles and Bell, 1968; Gleason, 1952; Fernald, 1950; and Small, 1933). The voucher specimens are deposited in the herbarium of Tennessee Technological University.

RESULTS

Available water, field capacities, and P.W.P. of the soils of the communities were characteristically different (Fig. 2, Table 1). Noteworthy among these data are the high moisture content of the soil of old field sites, the intermediate position of the Beech-Maple woods, and the low summer field moisture contents of the Oak-Hickory and Cedar communities. It is only in the Cedar Woods that the field moisture content approached or fell below the P.W.P. in the summer, while the field moisture content of the Beech-Maple and Oak-Hickory soils had an intermediate range between field capacity and P.W.P. The available soil moisture of the respective communities [(given as the difference between field capacity and the P.W.P.) (Platt and Griffiths, 1964)], was the highest at the old field sites (19.5) and the Beech-Maple sites (18.2), the Oak-Hickory sites (14.5), and the Cedar Woods (8.5) occurred in descending order (Table 1). It was only in the old field sites that the field moisture content closely approximated the field capacity of the soils. The relatively high P.W.P. of the soils of the Cedar Woods is the result of a high clay content while the low permanent wilting percentage of the soils of Oak-Hickory sites indicates a high chert content occurring in the sand size particles. There is a relatively consistent difference of 2-5 per cent between the field moisture content of the soils at the 7.6 cm level and at the 30.5 cm level.

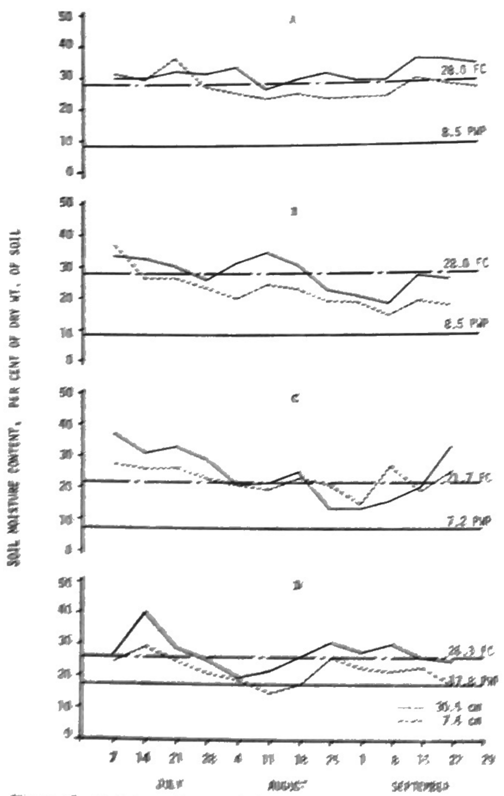

Figure 2. Moisture characteristics of soils from 30.5 cm and 7.6 cm depths: A) Old Field sites, B) Beech-Maple sites, C) Oaw-Hickory sites, and D) Cedar Woods. (F. C. Field Capacity; P.W.P. Permanent Wilting Point).

Vegetational analysis of the different communities shows distinct differences in composition (Table 2). The canopy vegetation of the Beech-Maple communities (number of taxa, 49) was characterized by *Fagus grandifolia* Ehrh., *Acer rubrum* L. Understory vegetation consisted mainly of saplings of the above with dogwood (*Cornus florida* L.), spicebush (*Lindera benzoin* (L.) Blume), and Euonymous (*Euonymous americanus* L.), (Table 2). The herb layer was made up of various species characteristic of a Beech-Maple forest as reported by Duncan and Ellis (1969). Such species as the dogtooth violet (*Erythronium americanum* Ker.), dwarf crested Iris (*Iris cristata* Ait.) Phacelia (*Phacelia bipinnatifida* Michx.), false Solomon's seal (*Smilacina racemosa* (L.) Desf.), Jack-in-the-pulpit *Arisaema triphyllum* (L.) Schott.), and maiden hair fern (*Adiantum pedatum* L.) were frequently found and are typical of this Beech-Maple community. The relatively high moisture coefficient (28.0 ± 1.4%, Table 1) is reflected by the presence of numerous species of plants found under such conditions.

Table 1

Characteristics of Plant Communities

	Old Field	Beech-Maple	Oak-Hickory	Cedar Woods
Number of taxa	74	49	37	8
Field Capacity *	29.1 ± 1.03	28.0 ± 1.4	21.7 ± 0.9	26.3 ± 0.1
Permanent Wilting Point *	8.5 ± 0.3	9.8 ± 1.2	7.2 ± 0.3	17.8 ± 1.4
Available water *	19.5	18.2	14.5	8.5
Soil Types and Slopes	Etowah (6-12%)	Etowah (12-20%)	Etowah (12-20%)	Rockland (35-45%)
	Mimosa (8-20%)	Mimosa (5-20%)	Bodine (18-40%)	Mimosa (20-35%)
	Dellrose (8-20%)	Dellrose (20-45%)		
		Bodine (18-40%)		
Position	Upland and Terrace	Terrace and Slopes	Slopes and Crest	Eroded Slopes
Exchangeable Calcium (milliequivalents per 100 gm)	Etowah (1.2-6)	Etowah (0.9-3.8)	Etowah (0.8-3.8)	Mimosa (5-11)
	Mimosa (5-11)	Mimosa (5-11)	Bodine (0.4-0.8)	
	Dellrose (1.5-2.5)	Dellrose (1.5-2.5)		
		Bodine (0.4-0.8)		

*Per cent water (dry weight base). Standard error of the mean is based on 24 soil samples from each community.

The canopy vegetation of the old field sites was characterized almost completely by tuliptree (*Liriodendron tulipifera* L.) along with such successional indicators as black locust (*Robinia pseudo-acacia* L.), honey locust (*Gleditsia triacanthos* L.), tree of heaven (*Ailanthus altissima* L.), butternut (*Juglans cinerea* L.), small saplings of elm (*Ulmus rubra* Muhl. and *U. thomasi* Sarg.), and sumac (*Rhus typhiana* L.). The understory vegetation consisted of small saplings of the above and buckbush (*Symphoricarpos orbiculatus* Moench.). The presence of a large number of species of plants (74) that are usually associated with secondary succession indicates the degree of disturbance of the sites even though many of these do occur in stable systems. Such herbaceous species as thistle (*Cirsium altissimum* L.), golden rod (*Solidago gigantea* Ait. and *S. ulmifolia* Muhl. *ex* Willd.), morning glory (*Ipomoea pandurata* (L.) G.F.W. Mey), dodder (*Cuscuta gronovii* Willd.), Asters (*Aster* spp.), wild sensitive plants (*Cassia nictitans* L.), and ragweed (*Ambrosia artemisifolia* L.) are characteristic of sites that are in various stages of secondary succession.

The canopy vegetation of the Oak-Hickory sites was characterized by such species as *Quercus alba* L., *Q. falcata* Michx., *Q. stellata* Wang., *Carya glabra* Mill., *C. ovalis* (Wang.) Sarg., and *C. ovata* (Mill.) Koch. (Table 2).The understory vegetation consisted primarily of mountain laurel (*Kalmialatifolia* L.), Viburnum (*Viburnum acerifolium* L.), and huckleberry (*Vaccinium* sp.) The few species (37) were plants characteristic of intermediate conditions. Spotted wintergreen (*Chimaphila maculata* (L.) Pursh.), blood root (*Sanguinaria canadensis* L.), pennywort (*Obolaria virginica* L.), christmas fern (*Polystitchum acrostihoides* (Michx.) Schott.), and beggar lice (*Desmodium nudiflorum* (L.) DC.), were found in abundance in the Oak-Hickory sites and the high frequency of such species is characteristic of the intermediate areas that have a relatively but not lowest available moisture coefficient (Table 1).

The lower profile depth and stoniness of the substratum may also have an influence on available moisture.

The canopy vegetation of the Cedar Woods was made up exclusively of red cedar (*Juniperus virginiana* L.), and only a few xerophytic species such as *Euphorbia corollata* L., *E. dentata* Michx. *Acalypha gracilens* Gray, *Ruellia humilis* Nuttall, and *Cercis canadensis* L. occurred. The total number of taxa is 8.

TABLE II. List of Species from the Various Sites

Species	Old Field	Beech-Maple	Oak-Hickory	Cedar Woods
Acalypha gracilens Gray				X
Acer rubrum L.		X		
Acer saccharum Marsh.		X		
Actaea pachypoda Ell.		X		
Adiantum pedatum L.		X		
Agrimonia pubescens Wallr.			X	
Agrimonia rostellata Wallr.			X	
Ailanthus altissima (Mill.) Swingle	X			
Alnus serrulata (Ait.) Willd.	X			
Ambrosia artehisiifolia L.	X			
Ammania coccinea Rottb.	X			
Amorpha fruticosa L.	X			
Anemone virginiana L.		X		
Anemonella thalictroides (L.) Spach.		X		
Arisaema triphyllum (L.) Schott.		X		
Ascqrum hypericoides L.			X	
Asplenium platyneuron (L.) Oakes	X			
Aster spp.	X		X	
Bidens cernua L.	X			
Bignonia capreolata L.	X			
Botrychium virginianum (L.) Sw.	X			
Brassica campestris L.	X			
Cardamine hirsuta L.	X			
Carex spp.	X			
Carya glabra (Mill.) Sweet			X	
Carya ovalis (Wang.) Sarg.			X	
Carya ovata (Mill.) K. Koch			X	
Cassia hebecarpa Fern.	X			
cassia nictitans L.	X			
Cassia obtusifolia L.	X			
Cerastium nutans Raf.		X		
Cercis canadensis L.				X
Chimaphila maculata (L.) Pursh			X	
Chrysopsis camporum Green	X			
Cirsium altissimum L.	X			
Commelina communis L.	X			
Cornus florida L.	X	X		
Cuscuta gronovii Willd.	X			
Cuphea petiolata (L.) Koehne			X	
Cynoglossum virginianum L.	X			
Dentaria laciniata Muhl.		X	X	
Dentaria multifida Muhl.		X		
Desmodium nudiflorum (L.) DC.	X			
Desmodium pauciflorum (Nutt.) D.C.	X			
Dicentra cucullaria (L.) Bernh.		X		
Diodia virginiana L.	X			
Dodecatheon maedia L.		X		
Elephantopus carolinianus Willd.	X			
Epifagus virginiana (L.) Bart.		X		
Erechtites hieracifolia (L.) Raf.	X		X	
Erythronium americanum Ker.		X		
Euonymus americanus L.		X		
Eupatorium coelestinum L.	X			
Eupatorium rugosum Houtt.		X		
Euphorbia corollata L.	X			
Euphorbia dentata Michx.	X			X
Euphorbia mercurialina Michx.				X
Fagus grandifolia Ehrh.		X		
Franixus americana L.		X		
Galium aparine L.	X			
Galium triflorum Michx.	X	X		
Geum canadense Jacq.		X		
Glecoma hederacea L.			X	
Gleditsia triacanthos L.	X			
Hedeoma pulegioides (L.) Pers.	X			
Helenium flexuosum Raf.	X			
Hepatica americana (DC.) Ker.			X	
Hordeum pusillum Nutt.	X			
Houstonia purpurea L.			X	
Hydrangea arborescens L.		X		
Hypericum punctatum Lam.	X			
Impatienens capensis Meerb.		X		
Impatienens pallida Nutt.		X		
Ipomoea pandurata (L.) G.F.W. Mey.	X			
Iris cristata Ait.		X		
Jeffersonia diphylla (L.) Pers.		X	X	
Juglans cinerea L.	X			
Juglans nigra L.		X		
Juniperus virginiana L.				X
Lespedeza cuneata (Dumont) G. Don	X			
Lespedeza repens (L). Bart.			X	
Lindera benzoin (L.) Blume		X		
Lippia lanceolata Michx.	X			
Liquidambar styraciflua L.	X			
Liviodendron tulipifera L.	X			
Lobelia inflata L.	X			
Lobelia siphilitica L.		X		
Lonicera japonica Thunb.	X			
Lycopus rubellus Moench.	X			
Magnolia acuminata (L.) L.		X		
Monotropa uniflora L.		X		
Myosotis macrosperma Engelm.			X	
Obolaria virginica L.			X	
Oxalis stricta L.	X	X		
Oxalis violacea L.		X		
Panax quinquefolium L.		X		
Phacelia bipinnatifida Michx.		X		

Species	Old Field	Beech-Maple	Oak-Hickory	Cedar Woods
Phlox divaricata L.		X		
Phytolacca americana L.		X		
Platanus occidentalis L.	X			
Podophyllum peltatum L.		X	X	
Polygonatum biflorum (Walt.) Ell.	X	X		
Polygonum convolvulus L.	X			
Polygonum pensylvanicum L.	X			
Polystichum acrostichoides (Michx.) Schott.		X		
Populus deltoides Marsch.	X			
Prenanthes alba L.	X			
Prunella vulgaris L.	X			
Prunus serotina Ehrh.	X			
Pueraria lobata (Willd.) Ohwi.	X			
Quercus alba L.		X	X	
Quercus falcata Michx.			X	
Quercus stellata Wang.			X	
Ranunculus allegheniensis Britt.			X	
Ranunculus micranthus Nutt. ex T. & G.			X	
Rhus toxicodendron L.		X		
Rhus typhina L.	X			
Robinia pseudoacacia L.	X			
Ruellia humilis Nuttall				X
Salix nigra Marsh.	X			
Sanguinaria canadensis L.		X	X	
Sassafras albidum (Nutt.) Nees.			X	
Saxifraga virginiensis Michx.		X	X	
Sedum pulchellum Michx.			X	
Senecio spp.	X			
Sisyrinchium angustifolium Mill.	X			
Smilacina racemosa (L.) Desf.		X		
Smilax hispida Muhl.				X
Solanum carolinense L.	X			
Solidago gigantea Ait.	X		X	
Solidago ulmifolia Muhl. ex Willd.	X		X	
Spiranthes grayi Ames	X			
Stylophorum diphyllum (Michx.) Nutt.			X	
Symphoricarpos orbiculatus Moench	X			
Tilia americana L.		X		
Tovara virginiana (L.) Raf.				X
Trifolium cuneatum Raf.				X
Trillium dubium Sibth.		X	X	
Trillium grandiflorum (Michx.) Salisb.			X	
Triodia flava (L.) Smyth	X			
Ulmus rubra Muhl.	X			
Ulmus thomasi Sarg.	X			
Uniola latifolia Michx.	X			
Urtica dioica L.	X			
Vaccinium sp.			X	
Verbascum thapsus L.	X			
Verbesina occidentalis (L.) Walt.	X			
Verbesina virginica L.	X			
Vernonia altissima Nutt.	X			
Viburnum acerifolium L.			X	
Viola rafinesquii Greene var. kitabeliana		X		
Vitis cinera Engelm ex. Millardet			X	
Woodsia obtusa (Sprang.) Torr.		X		

Discussion

Different communities occupied sites that varied in their available soil moisture. The relatively low available soil moisture constant (14.5) in Oak-Hickory communities are usually found in the drier sites of the northern Highland Rim (Duncan and Ellis, 1969) and Cumberland Plateau (Caplenor, 1965). Such species as *Desmodium nudiflorum* (L) DC; *Solidago* spp., *Hepatica americana* (DC.) Ker., *Polystichum acrostichoides* (Michx.) Schott, *Vaccinium* spp., *Chimaphilia maculata* (L.) Pursh., and *Sanguinaria canadensis* L. might be used as indicators of the Oak-Hickory community. It must be noted, however, that mere presence of these species is not sufficient; frequency and dominance percentiles must be considered before definite use of the species as indicators can be sanctioned as suggested by Cottam (1949). The soil of the Oak-Hickory sites had a great influence in the determination of species survival on the drier hillsides and ridge tops. Since the location of practically all the Oak-Hickory associations was above any influence of the permanent water table, the composition of the stands was determined in conjunction with both the structure and texture of the soils, which in turn affect the moisture holding capacity of the soils. It will be recalled from the soil descriptions that Oak-Hickory communities were found primarily on soils of the Bodine series which are silty loam soils with low moisture supplying capacities.

The Beech-Maple associations were found on soils with relatively high percentage (18.2) of available soil moisture. The silt loam soils of the Mimosa, Dellrose, and Etowah series have very good internal drainage and support stands of sugar maple and beech, and this association usually contains a rich concentration of herbaceous plants, some of which might be used as indicators of a Beech-Maple climax. A note of caution is relevant at this point. Since the western mesophytic forest region, in which Center Hill Lake lies, has a mosaic vegetation pattern that can involve a great many species combinations, it is better considered comparable in a limited way to an association segregate of the mixed Mesophytic Forest brought about by local habitat conditions than to the Beech-Maple association of the glaciated region to the north. Some examples of the herbaceous indicator species of mesic lake states forest are: *Adiantum pedatum* L., *Polygonatum biflorum* (Walt.) Ell., *Smilacina racemosa* (L.) Desf., *Hydrophyllum* spp., *Phacelia* spp., *Clintonia borealis* (Ait.) Raf. *Arisaema triphyllum* (L.) Schott, *Equisetum* spp. (Wilde 1933); *Mitella diphylla* L., *Osmorhiza* spp., *Claytonia* spp., and *Viola* spp. (Stearns, 1951).

The old field sites had the greatest percentage (19.5) of available moisture. This figure is reflected by the relatively high field capacity (28.0) and the relatively low. P.W.P. (8.5), of the old field sites belonged primarily to the Mimosa and Dellrose series, both of which are deep and well-drained, with the Dellrose soils having a relatively high amount of water available. These soils had been cleared for agricultural purposes at one time and the high number of species present is due primarily to the various stages of secondary succession. The small size of Tuliptrees and the presence of various taxa such as *Andropogon*, *Solidago*, *Aster*, *Ipomoea*, *Rhus*, *Gleditsia*, *Cuscuta*, *Solanum*, *Amorpha* and *Circium* show that the sites were greatly disturbed at one time and are now in various stages of secondary succession (Bonck and Penfound, 1945; Quarterman, 1950). In her study of early plant succession on cropland abandoned for 25 years in the central basin of Middle Tennessee, Quarterman (1957) listed, among others, species of *Asplenium*, *Desmodium*, *Eupatorium*, *Galium*, *Oxalis* and *Solidago*, which were found in all the old field sites examined. There is a close correspondence between the available soil moisture percentages and other soil and site characteristics between the old field sites (19.5), and the Beech-Maple sites (18.2).

The clayey soils of the Cedar Woods have particular effect upon forest growth. The small size of the clay particles permits the adsorption of tremendous amounts of water but the same adsorptive ability of the colloidal particles results in a minimum of available water and may result in physiological drought (Meyer, Anderson and Bohning, 1960). The latter characteristic is shown by the relatively high P.W.P. (17.8) of the Cedar Woods soils. With a very low (8.5) available water constant of the soils, only the hardiest species with high drought resistance can survive. Consequently, the high density of cedar and the small number of herbaceous species present on these sites is in agreement with the low amount of soil moisture in the sites. The higher amounts of moisture present in the old field and the Beech-Maple sites is due to the greater field capacity, lower P.W.P. of the soils, and the receipt of run-off water from the higher terrain. Certainly, a major factor in the development of plant communities on the study area is the amount of available soil moisture. It is not the intention of the authors to leave the impression that this is the only factor involved, but it is of such importance in the physiology of plants present in this area that it should be considered as an important source of plant community development and differentiation. It is further realized that these moisture coefficients are not the only factors influencing water availability; soil depth and stoniness are also important, and slope angle, and position influence run-off, seepage, soil temperature and evapo-transpiration. The relation of hill position and canopy density may also influence the unhindered fall of precipitation, but this study has been concerned only with the soil constants themselves.

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PTILONCODUS HARRISI; A NEW SPECIES OF CONDONT FROM THE VIOLA LIMESTONE (ORDOVICIAN) OF OKLAHOMA

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Abstract

The conodont genus *Ptiloncodus* was established in 1962 by Dr. R. W. Harris who named and described the single species *P. simplex*. This distinctive genus is easily recognized by its cylindrical to sub-cylindrical, pointed, hook-shaped cusp and absence of basil escutcheon. The type species, *P. simplex* Harris, is characterized by two subflattened, auricular expansions attached to opposite sides of the base at right angles to the plane of curvature of the "hook". These expansions are broken off most specimens. Harris described his species from the lower and middle Joins Formation to which it appears restricted. The species described here was obtained from the upper Viola Limestone and Fernvale phase of the Viola ("Fernvale Limestone") from outcrops along U.S. Highway 77, Oklahoma Highway 18, and from various horizons throughout the uppermost Viola section of the Flying L Ranch of the Arbuckle Mountains (Bordeau, 1967).

Introduction

Viola and Fernvale strata crop out along U.S. Highway 77, on the southern limb of the Arbuckle Anticline, in the center S½, NE¼, Sec. 25, T. 25, R. 1E., Carter County, Oklahoma. The Oklahoma Highway 18 section is along a small southward-flowing stream at the base of the road cut of Oklahoma State Highway 18, in center SW ¼,Sec. 12, T. 35,R.3E., Carter County, Oklahoma. The Flying L Ranch section, described by Wengard (1948), is on the south limb of the Dougherty Anticline, on the Flying L Ranch, NW¼, Sec. 27, 1. 15, R. 2E., Murray County, Oklahoma. The occurrence of this genus in the Upper Viola extends its known stratigraphic range upward into at least the Trenton.

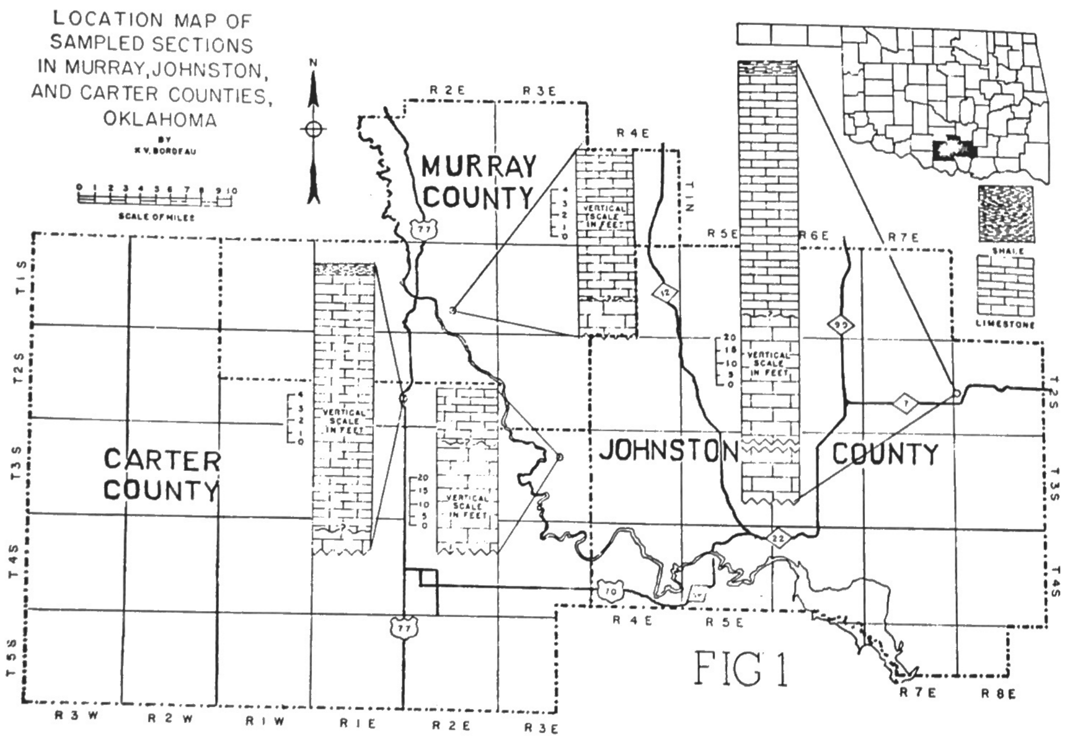

FIG 1

Description of the New Species

Ptiloncodus harrisi n. sp.

Subcylindrical, apically pointed, hook-shaped shaft. Possibly slightly inflated basally, some specimens show faint lateral flattening of the hook. Two small rounded knobs characterize opposite sides of the shaft base at right angles to the plane of curvature of the hook; the knob extends slightly beyond the end of the shaft to produce a forked appearance at the proximal end. The rounded basal knobs are thought to represent attachment scars. The length of the observed conodont elements, measured from the proximal knobs along the shaft to the bend of the hook, varies from 0.41 mm to 0.95 mm. The length of the holotype is 0.88 mm. See locality map fig. 1.

The species is named in honor of Dr. R. W. Harris. The holotype and figured cotypes are deposited in the collections of the Paleontological Research Institution, Ithaca, New York. The morphology of *P. harrisi* is strikingly similar to that of *P. simplex* and must be closely related to it. *Ptiloncodus harrisi* is distinguished by the presence of knobs at the proximal end instead of subovate, auricular lobes. Harris noted that the "wings" are missing from the majority of Joins specimens; however, no specimen in the material studied lacked the characteristic knobs of the new species.

The auricular appendages of *P. simplex* Harris now appear to be of specific rather than generic importance; thus the diagnosis of the genus must be emmended accordingly.

Ptiloncodus Harris, 1962 emmended

Conodont element having a simple, cylindrical to subcylindrical, hook-shaped pointed cusp, with auricular expansions or knobs attached to the opposite sides of the base, at right angles to the plane of curvature of the hook. No basal escutcheon present.

Harris noted a resemblance of this form to some recurved representatives of the Early and Middle Ordovician fibrous genus *Stereoconus* Branson and Mehl, but distinguished his genus by its characteristic hook-shaped cusp and basal "wings." Sweet (1963), and Lindstrom (1964), questioned the assignment of this form to the Conodontophorida; Sweet suggested possible affinity to the holothurians. Mound (1965) noted, however, that the material comprising *Ptiloncodus* is similar in appearance and substance to that of Joins conodonts. The present forms display the characteristic amber and white appearance of conodonts. Mound further noted that the type species is composed of numerous apatite crystals and is fibrous in structure; accordingly, he concluded that the assignment of the genus to the conodonts is warranted. The writer concurs wholly with this conclusion.

Specimens of *Ptiloncodus harrisi* have been found in samples containing the following conodont elements: *Phragmodus undatus, Panderodus gracilis, P. compressus, P. acostatus, P. panderi, P. unicostatus, Keislognathus gracilis, Drepanodus homocurvatus, Belodina compressa, Oistodus abandans, P. concavus, Dichognathus extensa, Scolopodus* cf. *quadraplicatus, Amorphognathus ordoviccica, Ambalodus triangularis*. There appears to be no constant relationship between the occurrence of *P. harrisi* and any one of the above species in the samples examined. The specimens from most samples are too few to establish valid statistical criteria, but it appears from the general absence of any suggestion of constancy in mutual occurrence of *P. harrisi* and any other conodont that the animal bearing the *P. harrisi* element bore no other form species. Therefore, while *Ptiloncodus* and *Ptiloncodus harrisi* must be considered conservatively as form genus and form species respectively, it is considered that they represent true biologic taxa.

PTILONCODUS HARRISI

1. *Ptilonocodus harrisi* n. sp., magnification 84 X, Viola Limestone, Fernvale Phase, Flying L Ranch Section, Southern Oklahoma P.R.I. cat. no. 7083.
2. *Ptiloncodus harrisi* n. sp., magnification 80 X, Viola Limestone, Fernvale Phase, Flying L Ranch Section, Southern Oklahoma. P.R.I. cat. no. 7084. This specimen has an exceptionally large hook. Knobs present on the proximal end of the shaft are obscure in the photograph.

3. *Ptiloncodus harrisi* n. sp., magnification 80 X, Viola Limestone, Fernvale Phase, Highway 77, Arbuckle Mountains, Oklahoma. P.R.I. cat. no. 7085.

4. *Ptiloncodus harrisi* n. sp., magnification 57X, Viola Limestone, Fernvale Phase, Highway 77, Arbuckle Mountains, Oklahoma. P.R.I. cat. no. 7086.

5. *Ptiloncodus harrisi* n. sp., magnification 83 X, Viola Limestone, Fernvale Phase, Flying L Ranch Section, Southern Oklahoma. P.R.I. cat. no. 7087. Lateral view of cotype. The lateral knobs present are obscure in the photograph.

6. *Ptiloncodus harrisi* n. sp., magnification 53 X, holotype, Viola Limestone, Fernvale Phase, Flying L Ranch Section, Southern Oklahoma. P.R.I. cat. no. 7088. Three quarters view of holotype. This specimen has the tip broken off, but was selected as holotype because it displays the amber and white appearance typical of conodonts. The apparent difference in size of knobs is due to photographic distortion.

7. *Ptilocodus harrisi* n. sp. magnification 90 X, Viola Limestone, Fernvale Phase, Highway 77, Arbuckle Mountains, Oklahoma. P.R.I. cat. no. 7089. Posterior view of a broken specimen showing shaft and characteristic knobs.

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