THE PREHISTORIC EXPLOITATION OF UNIONACEAN BIVALVE MOLLUSCS IN THE LOWER TENNESSEE-CUMBERLAND-OHIO RIVER VALLEYS IN WESTERN KENTUCKY

by

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ABSTRACT

Large heaps of freshwater bivalve shells are a common feature at Archaic sites in many areas of the southeastern United States. However, the distribution of these features is discontinuous and patchy. In the lower Tennessee, Cumberland and Ohio river valleys in western Kentucky, Archaic sites occur, yet none are associated with shell deposits. The purpose of this study is to examine the absence of shellmound Archaic sites from the lower Tennessee, Cumberland and Ohio region.

A review of the environmental requirements of unionids (freshwater bivalve shellfish) and a discussion of the role of shellfish in prehistoric economies indicates that unionids provide prehistoric peoples with a highly seasonal resource of relatively low nutritive value. Samples of shell deposits from six Mississippian (ca 900 - 1700 bp) sites in the lower Tennessee, Cumberland and Ohio region were examined to assess the prehistoric riverine environment and the cultural orientation toward bivalve shellfish.

Results indicate that even during Mississippian times shellfish collecting was not an important activity in the area and collection episodes were limited to periods of extremely low water when large numbers of unionids were unusually accessable. It is suggested that Archaic peoples in this part of western Kentucky may have been inhabiting riverine sites on a seasonal basis - possibly between late autumn and early spring when high river levels would preclude the procurement of freshwater bivalve molluscs.

It is further suggested that the phenomenon of the "Shellmound Archaic" has been overemphasized in the literature and that shellmound Archaic sites are a response to a specific set of environmental and cultural circumstances. Shellmound Archaic sites occur in areas where unionids are unusually abundant, in areas which provide natural fords, and at the interface of trade routes. Aggregation phases for the purpose of trade or the collection

of seasonal resources at these points permitted the prehistoric site occupants to exploit labour-intensive resources such as shellfish.

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To my family, friends and fellow students who bore with me, especially through the last manic six months of this project, thank you so much for your support - and I

appologise to all those people I inadvertantly insulted. Many, many thanks to Ingrid Bell for always managing to make sense of things and for providing care, diversions and wonderful food. My parents, Janet and Colin Casey deserve special mention for helping in every possible way. Finally, I would like to thank Richard Lazenby, not only for being my husband and friend, but also for the help and support he has given me throughout every stage of this research. I have certainly benefitted from seeing the high academic standards Richard sets for himself and, of course, he has made this exercise a much more enjoyable one.

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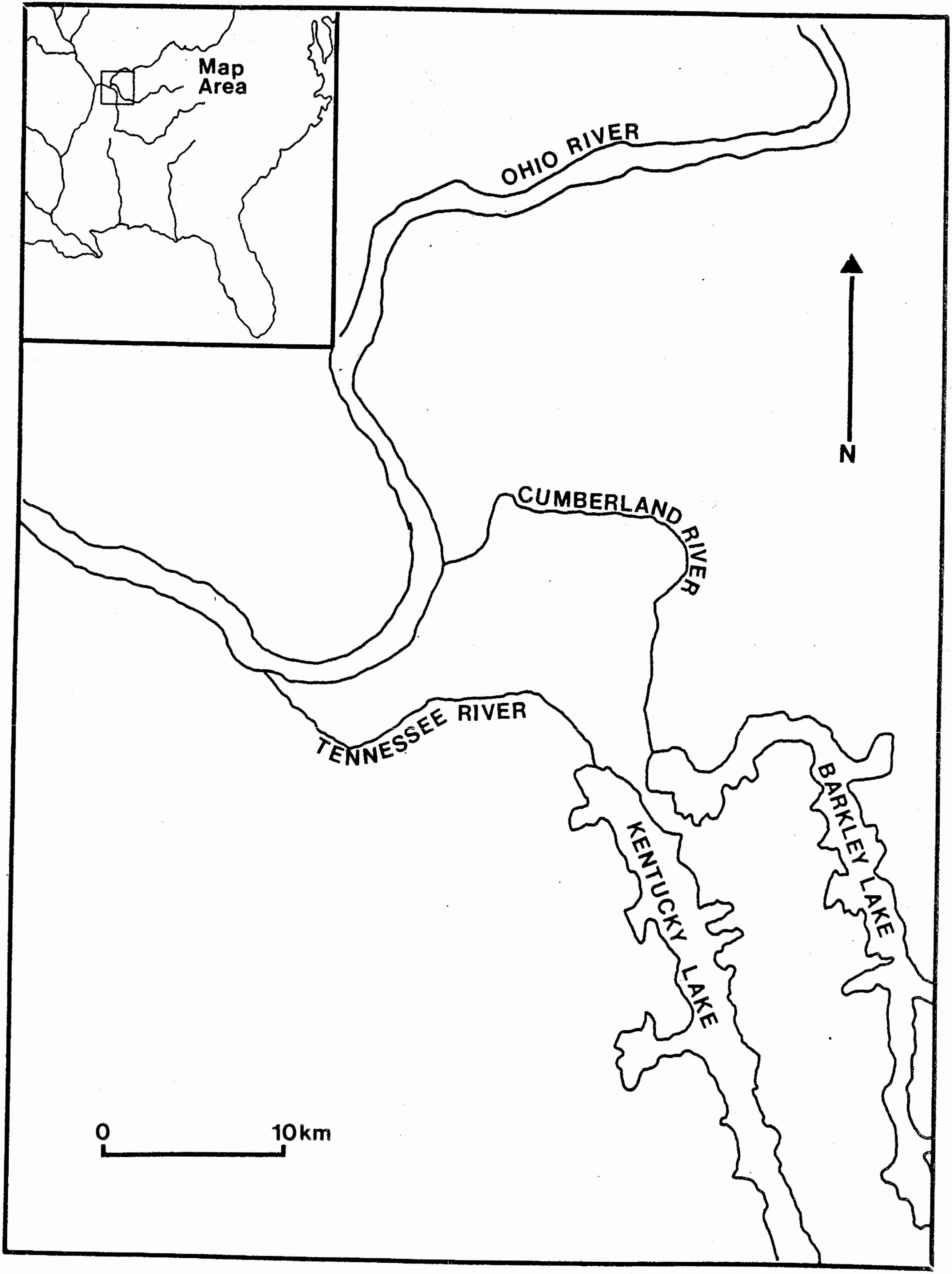
CHAPTER I

INTRODUCTION

This thesis concerns the use of freshwater bivalve molluscs by the prehistoric inhabitants of the southeastern and midwestern United States. The research was undertaken as part of the Lower Cumberland Archaeological Project (LCAP) which has been conducting investigations into the Archaic Period in western Kentucky since 1978. The current research arose from the desire to understand why shellmounds dating to Archaic times are not found on the lower reaches of the Tennessee, Cumberland, and Ohio rivers in the LCAP study area (Figure 1). Large mounds of the shells of freshwater molluscs are a common feature at Archaic sites in many areas of the southeastern United States, and, although many Archaic sites occur in the LCAP study area, none are associated with shellfish remains. During the later Woodland and Mississippian periods, however, freshwater shell accumulations do occur in the area.

This research is important for a number of reasons. First, although this thesis is not an investigation of Mississippian subsistence practices, it does provide a list of unionid (freshwater bivalve mollusc) species from six Mississippian sites in the lower Tennessee, Cumberland and Ohio river valleys. Second, this area is an important one faunistically. The Tennessee and Cumberland rivers support a unique mussel fauna from their upper reaches to their approximate mid-sections. Before the construction of the dams had impounded sections of the rivers, biologists and malacologists undertook surveys of the rivers in order to chart the movements and distributions of the various mussel species. The material from this research, and from several other shell-bearing archaeological deposits along the rivers permit the addition of the dimension of time to our knowledge of species distributions in the area. Third, although shell midden research has a long history on the coasts of the world, it is apparent that researchers investigating interior freshwater shell accumulations have largely relied on methods developed in coastal archaeology. The two cases are not analagous, however. This

Figure 1: The Lower Cumberland Archaeology Project Study Area


Map
Area
OHIO RIVER
N
CUMBERLAND RIVER
TENNESSEE RIVER
KENTUCKY LAKE
BARKLEY LAKE
0
10km

2b

research investigates the differences between freshwater and marine shellfish both as a prehistoric resource and in archaeological deposits.

A Brief History of Shell Midden Research

Shell middens are a common archaeological feature found on rivers, lakes, and coastlines around the world. A shell midden has been defined as any cultural deposit in which particles of animal shell are the dominant class of refuse over 1 mm in size, calculated by weight (Muckle 1985:16–17). Shell middens can be extremely large – often acres in extent and several metres deep – and, with the dominant constituent commonly being white shell, they are highly visible archaeological features. This, in addition to the fact that carbonates released from decomposing shell create an environment favourable for the preservation of organic remains (Sanger 1981), have made shell middens a popular subject for archaeological investigations (Wessen 1982).

Jepetus Steenstrup was the first to distinguish cultural shell middens from naturally occurring fossil shellfish beds on the Danish Coast in 1837 (Daniel 1950). Shell midden archaeology came into its own early this century largely due to the pioneering work of Nelson (1909) and Gifford (1912) who first questioned the amount of food represented by shellmounds along the California Coast. Theirs was the first attempt to estimate the age of the shellmounds by calculating how long it would have taken an "average–sized" band to accumulate a given amount of meal refuse. This work was reassessed and expanded upon some decades later by Cook (1946, 1950) and by others (Ascher 1959, Cook and Treganza 1947, 1950; Treganza and Cook 1948; Glassow 1967, Greengo 1951; Greenwood 1961) who form what has been termed "the California School" (Ambrose 1967:170). Their primary focus was on the development of a sampling methodology that would permit estimation of the composition of shell midden deposits (Ambrose 1967).

Since the 1960's the focus of shell midden archaeology has diversified and expanded. Sampling continues to be a major concern in shell midden archaeology (Ambrose 1963; Coutts 1971; Davidson 1964a; Hester and Conover 1970; Smart 1962; Terrell 1967) but a number of other important questions are also being asked. Notable foci of shell midden research are: methods of analysis (Bowdler 1983; Davidson 1964b; Davis 1972; Koike 1979; Koloseike 1969, 1970a; Meighan et al 1958; Nichol 1984; Shaw 1978; Tartaglia 1976), seasonality studies (Bailey, Deith and Shackelton 1983; Coutts 1975; Claassen 1982, 1984, 1986; Deith 1983a, 1983b, 1985, 1986; Ham 1982; Ham and Irvine 1975; Keen 1979; Killingley 1981; Koike 1973, 1975, 1979; Nicholson 1980; Ray 1976; Shackelton 1973) resource selection (Anderson 1981; Autry and Loftfield 1976; Coutts 1971; Terrell 1967; Shawcross 1967), formation and deformation proccesses (Barber 1982, Brennan 1974, 1977, 1981; Coutts 1969; Ceci 1984; Hester 1975; Marquardt and Watson 1979; Muckle 1985; Sanger 1981; Wessen 1982), and changes in the composition of shellfish species both spatially and temporally (Botkin 1980; Bowdler 1976; Braun 1974; Gould 1964; Ritchie 1965; Snow 1972; Swadling 1976, 1977a, 1977b; Wessen 1982). A number of researchers have addressed the question of the role of shellfish in the prehistoric diet (Bailey 1975, 1978; Koloseike 1970b; Meehan 1977b; Meighan 1969; Osborn 1977; Will 1976), and a few have done ethnographic work on aboriginal procurement, processing and discard of shellfish (Bigalke 1973; Bowdler 1976; Meehan 1977a, 1977b, 1982; Voight 1975).

A Brief History of Freshwater Shell Midden Research in the Southeastern United States

The vast majority of shell midden research has taken place along the coasts of the world. The history of research into freshwater shell middens and riverine/lacustrine adapted cultures has been minimal by comparison.

In the southeastern United States Jeffries Wyman (1868, 1875) was perhaps the first to explore and describe prehistoric freshwater shell accumulations along the St. John's River in

Florida. In the mid 1920's F.C. Baker (1924, 1930, 1931, 1936) became interested in how the shellfish found in archaeological sites were used as a food source and as a raw material by the prehistoric site inhabitants. His work consisted primarily of species lists and descriptions of shell artifacts.

In 1942 J.P.E. Morrison published the first major analysis of the shells from southeastern freshwater shell middens. His report was written in conjunction with the archaeological excavations that were undertaken in the Pickwick Basin by W.S. Webb (Webb and DeJarnette 1942). Webb's excavations throughout the southeastern United States have produced what has been termed "the largest and most comprehensive corpus of excavation derived data on Archaic sites in all of eastern North America" (Winters 1974:3). Much of Webb's work on Archaic shellmounds was salvage–oriented and was undertaken often only barely ahead of the flooding of the river valleys. While much information on the material culture of the Archaic was recovered, the loss of potential information which could have been provided by the shells was great. Although Morrison's sample of seven shell mounds was small considering the huge numbers of shell mound sites that once occurred in the now flooded river valleys, his work still stands as probably the first real analysis of shell from freshwater shell mound sites. His report includes detailed species lists for each site, comparisons of the past and present status of mollusc fauna in the area and a detailed account of the habitat requirements for each species of mollusc found at the sites.

In the 1950's Max R. Matteson (1953, 1958, 1959, 1960) became the main advocate of the use of archaeological shellfish remains for reconstructing past environments. His work emphasized the importance of saving mussel shells from archaeological sites, outlined techniques for the analysis of shells, and drew on examples from a number of sites in Illinois.

Up until the 1960's the analysis of the shell from freshwater shellmidden sites had been undertaken primarily by zoologists or malacologists with little or no archaeological training. The concerns of these researchers were often quite removed from those of the archaeologist. Most of the early analyses were primarily concerned with compiling species lists, comparing the past and present status of molluscs in the area, and reconstructing the past environment, while the cultural aspects of shellfish collection were largely ignored. These early analysts were similarly unconcerned with archaeological methods and were dependent upon archaeologists for their samples.

During the 1960's, however, archaeologists began to ask more questions about freshwater shell middens and shell mound research became much more integrative. An important figure during this transitional period is Paul Parmalee who has analysed the molluscan fauna from more archaeological sites in the Southeast than perhaps anyone else (Parmalee 1956, 1958, 1960, 1969; Parmalee, Klippel and Bogan 1980, 1982; Parmalee and Bogan 1977; Parmalee Paloumpis and Wilson 1972; van der Schalie and Parmalee 1960).

Since the 1960's major foci of freshwater shell midden research has concerned shell midden formation processes (Watson and Marquardt 1979), the role of freshwater shellfish in the aboriginal diet (Parmalee and Klippel 1974), and seasonality (Claassen 1982, 1986, Manzano 1985; Nicholson 1981; Ray 1976). On the whole, recent freshwater shell midden analyses have emphasized both cultural and natural processes, and have included other material from archaeological research to address these research topics (Brose 1972; Cumbaa 1976; Klippel, Celmer and Perdue 1978; Murphy 1976; Patch 1976; Warren 1975).

Goals of the Current Research

There are three major goals of this research. First, this thesis will investigate the role of freshwater shellfish in prehistoric economies. Second, it will assess the changes in the past and present status of the unionid fauna in the lower Tennessee, Cumberland and Ohio rivers.

And third, this thesis will explore the possible reasons why this resource was not exploited by the Archaic inhabitants of the lower Tennessee, Cumberland, and Ohio area.

Chapter Outline

The present study begins with a discussion of the biology and ecology of Unionacean bivalve molluscs. Chapter III explores the role of shellfish in prehistoric economies by discussing shellfish from the point of view of nutrition and aboriginal procurement strategies. In Chapter IV the sites are introduced. This chapter also includes a discussion of the techniques used in the excavation, preparation and analysis of the assemblage. A full account of the species found at the archaeological sites appears in Chapter V. Chapter VI discusses the Shellmound Archaic manifestations in the southeastern United States. Chapter VII contains a summary and concluding remarks.

CHAPTER II

BIOLOGY AND NATURAL HISTORY OF THE UNIONIDAE

Bivalve molluscs, also known as pelecypods or lamellibranches, are a class of the phylum Mollusca. There are approximately 15,000 species of bivalves, all of which are aquatic. Twelve hundred of these species are freshwater varieties. There are four groups of freshwater bivalves, two of which did not occur prehistorically in North America. The other two groups, the unionids and the sphaeriids, both occur in bodies of freshwater throughout North America. The sphaeriids, however, only reach a maximum length of two and one half centimetres, and, although they are occasionally found in archaeological sites, their occurrence is presumed to be incidental (Brose 1972). The unionids, the largest and most conspicuous of all freshwater shellfish, occur world wide with over 1000 species divided among several families (Solem 1974:122). Unionids are also referred to as freshwater "clams" or "mussels".

Unionids may be found in diverse habitats: in rivers, lakes, ponds, marshes, sloughs and swamps. Although lakes offer a variety of conditions, only a limited number of species of unionids inhabit them. The smaller, more still waters of ponds, marshes, sloughs and swamps, generally produce but small, thin-shelled varieties of mussels. Rivers and streams provide the best habitat for mussels. Here, unionids attain their greatest numbers of species and individuals, and reach their largest sizes (Coker et al. 1920).

As regards the growth of mussels, the suitability of any section of river - or any other body of water - depends upon a number of environmental factors. These factors are best understood by considering the animal's requirements for respiration, feeding and reproduction. General biological information may be found in most sources on freshwater bivalves. The information presented here is taken primarily from Coker et al. (1920); and from Solem (1974).

The bivalve mollusc consists of two shells of calcium carbonate which are covered by a thin layer of periostracum, and joined by a flexible ligament. The soft tissues are encapsulated between the two shell valves. As they are rarely if ever preserved in archaeological deposits, the soft parts of the mollusc are not usually of any concern to the archaeologist. They will be mentioned briefly here, however so that the ecology of the animal may be better understood. The major parts of the pelecypod are the foot, siphons, gills and mantle.

The unionid is basically a sedentary organism. Although its foot provides the organ of locomotion, this foot is used infrequently, only over short distances, and generally in response to such extreme circumstances as drought or flood. As unionids cannot move to pursue their food, it must be brought to them. The primary food sources, detritus and plankton, are found suspended in the surrounding water. Freshwater bivalves feed and respire by pumping water in through the incurrent siphon, filtering it through the gills (where nutrients and oxygen are removed) and pumping excess water and wastes out through the excurrent siphon. The gills are an important organ to the mollusc: not only do both sexes use them to feed and respire, but, in many species, the gills of the females serve as a modified marsupium or brood pouch in which the young are incubated.

Most unionids reproduce sexually, although asexual and hermaphroditic species are known (van der Schalie 1970a). Sperm released into the water by the male is picked up through the incurrent siphon of the female and carried to tubes in the female's gills where the eggs have previously been deposited after having been discharged from the ovaries. Fertilization occurs, and the fertilized eggs develop into larval mussels, or glochidia, in the female's gills. Once the glochidia are fully mature they are expelled into the water. A moving environment is thus necessary for renewing the food and oxygen supply and for removing wastes. In addition, it plays a part in reproduction by insuring that sperm is distributed over a large area – thus making fertilization more likely, and, at the same time, reducing the possibility of inbreeding.

Although a single gravid female can produce hundreds of thousands of glochidia, only a small number of these glochidia ever come to maturity. Once expelled into the water, the young must attach themselves to a passing fish. It was once thought that each unionacean bivalve species had only one or two host species that could serve its young. However, subsequent research has found that there is a rather low degree of host specificity among unionids. For example, some species of *Anodonta* will parasitize over 30 host species (Kat 1984). Although most glochidia parasitize fish, one species of unionid, Simpsoniconcha ambigua, parasitizes a salamander (Howard 1951). If contact with an appropriate host is not made, the glochidia will die in a few days. If contact with a suitable host is made, the larvae will then attach themselves to the host's gills or fins where they encyst. There they remain as parasites for 10 to 20 days or longer during which time the host organism may travel a considerable distance. After the prescribed length of time, the glochidia drop off into the substrate where, if conditions be suitable, they will remain for the rest of their lives. Glochidia which drop off into unsuitable conditions soon die.

The parasitic stage is vital to unionids as a mechanism for dispersal throughout a river system or lake. Dependence upon a host has two major conditions. First, in order for any species of unionid to reproduce, both the mussel and the host must be present. Second, in order to enhance the possibility of encountering a suitable host, unionids must come in close contact with the host fish. As noted above, the gills might be considered the bivalve's most important organ, as these structures permit the animal to eat, breathe, and, in most cases, reproduce. Most species of unionids are intolerant of waters which contain a high concentration of fine mud particles in suspension. These fine particles can clog the gills and lead to suffocation or starvation. Water current is important for removing fine particles and providing a clean substrate for mussel habitation. In lakes mussels are often found near the shore where wave action circulates the water; they avoid the middle regions of these bodies where the still water allows particles to settle out.

The nature of the river bottom is another major variable that affects the survival and growth of mussels. The nature of the rock or soil through which the stream runs combined with current velocity, largely determine the bottom type. While mussels can live in a variety of bottom types, they prefer a firm bottom that consists of sand, firm mud, clay or rocks, in various combinations. No mussels can live in shifting sand and few species can survive in soft mud.

Water temperature can affect mussels in two ways: it determines the amount of plankton available, and affects the bodily functions of the mussel. During the cold winter months, shellfish may go into a dormant state where they eat little and where they virtually cease activity. It appears that the water must reach a critical temperature in the spring before unionids reproduce. During exceptionally cold years reproduction may not take place at all (Matteson 1955:135). It is not known whether unionids migrate to deeper waters in the winter or burrow into the substrate, but they have been known to reproduce after having been frozen solidly in blocks of ice (Yen 1947:294). Temperatures which are too warm are known to be highly detrimental to freshwater molluscs, though it is not known how much of a temperature increase can be tolerated by these animals. However, cultivation of land adjacent to many small rivers in Illinois for exaple, has been blamed for the elimination of mussel populations from many areas. This cultivation leads both to excessive silting from fields and denuded river banks, and, because of the loss of shade that resulted from the destruction of forests which once grew along the the river bank, to an increase in water temperature (Matteson 1955:127).

The nature of the water itself also affects a mussel population. As the shell is composed primarily of calcium carbonate, rivers that run through limestone deposits and other sources of calcium are presumed to provide the best conditions for shell production. The relationship between water hardness and the calcium content of shells is not well understood. Recent research indicates that where a relationship can be shown to exist at all, the correlation is not, in most cases, a direct one (Burky et al 1979; Mackie and Flippance 1983). Conversely, water that is acidic can erode shells and is less suitable for mussels. This latter condition occurs in the soft waters of the Atlantic Slope where mussels are thin-shelled, small and eroded (Coker et al. 1920:115).

Mussels are not found in all rivers and lakes, nor are they found in all parts of the rivers and lakes in areas where they do occur. Conditions can change radically within a body of water. A river's conditions vary from the headwaters to the mouth, and most rivers show a succession of mussel species along their courses. In general, a greater variety of species are found at the lower end of a river. Although at the upper end shallow water habitats predominate, toward its mouth the river becomes wider and deeper and thus provides a greater area for fish and mussels, a range of depths between the main channel and the shore, and an increased variety of habitats for both the mussels and their fish hosts (Coker et al. 1920:95–6).

Conditions may change at any point along the river's course. Tributaries entering the river can have major effects by increasing plankton and detritus concentrations, by increasing sediment load or by producing sediment bars at their point of entry. The type of deposit over which the river runs can change throughout its course, affecting changes in sediment load, bottom type and water content. Deep or ponded sections of rivers can produce quiet water conditions in an otherwise moving environment. Likewise, conditions on the shores adjacent to the river have an effect by adding to the types and quantity of sediments and detritus that are deposited in the system.

Each species of mussel that is documented for North America has its own level of tolerance to various environmental conditions. Some respond so fastidiously to the key features of their environment that small deviations from the optimum in one or more conditions will determine the presence and abundance of species in any particular environment (Matteson 1955:127).

The Nature of the Shell

Figure 2 shows a unionid shell and indicates the important features that are used to identify shells. This information is taken primarily from Bogan and Parmalee (1983); Burch (1975); Murray and Leonard (1962); and Parmalee (1967).

Umbo (umbone; beak): This is the raised, dorsal portion of the shell. It is formed by the embryonic shell, and the rest of the shell develops around it - distally and in a concentric manner. This is the oldest and generally the most prominent part of the shell, and it is often the first part to show erosion.

Ligament: The ligament is a flexible organic structure on the dorsal margin of the valves. It is the axis upon which the valves pivot when opening and closing. An organic constituent, it is rarely present archaeologically.

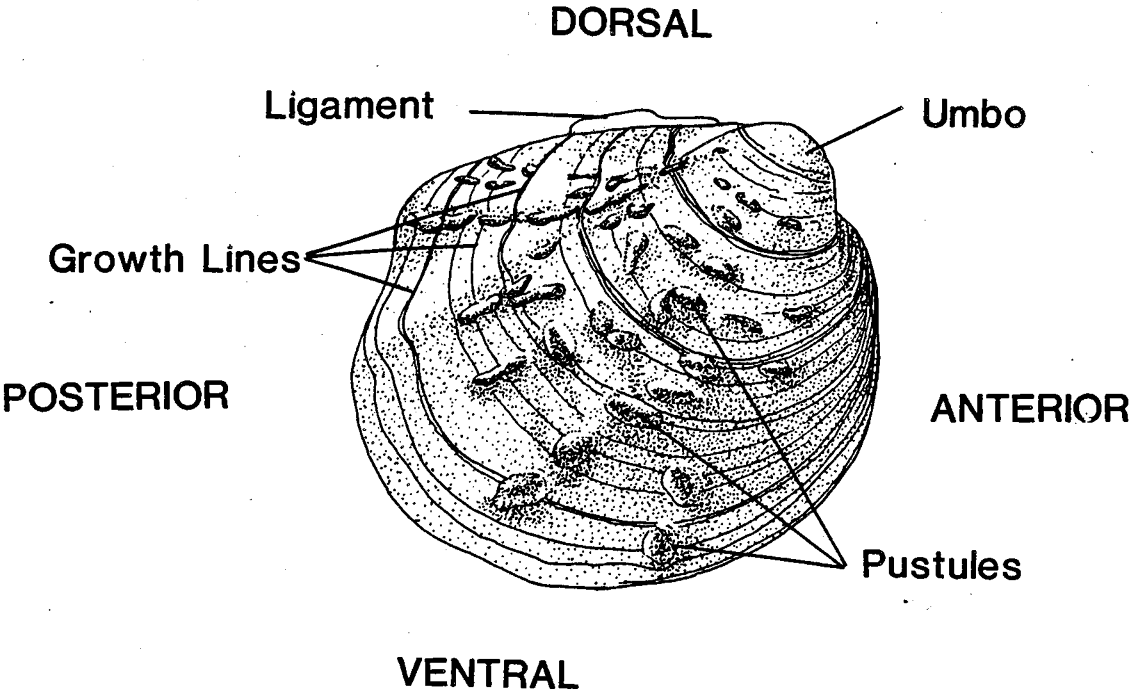
Lateral Teeth: Located along the hinge line of the valve, the lateral teeth appear as elongated, raised structures.

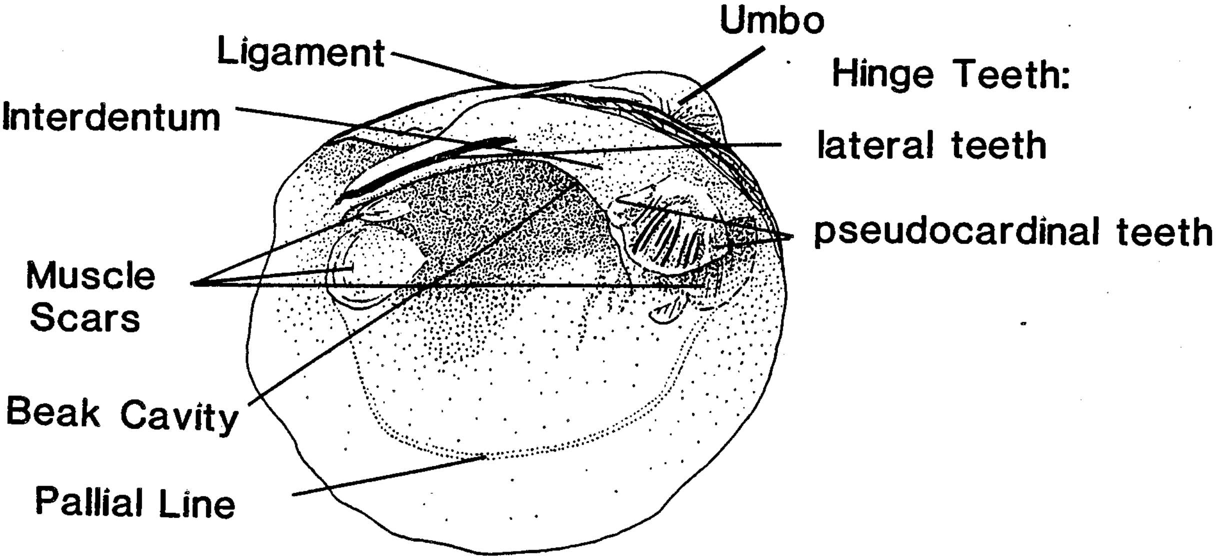
Pseudocardinal Teeth: These structures are located near the anterior dorsal margin of the shell and appear as raised, triangular structures.

Interdentum: This is the flattened region between the lateral and pseudocardinal teeth.

Muscle Scars: The depressions on the inside of the shell that occur anteriorly and posteriorly are the muscle scars. These scars indicate the points of attchment for the adductor muscles and the pedal protractor and retractors. These muscles are responsible for closing the

Figure 2: Unionid Shell Morphology
Exterior of right valve (top) and interior of left valve (bottom) of *Cyclonaias tuberculata*


DORSAL
Ligament
Umbo
Growth Lines
POSTERIOR
ANTERIOR
Pustules
VENTRAL


Umbo
Ligament
Hinge Teeth:
Interdentum
lateral teeth
pseudocardinal teeth
Muscle Scars
Beak Cavity
Pallial Line

valves and projecting and retracting the foot.

Pallial Line: The pallial line is an indented groove running roughly parallel with the ventral shell margin. It indicates where the mantle was fastened to the shell.

Beak Cavity: This is the cavity leading to the beak (umbo). It is located on the inside of the valve and under the interdentum.

Pustules: Also known as nodules, warts, shell sculpture, or ornamentation, these are small raised structures on the outside of the shell. In some species shell sculpture appears as a series of ridges. It has been suggested that shell ornamentation may serve several functions including aiding the animal in burrowing and/or stabilizing itself in a shifting substrate (Stanley 1981:384). Shell sculpture is extremely useful for identifying species.

Sulcus: Though not shown in Figure 2, the sulcus generally refers to a longitudinal furrow or depression on the exterior of the shell. This depression runs postero–ventrally from near the umbo.

Shell Formation

Unionid shell is composed of three layers which are secreted by the mantle (Figure 3). The outermost layer is known as the periostracum or epidermis. It is composed of organic membranes and serves to protect the inner calcareous shell layers from erosion (Kobayashi 1969:663). The calcareous portion of the shell is composed of two layers of calcium carbonate in the form of aragonite. The outer calcareous layer is known as the prismatic layer and is composed of long rectangular rods. The prismatic layer is relatively thin, and as it grows it contributes to the length and width of the shell. The innermost shell layer is known as the nacreous layer. It is formed of flat tablets of calcium carbonate. The thickness of the shell increases as this layer grows (Kobayashi 1969:664–669).

The nacreous layer of the unionid shell is very smooth, lustrous and often very thick. The word Unionidae comes from the root *unio* meaning "a pearl" (Woodward 1890:438), and in fact, this group of freshwater mussels, because of the lustrous nature of their nacreous shell layer, is sometimes known as the "pearly" freshwater mussels. Nacre may be found in colours that range from pure white through shades of pink, salmon and yellow to deep purple. Pearls are formed when a foreign object becomes lodged between the mantle and the shell. This intrusion causes an irritation, that the animal responds to by secreting a layer of nacre around the offending object. Pearls, often of great value, are not uncommon in the unionids of the eastern United States. They have been an important part of the present day mussel industry (Coker et al. 1920; Kunz 1897a, 1897b, 1968; van der Schalie 1970b; Ward 1985); their use by aboriginal peoples has been noted both ethnographically (Fowke 1902; Jones 1973; Swanton 1940; Varner and Varner 1962) and archaeologically (Shetrone 1930; Webb 1974; Webb and DeJarnette 1942; Winters 1968, 1969).

Another important feature of bivalve shell is the growth line. Growth lines are "the result of quantitative changes in calcareous and organic deposition related to periodic physiological changes in molluscs" (Kobayashi 1969:664). During cold weather mussels become inactive and secretion of shell is significantly reduced. Thus, distinct bands separating fast summer growth and winter rest lines are evident in the shell. Daily increments are produced within each annual increment as the animal adds a small layer of calcium to the shell. The study of these growth increments has been researched and developed extensively in the fields of paleontology, biology, and geology [see especially Rosenberg and Runcorn (1975); Barker (1964); Cunliffe and Kennish (1974); Crabtree, Clausen and Roth (1980); Hughes and Clausen (1980); and Jones (1980)] and has also found useful application in archaeology as a means of establishing the season of death of the molluscs and hence the season of occupation of the site (Claassen 1982, 1984, 1986; Ham 1982; Ham and Irvine 1975; Ray 1976; Coutts 1970, 1975; Koike 1973, 1975, 1979; Wessen 1982; Deith 1983, 1985, Manzano 1986). These studies are being done on both freshwater and marine bivalves with varying amounts of success (Nicholson 1980).

CHAPTER III

THE ROLE OF SHELLFISH IN PREHISTORIC ECONOMIES

There has been much debate about the role of shellfish in the aboriginal diet. The huge heaps of shell at archaeological sites along coasts, rivers and lakes throughout the world led many investigators to believe that shellfish were a highly nutritious food source and constituted the primary dietary element for many prehistoric peoples (Childe 1925; Matteson 1958; Sauer 1961; Meighan 1969). However, recent research has found that shellfish are so low in caloric value that simply attempting to meet the energy needs of even a relatively small band would quickly reduce local shellfish populations and would produce shell middens many times larger than those currently observable (Cook 1946; Parmalee and Klippel 1974). The view that shellfish are undesirable and are only exploited as an alternative to starvation has also been proposed (Osborn 1977).

Many recent studies of prehistoric diet have used optimal foraging theory as a means of explaining and predicting aspects of subsistence behavior. The concept of optimization or maximization is central to optimal foraging theory. The hypothesis is that, with regard to whatever constraints are operating,natural selection will favour foraging behaviors that result in maximum or optimal fitness. "In other words, there will be a differential survival of those behaviors which best allow an individual or population to achieve its life goals in a specific environment" (Keene 1981:8). Smith (1981:627) sums up optimal foraging theory as an attempt to specify a general set of "decision rules for predators" based on cost–benefit considerations deducible from first principles of adaptation via natural selection.

In general, studies have concentrated on the amount of time and energy required to find, procure, process and consume a food item (cost) as compared to the amount of energy or calories provided by that item (benefit) with the expectation that the net rate of energy intake will be maximized (Pyke et al. 1977:138). For a number of reasons energy has been chosen as the currency in most studies (see Winterhalder 1981b:20–21) the two major ones being that (1) energy is easy to quantify and manipulate in the context of optimal foraging models and (2) energy has been assumed, in most ecological studies, to be the most important component of food (Schoner 1971:369; Pyke et al. 1977:139; Winterhalder 1981b:21). Optimal resources are found by ranking food types by ratios of food value (calories or units of weight) to handling time.

With the constraints imposed by the optimal foraging model, both marine and freshwater varieties of shellfish appear to be a non–optimal resource. In terms of food value they are extremely low in calories. The length of time required to find and harvest shellfish depends upon whether the individuals or species of shellfish occur above or below the water line, singly or in groups, clinging to rocks or buried in the substrate. The edible parts of the mollusc must be removed from the shell before consumption so processing time and costs are a major consideration when calculating the resource value of this food. Many species of molluscs contain only a small amount of meat to a large amount of shell.

In addition to calories and procurement costs, there are a number of other factors, both nutritional and cultural, that must be considered when evaluating shellfish as a food resource. Optimal foraging models were developed from observations of the feeding strategies of solitary foragers, and as such are in many ways inapplicable to the human situation (see Durham 1976, 1981; Jochim 1976, 1981; Smith 1983; Winterhalder 1981b). Optimal foraging models are based on the assumption that in making prey choices and in foraging activities, human groups function as a single individual. These models are primarily concerned with the numbers of calories expended and consumed in feeding strategies and with ratios of energy and time. Exploitation of shellfish appears to be a very inefficient subsistence activity within the narrow confines of these restricted optimal foraging models. If these models are expanded to take into account some of the other requirements and possibilities for human subsistence, the shellfish resource does not fare so badly.

Shellfish and Nutrition

Table 1 shows the nutritional make-up of 100 grams of four types of raw shellfish meat. The estimates for freshwater shellfish are taken from Parmalee and Klippel (1974) and are an average of the two species given (*Proptera alata; Actinonaias carinata*). Freshwater and marine shellfish are similar in terms of calories, proteins, fats and in some vitamins, but they differ significantly in mineral content. Freshwater shellfish are very much higher than marine shellfish in calcium, phosphorous and iron, and very much lower in sodium, potassium, vitamin A, and in the one comparable value for ascorbic acid. These differences in the mineral content of the flesh are probably primarily due to differences in the aquatic medium in which these two orders of pelecypods are found. Table 2 shows the Minimum Daily Requirements (MDR) for various human age groups. MDR values specify the amounts of certain nutrients considered necessary for the prevention of deficiency diseases (Wing and Brown 1979:17). There are many problems with estimating daily nutritional requirements for groups of people. Depending upon a number of genetic, physiological, behavioural, and environmental factors, requirements can vary significantly (Wing and Brown 1979:17). The table presented here is intended only as a guide to illustrate the point that the value of foods in the diet goes beyond the mere counting of calories.

In Table 2 the MDR values are also represented in terms of (1) the number of grams of raw freshwater shellfish meat necessary to meet minimum nutritional requirements; and (2) the number of whole shellfish required. This latter figure is based upon an average shellfish size (weight) of 37.2 grams. Shellfish sizes are taken from Parmalee and Klippel (1974) and are listed in Table 3. This table represents average sizes for 39 species of freshwater mussels that are found in the southeastern United States. The value 37.2 is the grand mean derived from Table 3. As most cultural shellfish accumulations consist of a variety of species and sizes of shellfish, this average figure is perhaps the most useful for evaluating the contribution of shellfish towards the MDR for any given nutrient.

Table 1 . Nutritional Composition of Shellfish per 100 Grams (Raw, Edible Portions).

	Freshwater Mussels[1]			Oysters[2]	Clams[2]	Scallops[3]
	P. alata	A. carinata	mean			
moisture (%)	76.5	82.2	79.4	85.0	82.0	73.0
kcalories	77.0	58.0	67.5	67.8	56.0	127.0
protein (gm)	9.5	7.8	8.6	8.6	7.8	26.3
fat (gm)	.8	.7	.8	1.8	.6	1.6
fibre (gm)	1.1	1.2	1.2	-	-	-
carbohydrates (gm)	7.8	4.5	6.1	3.6	5.8	-
ash (gm)	4.3	3.0	3.6	-	-	-
calcium (mg)	370.0	320.0	345.0	96.4	68.6	114.4
phosphorous (mg)	812.0	520.0	666.0	146.4	151.6	337.0
iron (mg)	12.5	12.2	12.3	5.7	7.6	3.0
sodium (mg)	23.0	7.0	15.0	74.8	205.9	264.0
potassium (mg)	41.0	26.0	33.5	121.4	311.7	475.2
B vitamins (mg):						
thiamin	0.0	0.0	0.0	.1	.1	-
riboflavin	.3	.2	.3	.2	.2	-
niacin	2.0	.9	1.5	2.5	1.3	-
ascorbic acid (mg)	.3	.3	.3	-	9.4	-
vitamin A (IU)	-	17.0	17.0	321.3	106.2	-
% kcalories from						
protein	49	54	51			
carbohydrate	41	31	36			
fat	9	11	9			

1. Parmalee and Klippel (1974), except vitamin A (Keene 1981)
2. Witney and Hamilton (1981)
3. Kreutler (1980)

Table 2.. Minimum Daily Requirements (MDR) for Various Age/Sex Cohorts. Values in Parentheses are (grams of freshwater shellfish required to meet MDR/number[1] of whole shellfish required, based on a mean weight of 37.2 grams per shellfish).[1]

nutrient	$\bar{x}$ content per 100 gm freshwater shellfish	0 to 10 years	10 to 18 years	
			male	female
kcalories	67.5	1095 (1622/44)	2900 (4296/116)	2490 (3689/100)
protein (gm)	8.6	23 (267/10)	42 (488/ 14)	36 (418/ 12)
fat (gm)	.8			
fibre (gm)	1.2		NO DATA AVAILABLE	
carbohydrates (gm)	6.1			
ash (gm)	3.6			
calcium (mg)	345.0	450 (130/ 4)	650 (188/ 5)	650 (188/ 5)
phosphorous (mg)	666.0	800 (120/ 4)	800 (120/ 4)	800 (120/ 4)
iron (mg)	12.3	5 (40/ 2)	9 (73/ 2)	12 (97/ 3)
sodium (mg)	15.0	115 (767/21)	900 (6000/162)	900 (6000/162)
potassium (mg)	33.5	350 (1045/29)	1525 (4552/123)	1525 (4552/123)
thiamin (mg)	0.0	.2	1	1
riboflavin (mg)	0.3	.5 (250/ 7)	1.1 (550/15)	1.1 (550/15)
niacin (mg)	1.5	8 (533/15)	16 (1066/ 29)	14 (933/ 26)
ascorbic acid (mg)	0.3	20 (7692/107)	30 (11538/311)	30 (11538/311)
vitamin A (IU)	17.0	1375 (8088/218)	3625 (21323/574)	3625 (21323/574)

1. MDRs from Keene (1981), except sodium and potassium which are Recommended Daily Allowances (RDA) from Kreutler (1980), expressed here as the lower value from a given range.

Table 2. cont'd.....

nutrient	18 to 50 years		50+ years	if pregnant, add	if lactating, add
	male	female			
kcalories	3000 (4444/120)	2200 (3259/ 88)	2550 (3778/102)	350 (519/ 14)	550 (815/ 22)
protein	42 (488/ 14)	34 (395/ 11)	38 (441/ 12)	4 (215/ 6)	12 (139/ 4)
fat					
fibre					
carbohydrates	NO DATA AVAILABLE				
ash					
calcium	450 (130/ 4)	450 (130/ 4)	450 (130/ 4)	110 (31/ 1)	110 (31/ 1)
phosphorous	800 (120/ 4)	800 (120/ 4)	800 (120/ 4)	500 (75/ 2)	500 (75/ 2)
iron	5 (40/ 2)	14 (113/ 3)	14 (113/ 3)	4 (32/ 1)	4 (32/ 1)
sodium	1100 (7333/198)	1100 (7333/198)	1100 (7333/198)	NO DATA AVAILABLE	
potassium	1875 (5597/151)	1875 (5597/151)	1875 (5597/151)		
thiamin	1	1	1	.1	.1
riboflavin	1.5 (750/21)	1.5 (750/21)	1.1 (550/15)	.3 (150/ 4)	.5 (250/ 7)
niacin	16 (1066/ 29)	14 (933/ 26)	15 (1000/ 27)	6 (400/ 11)	11 (733/ 20)
ascorbic acid	30 (11538/311)	30 (11538/311)	30 (11538/311)	10 (3846/104)	5 (1923/ 52)
vitamin A	3750 (22058/593)	3750 (22058/593)	3750 (22058/593)	750 (4411/119)	1200 (7058/190)

Table 3. Meat Weights of Freshwater Shellfish (from Parmalee and Klippel, 1974:424).

SPECIES	range	mean	n
Amblema peruviana	13 - 66	42	15
Amblema costata	9 - 107	36	31
Lasmigona complanata	24 - 266	99	9
Lasmigona costata	11 - 55	31	10
Cyclonais tuberculata	10 - 52	30	17
Strophitus rugosus	12 - 38	18	8
Elliptio dilatata	4 - 37	12	23
Elliptio crassidens	38 - 61	48	5
Actinonaias carinata	4 - 107	45	90
Actinonaias ellipsiformis	4 - 13	7	16
Carunculina parva	2 - 3	3	8
Fusconaia ebena	15 - 52	29	10
Fusconaia flava	3 - 25	16	12
Fusconaia undata	11 - 34	19	22
Lampsilis anodontoides	37 - 153	82	10
Lampsilis fallaciosa	21 - 45	26	10
Lampsilis siliquodea	39 - 70	55	2
Lampsilis ventricosa	11 - 152	80	40
Plethobasus cyphyus	21 - 57	37	13
Meglonaias gigantea	25 - 237	82	30
Pleurobema cordatum	10 - 56	29	14
Leptodea fragilis	4 - 86	44	29
Leptodea laevissima	13 - 106	63	7
Quadrula metanevra	12 - 40	22	8
Quadrula nodulata	8 - 23	14	12
Quadrula pustulosa	5 - 45	18	38
Quadrula quadrula	4 - 101	25	53
Ligumia recta	55 - 116	76	8
Ligumia subrostrata	3 - 32	15	5
Obliquaria reflexa	1 - 11	7	24
Tritogonia verrucosa	13 - 183	80	27
Obovaria olivaria	10 - 17	14	3
Alasmidonta marginata	16 - 28	21	3
Plagiola lineolata	7 - 40	23	32
Anodonta grandis	19 - 250	94	40
Proptera alata	17 - 91	56	41
Anodonta imbecillis	4 - 10	7	5
Truncilla truncata	6 - 11	7	13
Arcidens confagosus	7 - 138	39	49
GRAND MEAN		37.2	

It is evident from Tables 1 and 2 that freshwater shellfish are low in calories and offer little in the way of B vitamins (thiamine, riboflavin and niacin) or vitamins A and C. They do, however, provide significant amounts of calcium, phosphorous and iron. Only a few shellfish can satisfy an entire day's requirement for these minerals. Freshwater shellfish also supply a moderate amount of protein. As the proteins in shellfish are complete, consumption of only a few shellfish can provide a significant portion of the daily protein requirement.

Several authors (e.g., Parmelee and Klippel 1974; Cook 1946) have hypothesized about the possibility of groups of people supporting themselves - even if only for short periods of time - on a diet consisting only of shellfish. These authors have pointed out that such a diet would quickly decimate shellfish populations. Not immediately obvious, however, are the possible nutritional problems that a group attempting such a feat would rapidly encounter.

Nutritionally, shellfish of all species are extremely low in calories. They have even been referred to as being "dangerously low" (Yesner 1980:733). To satisfy even minimal daily calorie requirements an average male would require over one hundred average-sized freshwater shellfish as defined on Table 3. In meeting caloric needs, requirements for protein and for the minerals calcium, phosphorous and iron would be more than met, as would requirements for niacin and riboflavin. It would take many more shellfish to meet requirements for vitamins A and C, and no amount of shellfish would come close to meeting requirements for thiamine.

Deficiencies of vitamins can give rise to a number of problems in the growth, development, and maintenance of healthy bodies. Of more immediate concern, however, is the contribution of the three major energy nutrients: protein, carbohydrate and fat. The Senate Committee on dietary goals for the U.S.A. (see Whitney and Hamilton 1981:109) recommends that of the total number of calories consumed in a day, 10–15% should come from protein, 58% or more from carbohydrates and 30% or less from fat. Given that proteins and carbohydrates contain 4 calories per gram, and fats 9 calories per gram, the contribution of each of these energy nutrients to a diet of freshwater shellfish is: 51% protein, 36% carbohydrate and 9% fat (Table 1).

It is possible that these proportions of the energy nutrients fluctuate seasonally. Cold weather during the winter makes freshwater shellfish inactive and their food supply scarce. During the floods of early spring, freshwater shellfish risk suffocation due to an increase in suspended silt particles. It has been observed (Matteson 1955) that, until the danger is passed, mussels will stay tightly closed during periods of increased toxicity or siltation. Shellfish that have remained closed for extended periods are subject to dessication, starvation and tissue breakdown. It is likely that after having endured the hardships of winter and early spring, most mussels are in a depleted state. This state of depletion may be reflected in the relative proportions of protein, fat and carbohydrate in the shellfish flesh.

It has been noted in marine shellfish that there is an increase in weight associated with the reproductive cycle (Koloseike 1970:151) A similar phenomenon has been noted in at least two species of unionids (Huebner 1980). The body weight of these two species (*Lampsilis radiata; Anodonta grandis*) fluctuates seasonally so that both species are "meatiest" in the spring (Huebner 1980:1982). It is possible that, if this occurs in other species of freshwater shellfish, the best times for collecting most species would be between the months of April and August (see Coker et al. 1921:141-142). According to Hildreth (1828, cited in Murphy 1976:11), two species of freshwater shellfish in particular "are very large, and in the month of September abound in fat, to the extent of one or two ounces of clear oil in a single individual." It is difficult to make out what exactly Hildreth means by this statement; however, it is highly unlikely that the substance mentioned was pure oil. The occurrence of one or two ounces of pure oil would raise the food energy value of a single shellfish by as much as 486 calories.

The possibility of freshwater mussels forming an important starvation resource in the winter and early spring when other food sources are low has been suggested (Lyman 1984). Fishing for shellfish when rivers are frozen has been noted (Post 1938 Smith 1897); however, it is probable that this was an extremely time consuming operation. The yield would be shellfish in an extremely depleted state, and as a result, the shellfish would be a somewhat questionable food resource, especially during times of starvation.

According to Speth and Spielman (1983), hunter-gatherers who depend primarily upon ungulates, as do most temperate-forest dwellers, undergo extreme dietary stress in the early spring when winter stores are depleted and spring vegetation is not yet available. At this time deer are very lean, having used up the fat accumulated in the summer and fall. When energy from nutrients other than protein is unavailable, dietary protein will not be used efficiently by the body.

> The body assigns top priority to meeting its energy needs, and when kcalories from other sources are not available, it will break down protein to meet this need. Stripping off and excreting the nitrogen from the amino acid, it will use their carbon skeletons in much the same way it uses those from glucose or from fat. ...Other conditions may also affect the body's use of protein. The presence of other nutrients - vitamins, minerals and water - is needed to process the protein, and the body itself must be in a healthy state to assimilate it (Whitney and Hamilton 1981:107).

Heavy reliance on lean meat raises the metabolic rate and requires that more calories be consumed. The ingestion of larger amounts of protein only exacerbates this problem and leads to both starvation and protein poisoning. The result is that in times of extreme resource stress, fat-depleted animals should be avoided, lean cuts of meat should be abandoned and behaviours which promote the pursuit and accumulation of resources high in carbohydrates and fats should be emphasized (Speth and Spielman 1983).

Table 4. **Percent Calorie Contribution: Deer vs Shellfish.**

SOURCE	Protein	Carbohydrate	Fat
shellfish[1]	51	36	9
deer (normal)[1]	67	0	29
deer (depleted)[2]	ca. 94	0	< 2
recommended[3]	10–15	> 58	< 30

1. Parmalee and Klippel (1974)
2. Speth and Spielman (1983)
3. Whitney and Hamilton (1981)

It is not known what the exact effects of seasonal inactivity and deprivation of nutrients will have on the nutritional content of shellfish flesh. If shellfish retain their stores of carbohydrates and fats throughout the winter, they could represent a resource which, though marginal, is a viable alternative to deer (Table 4). Conversely, if the proportions of carbohydrates and fats are depleted in the winter, as is likely, shellfish may represent a resource which should be avoided in times of stress. If any vegetable matter in the form of nuts and seeds left over from the winter stores, or roots, tubers, or new shoots which can provide carbohydrates and/or fats is at all available, the addition of shellfish protein, even in a state of depletion, may be sufficient to stave off starvation.

Cultural Aspects of Shellfish Exploitation

Ethnographic studies of maritime–adapted hunter–gatherers have found that the value of shellfish is not so much in the absolute number of calories and other nutritive elements they provide, but in the place they fill in the subsistence system as a whole. The role of freshwater shellfish in the aboriginal diet has not been established. Cultural groups exploiting freshwater shellfish represent a very different cultural/environmental orientation from maritime–adapted cultures and, while this fact has occasionally been noted (Patch 1976:16), it has never been made explicit. There seems to be a general tendency on the part of many investigators, to view as analagous those cultures that exploit marine shellfish and those that exploit freshwater shellfish (Will 1976). A major reason for this tendency may be due to the paucity of ethnographic data on those aboriginal groups that once exploited freshwater shellfish. Ecologically, freshwater shellfish are qualitatively distinct from marine shellfish and provide aboriginal populations with a completely different resource.

The most often cited reason for the importance of marine shellfish is their dependablity. Any given stretch of coastline may contain a variety of habitats for intertidal marine life. Most maritime-adapted hunter-gatherers prefer a rocky shore environment for this very reason (Yesner 1980). A coast is at the interface between terrestrial and aquatic environments and, depending upon the combinations of sand, rock and mud in the intertidal zone - and on landforms such as hills and streams - a coastal habitat may provide easy access to a number of ecotones. This makes a coastal environment potentially one of the most productive in terms of subsistence choices. It is doubtful that any cultural group would choose to inhabit an area simply because of the number of shellfish available; however, people drawn to a coastal environment by the variety and abundance of other food sources would find shellfish to be a virtually "free" resource - abundant, dependable and easily obtained.

Marine shellfish are available year round. Although there may be seasonal fluctuations in species abundance, the numbers and varieties of most shellfish ensure that there is always something available. Thus, on days when the quest for other sources of protein is unsuccessful, the high quality protein of shellfish, when it is combined with plant foods, can provide an adequate meal. In addition, shellfish can be gathered fresh each day, and in hot, humid climates where meat quickly spoils, this is a great advantage (Meehan 1982).

Intertidal shellfish are easily gathered. In most hunting-gathering groups the gathering is done primarily by the women, but, as gathering shellfish is safe and easy, elderly persons and small children may also participate. Shellfish gathering generally requires little in the way of equipment, and, if the source be nearby, no advance planning would be necessary. In this respect, shellfish can fill a special place in the economy as otherwise non-productive members of society can participate in the food quest.

By contrast, freshwater shellfish are not nearly so dependable a resource. The riverine environment does not support as wide a variety of animal life as the intertidal zone. The shellfish in a freshwater environment all belong to the same superfamily and do not inhabit such a variety of habitats. The riverine environment may be heavily influenced by a number of localized factors, which in turn dictate the abundance and species composition of the mollusc fauna. For reasons that may not be immediately evident from the shore, the occurrence of mussels in a river may be discontinuous and patchy. This discontinuity makes it difficult to predict where mussels occur.

While intertidal shellfish may be easily located when the tide is out, freshwater shellfish are only easily located when river levels are low. Unionids are most often submerged in water of various depths and are often half-buried in the substrate. It is only in the late summer and early fall (when rivers are low) that freshwater mussels are easily collected by wading in the shallow water. In winter rivers are cold, or even frozen, and in spring they are high and sediment-laden with run-off. Mussels are both difficult to see and to obtain at these times. At best, freshwater mussels are a highly seasonal resource.

Aboriginal Procurement of Freshwater Shellfish

Ethnographic data on the procurement and processing of shellfish are scant; what little do exist concern marine resources (Bigalke 1973; Bowdler 1976; Meehan 1977a, 1977b, 1982; Voight 1975). Literature on the procurement and processing of freshwater shellfish is minimal. Aboriginal groups in eastern North America (where freshwater shell middens are most abundant) were among the first peoples on the continent to be affected by European contact. Complete disruption or removal of many groups occurred before they could be studied. Detailed descriptions of mussel collection are not a prominent feature of such ethnographies as do exist. Elsewhere on this continent, and on others, there is a similar paucity of ethnographic information from which to draw analogies. However, by piecing together the few scraps of available ethnographic information, by looking at modern methods of collecting shellfish, and by considering the archaeological data, it is possible to suggest some methods by which aboriginal North Americans may have procured and processed freshwater mussels.

The simplest method of collecting shellfish is to wade into the river, stream or lake and pick them up by hand. As previously noted, this procedure is easiest to do when water levels are low in late summer and fall. In more recent times, during the late 1800s and early 1900s, this was a common method employed by commercial musselers who gathered unionid shells for the pearl button industry and for the pearls they sometimes contain (Coker 1918; Smith 1898; Kunz 1898a, 1898b).

There are two reasons why simple hand-picking is most likely the method used by aboriginal peoples. First, it is the method which requires the least amount of effort and equipment; and second, when river levels are very low, collecting may be done by all members of society. It is during this time that the freshwater shellfish resource becomes most like a marine shellfish resource. Such a scenario is also supported archaeologically. There is a high preponderance of shallow water species in most archaeological sites. While the presence of deep water species is thought to represent periods of extremely low water (Parmalee 1960), an alternate explanation suggests that these are species which have migrated into shallower water (Morrison 1942). Recent studies of shell growth increments have shown that freshwater mussel collecting is almost exclusively a summer/fall activity (Claassen 1982, 1986; Manzano 1985).

Currently, the most commonly applied method for retrieving mussels from deep water is the dredge (brail). The modern dredge consists of a long bar strung with hooks which is lowered from a boat and dragged over the mussel beds. Mussels lie in the substrate with their valves slightly gaping. If anything touches the animal, the valves will clamp shut. When a mussel is touched by the clammer's hook the mussel closes and clings to it until lifted into the boat and removed from the hook. Although the dredge may be employed in relatively deep water, it has some limitations. For instance, not all species of mussels have the same inclination to "bite" and during the winter when mussels become less active, they may cease to "bite" altogether (Coker et al 1920:85). Additionally, dredges have a tendency to hook onto anything occupying the river bottom and may become tangled on rocks and submerged branches.

Kunz (1897:327) noted that rudimentry dredges made of weighted branches or bushes have been employed by "Canadian Lumbermen" who "drag them after their rafts in shallow streams". A method similar to this one was employed by the Maori in New Zealand for collecting freshwater shellfish from inland lakes (Best 1924). Dredges could easily have been manufactured by prehistoric peoples in the southeastern United States; however, dredging requires considerably more time, effort and equipment than do the other methods of collecting shellfish, thus creating a significant rise in the cost of the resource.

A variety of dipnets, rakes and scissor tongs were employed by early commercial musselers to scoop large quantities of mussels out of relatively shallow water (Coker

1918:56–57). Any of these implements would have required only simple technology to construct. Rakes, tongs and sticks were useful for obtaining mussels from beneath the ice when rivers were frozen in winter (Smith 1898:297; Post 1938:29). Collecting through the ice was probably an extremely time consuming and tedious occupation, resorted to only during times of desperation. As mussel beds are not continuous throughout most rivers, an excellent knowledge of where mussel beds occur in an area is required when attempting to fish them from beneath the ice. There is, unfortunately, no archaeological evidence for the use of tools for collecting mussels in the southeastern United States. However, as these implements would probably have been constructed from perishable materials, it is unlikely that any would have survived.

Diving for shellfish in the ocean and in rivers and lakes is known to be practiced in many cultures throughout the world. For example, in Ghana, during the dry season when rivers are clear, shallow and warm, men and women dive in 2 to 4 metres of water to collect *Egeria* (Noe–Nygaard 1967:192). This activity probably requires a boat and is best undertaken in slow, ponded sections of rivers.

CHAPTER IV

MATERIALS AND METHOD

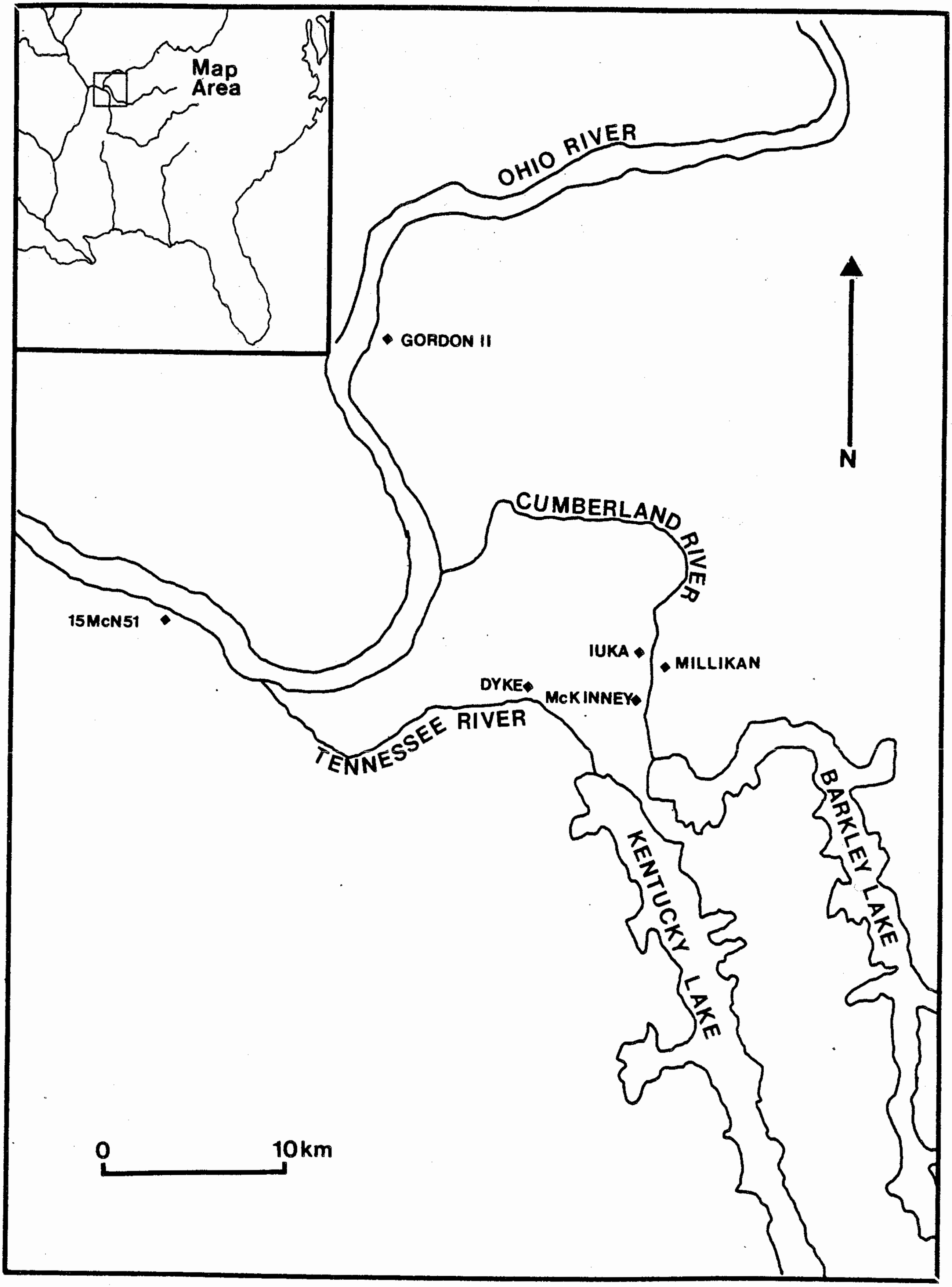
Introduction: The Sites

Six sites were examined for the current analysis. They are located on the extreme lower ends of the Tennessee, Cumberland and Ohio rivers (Fig. 3). With the exception of 15McN51, excavations and/or surface collections were undertaken at all sites between 1982–1984. Investigations were initiated in order to obtain samples of shell and diagnostic artifacts. 15McN51 was excavated as part of a salvage project in 1981. Where excavation occurred, all units were excavated in 10 cm levels and screened through 1/4 inch mesh. Bulk samples were taken for flotation, and column samples were taken for soils analysis. Charcoal and organics were sparse and scattered at all sites and therefore, at all sites except Gordon II, made the collection of samples for radiocarbon determinations impossible. Approximate dates for the sites were obtained through analysis of the ceramics. The analyses of the ceramics were accomplished by Hensley (1983) and Nance (1985) at all sites, with the exception of 15McN51. All sites are primarily Mississippian in age, though in most cases, Woodland pottery also occurs. At most sites shell occurred in a single small lens and for the purpose of this analysis it is treated as a single unit.

15McN51

This site is located on the Ohio River on the west side of the town of Paducah, Kentucky. Investigations were undertaken by the Department of Anthropology at Murray State University under the direction of Dr. Ken Carstens in 1981. Excavation of this site was extremely difficult since the activities of numerous relic collectors had left the site badly pitted and had destroyed much of the continuity. Shells recovered from 15McN51 were in extremely poor condition, with only 19% of the recovered sample being identifiable. As there

Figure 3: Locations of the LCAP Sites


Map
Area
OHIO RIVER
GORDON II
N
CUMBERLAND RIVER
15McN51
IUKA
MILLIKAN
DYKE
McKINNEY
TENNESSEE RIVER
BARKLEY LAKE
KENTUCKY LAKE
0
10km

are so few identifiable shells from this site, they are not separated into levels.

Gordon II

The Gordon II Site is located in a cultivated field on the bank of Chipps Lake – an old meander scar of the Ohio River, on the second terrace of the Ohio, 8.4 km upstream from the confluence of the Cumberland and Ohio rivers. The site appears to be a large Mississippian hamlet, the extent of which has not yet been determined. Farmers have reported the occurrence of stone box graves. The presence of cane–impressed daub indicates that habitation structures once existed here. In 1982, surface collections were undertaken and two test pits were excavated (Casey 1982). The surface collections indicated that shell was distributed more or less continuously over the field. Test pits were excavated where concentrations appeared to be densest. Upon excavation, however, only one pit contained any shell. The shell occurred just below the plough zone in a dense lens approximately 10–15cm thick. The shell lens was directly above a lens of charcoal from which a radiocarbon date of 1060 +/– 100 bp (SFU 306) was obtained. Subsequent analysis of the pottery from the site has rendered the validity of this date questionable (Nance 1985:2). The ceramic assemblage from Gordon II was dominated by Neeley's Ferry Plain, but also included Bell Plain and Kimmswick Fabric Impressed, as well as a few sherds of Tolu Fabric Impressed, Old Town Red and Mathews Incised (Hensley 1983), thus indicating a much later occupation. Below the charcoal lens, matrix was culturally sterile. The shells at Gordon II were in a good state of preservation. This is the only site at which a shell artifact was recovered.

Dyke

The Dyke Site was the only site examined on the Tennessee River. It is located on the right bank of the river at Tennessee River Mile (TRM) 17.4. in a cultivated field some 40–50 metres from the river bank. Initial surface examinations indicated a continuous scatter of lithic debris over an area of approximately 480 x 100 metres. The scatter ran roughly east-west, paralleling the river bank and following a low ridge. Concentrations of lithics were heaviest at the eastern edge of the site. Shell occurred in two concentrations, one near a lithic concentration toward the western edge of the site and the other near the eastern edge (Fig. 4).

Five 1.5 x 1.5 m test pits were excavated at the Dyke Site. Initially one pit was excavated at a lithic concentration at the eastern edge of the site and one at each shell concentration. The shell concentration to the west only yielded a small amount of very poorly preserved shell fragments. Two subsequent pits were excavated in the eastern shell concentration since specimens were more numerous and better preserved.

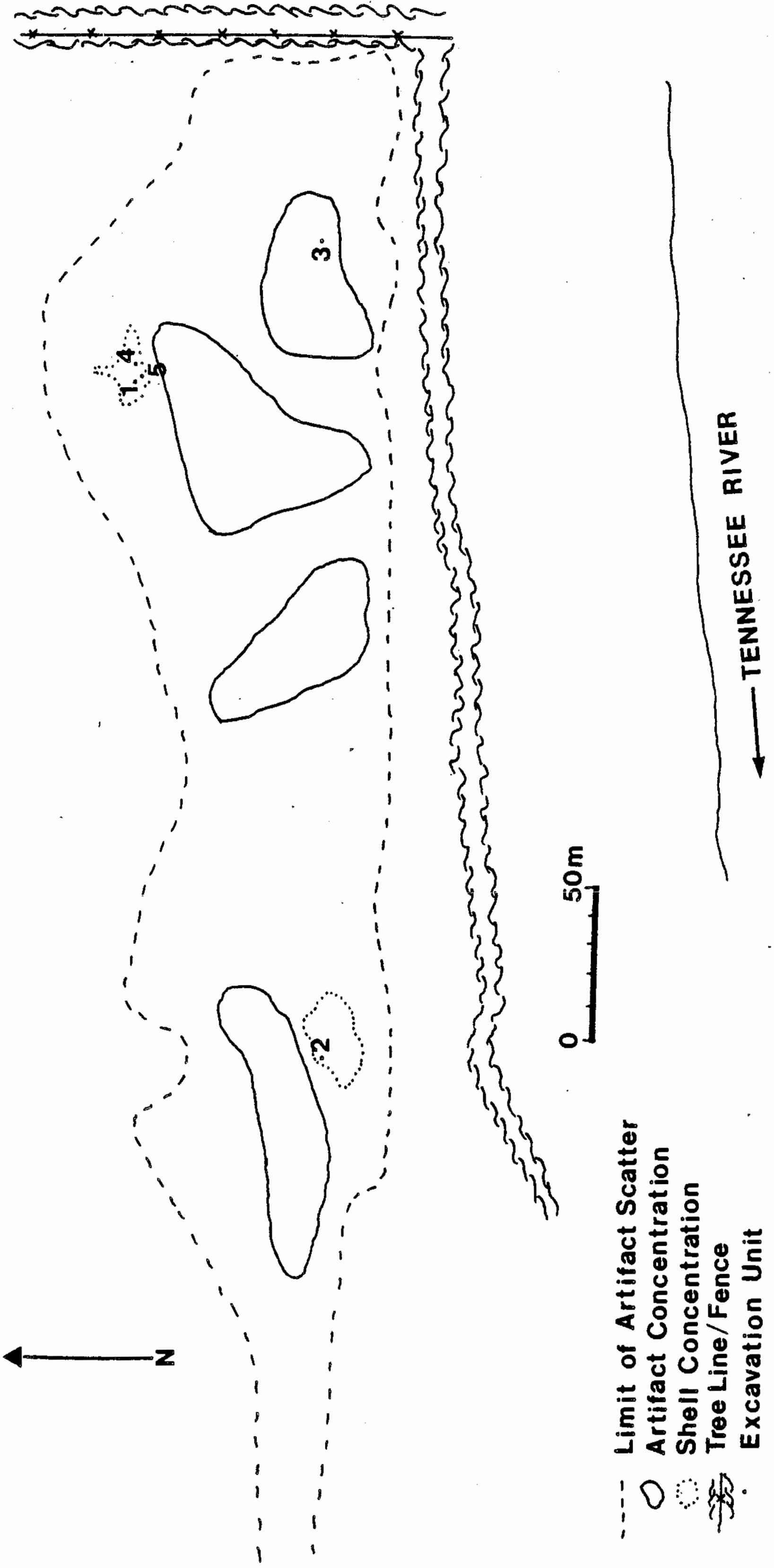
The shell at Dyke was in a poor state of preservation, with only 50.1% being identifiable. Cultural materials were confined to the upper 30 cm of the deposit. As much of this region is in the plough zone, fragmentation of the shells was probably hastened by disturbance from machinery and increased water percolation through the regularly aerated soil.

With the exception of some small fragments of pottery, no diagnostic artifacts were recovered. Ceramics recovered include a sand and clay tempered type (Baumer Fabric Impressed), that indicates Early Woodland, a cordmarked type (Mulberry Creek) thought to be Late Woodland, and shell-tempered wares (Neeley's Ferry Plain and Bell Plain) which are Mississippian. There are also a few other sherds with shell included in the paste. As yet they are unidentified. However, the most dominant class of ceramics at this site are Early Mississippian (Nance 1985:3).

Iuka

The Iuka Site, located in the community of Iuka, Livingston County, Kentucky, is on the left bank of the Cumberland River at approximately CRM 26. The site appears to be a large Mississippian hamlet or town and extends some 250 metres parallel to the river bank,

Figure 4: Map of the Dyke Site.


TENNESSEE RIVER
3
1
4
5
2
0
50m
N
Limit of Artifact Scatter
Artifact Concentration
Shell Concentration
Tree Line/Fence
Excavation Unit

and about 85-90 m east.

In 1982 shell was collected from the surface of one portion of the site. In 1984 one 1.5 x 1.5m test pit and four 1 x 1m test pits were excavated where shell concentrations appeared to be densest. Bivalve shell was very sparse at Iuka, but there was a high incidence of gastropod shells, primarily *Campeloma integrum* and *Pleurocera spp.*

Recovered cultural materials include shell tempered ceramics and small, triangular projectile points which indicate Mississippian occupation. Also recovered were pieces of daub with cane impressions that indicatethe former presence of structures.

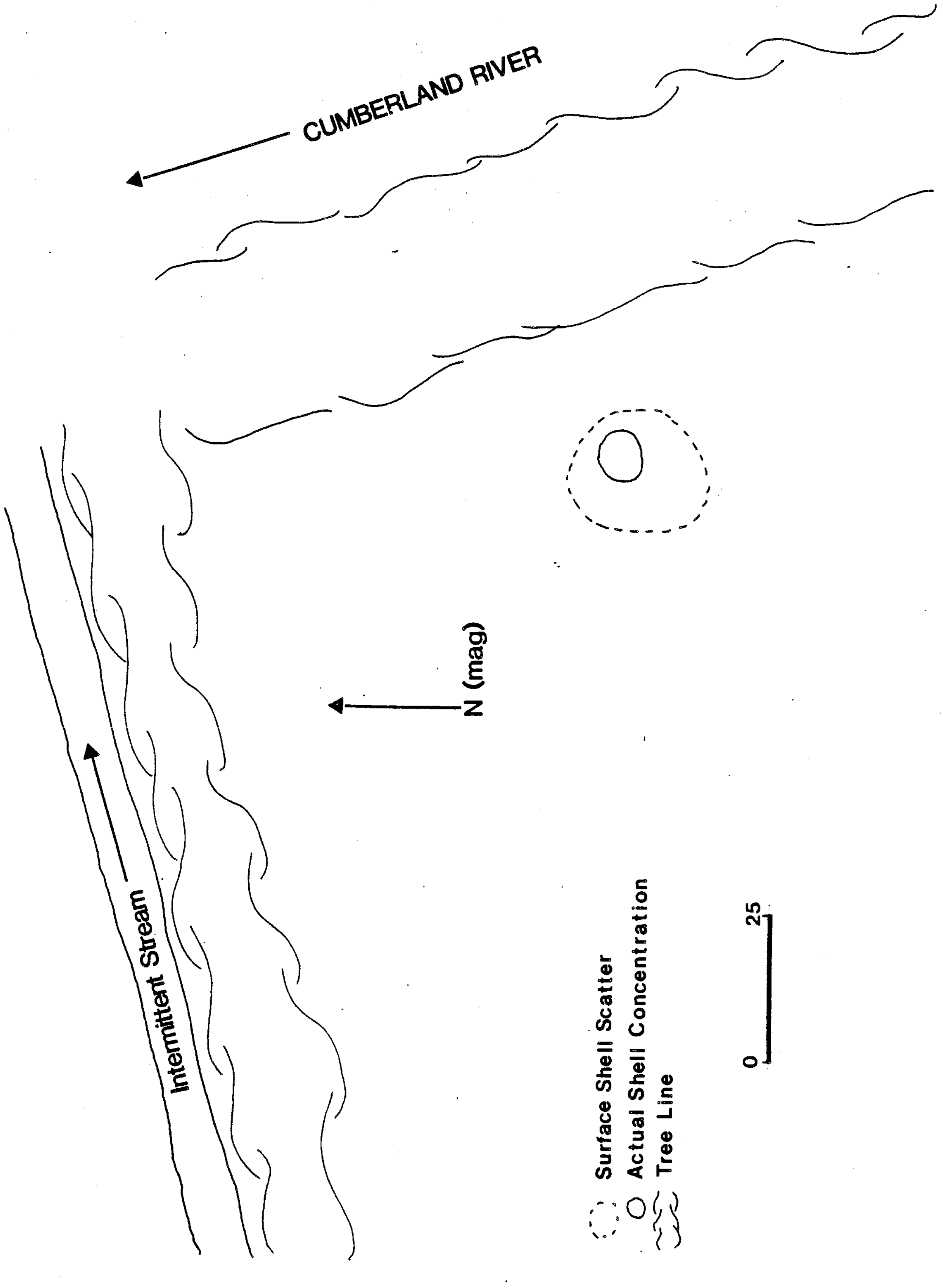
McKinney

This site is located on the left bank of the Cumberland River, at CRM 27.5, in a cultivated field on the floodplain. The extent of this site is unknown. The shell concentration was associated with very little in the way of artifactual material. An unconfirmed site is supposed to exist some 250 m south of the shell concentration, and it is possible that the McKinney Site is associated with this feature (Nance 1985:14).

In 1984, six 1 x 1m test pits were excavated in the shell concentration (Fig. 5). Shell was extremely dense at this site and occurred in a single lens. From the surface the shell concentration appeared to be about 20 m across. Upon excavation, however, unit 3 contained the densest concentration of shell, but units 1, 4 and 5 also produced a substantial quantity. Unit 2 was virtually empty and the lens appeared to be "pinching out" in unit 6. The actual concentration was, therefore, probably not more than 10 m across, the halo effect being produced by movement of shells during farming activities. Although shells were numerous at McKinney, they were quite difficult to recover intact.

The ceramic assemblage from McKinney is an unusual one. Two types of rare occurrence in the area are found here. The inclusion of crushed rock in the paste of one

Figure 5: Map of the McKinney Site.


CUMBERLAND RIVER
Intermittent Stream
N (mag)
Surface Shell Scatter
Actual Shell Concentration
Tree Line
0
25

type has only been reported from one other site in the region (Owen - Late Woodland; Allen 1976). Shell tempered, cordmarked pottery (McKee Island Cordmarked) is also reportedly quite rare (Clay 1963). Other Late Woodland and Mississippian wares recovered at McKinney include Blue Lake Cordmarked, Baytown Plain and Mulberry Creek Cordmarked, which are Woodland; and Bell and Neeley's Ferry Plain and Kimmswick Fabric Impressed, which are Mississippian (Nance 1985:2).

Millikan

The Millikan Site lies across the river and just upstream from Iuka at CRM 26.6. The limits of this site have not been determined, but lithic debris may be seen to extend back from the riverbank into a cultivated field. Erosion of the riverbank at the edge of the field had exposed a lens of shell. Due to instability of the bank, excavation was not permitted. All visible shell and pottery were collected from the surface, with the exception of that which was actually in the bank. The sandy matrix at this site is credited for the good preservation of the shells.

A few pieces of chipped stone were recovered during the collection of the shells; however, no formed tools were evident. The ceramics from the site include both shell tempered (Neeley's Ferry and Bell Plain, and Kimmswick Fabric Impressed) and fired clay tempered wares (Baytown Plain and Mulberry Creek Cordmarked), indicating Late Woodland/Mississippian occupation (Nance 1985:3).

Analysis

The first field season for this aspect of the Lower Cumberland Archaeological Project was the summer of 1982. It was necessary to accomplish several things during the initial season: assemble a comparative collection of the local molluscan fauna, undertake an initial reconnaissance of the archaeological sites in the study area containing shell, and perform surface collections and test excavations of some of the sites (Casey 1982).

Creation of a comparative collection was the most important aspect of the first season's work, since it provided an opportunity to become famliar with the mussel species in the area, to learn about the ecology of the mussels, and to become acquainted with the riverine environment. Unfortunately, damming and dredging of all three rivers in the area has eliminated shoals and beaches and has made mussels very difficult to find. River banks and mid-channel islands were surveyed by canoe and on foot in search of any good shell specimens that may have washed up. A musseling camp at the now discontinued Haddox Ferry crossing on the Tennessee River (approximately TRM 17.2) provided an excellent source of specimens.

The musseling camp was in use during the summer of 1982 and the shellers were kind enough to take me out with them so I could collect specimens and see how modern musseling is done. It was here that I learned many initial identifications.

The musselers from the Haddox Ferry camp dredge the Tennessee River for mussels and return to the camp to open the shells by steaming them. They search the flesh for pearls or "slugs" and then cull the shells. Those shells that are perfectly white are sold to a broker in Tennessee who in turn sells them to Japan. In Japan, beads ground from the shells are used in the cultured pearl industry. Any shells that have coloured nacre ("pinks"), or that are stained, are thrown into the cull heaps. These cull heaps were an excellent source of comparative specimens.

Ideally, comparative specimens should have been obtained from each of the three rivers in the study area as, depending upon river conditions, members of the same species can differ morphologically (Ortmann 1920). On the Cumberland River specimens were found at only one place, when water, regulated by the dam, was extremely low. These specimens were badly eroded and virtually useless. The best specimens came from the Tennessee River, from the musselers cull piles, and washed up on the beach at Altona (approximately TRM 12.8). The shells at Altona were in extemely good shape, often having both valves still attached by the ligamentous hinge. The uniformly small size of these specimens along with the characteristic fracture on the posterior margin of virtually every shell, suggests that these animals were victims of the commercial musselers. So that, in theory, these young animals can mature and reproduce, musselers are obligated to throw back all individuals that are less than 2 1/4 inches in diameter. Unfortunately, many sustain such severe damage from the brail hook that they do not survive these encounters. The large numbers of victims at Altona are sad testimony to this. Other comparative specimens were found on the gravel bars all around Cumberland Island at the confluence of the Cumberland and Ohio Rivers. Most of these shells were bleached and water worn, but a number of good examples were available.

During the 1982 field season the Gordon II Site was surface collected and excavated. This same year a field at the Iuka Site was also collected.

The 1984 field season took place in the fall, from September to November. This was planned in order to investigate a number of sites which, due to crops, were inaccessible during the summer. Unfortunately, because the fall of 1984 was an unusually wet one, harvesting was delayed at some sites. As a result, excavation schedules were quite tight. The Dyke, Iuka, McKinney and Millikan Sites were investigated during this season and only one site (Altona) was abandoned because of inclement weather.

Sampling and Excavation

Whenever possible, before test units were selected, sites were surveyed, surface collected and density mapped for artifact and shell concentrations. Due to time restrictions imposed by bad weather, this was not possible at the McKinney Site. It was also not possible at

Millikan as the field containing the site was still in crop at the time. As the purpose of the excavations was to obtain information on the range of mussel species present, test pits were located where concentrations of surface shell were thickest.

At Iuka the shell concentrations were small and dispersed with no obvious midden area present; hence scattered test pits were employed. By contrast, because the limits of the shell accumulations at McKinney and Dyke were more circumscribed, more closely concentrated test units were necessary to discover the nature and dimensions of the lenses. Time considerations limited the number of units possible at Gordon II.

Whenever shell was discovered during excavation, techniques to ensure its intact removal were adopted. Removal of the shells was often made difficult by the badly decomposed nature of many of the specimens. The worst condition was at McKinney, where the shell lens was very dense and where the shells were often lying tightly one atop another. This made individual excavation nearly impossible. The problem was compounded by the tendency for the nacreous and prismatic shell layers to separate.

It often seemed that excavation of these sites was a struggle between having either quantity or quality of shell material, the two categories being apparently mutually exclusive. If one selected quality, one ran the risk of opening fewer test units thereby learning less about the structure of the accumulation and possibly forfeiting species which may have been dumped in discrete places. If one selected quantity, one risked the systematic under representation of species that are rendered unidentifiable by being easily broken and fractured. A compromise was struck by removing as many of the shells as possible in clumps of matrix. Not only did this technique speed up the excavation, but the surrounding matrix helped to hold the shells together.

Upon removal from the units, shells were packed in large bags and taken back to the lab at camp. Since the matrix was quite wet, it was feared that packing the shells as they had been excavated would promote the development of mildew, and thus further aid decomposition. The shells in their matrix were spread out on large racks and allowed to air-dry. Matrix hardened around the shells, and the clumps were wrapped in newspaper, packed into bags and boxes, and transported back to Canada.

At the Simon Fraser University lab, I began the process of washing the shells in the spring of 1985 with the help of two assistants. Washing was accomplished by submerging a block of shells in matrix in a basin of water and gently loosening them. Shells that were intact and relatively solid were given a gentle scrub with a soft toothbrush. Although nacreous and prismatic layers often separated during the washing process, it was generally possible to reunite the two parts and glue them back together when dry.

Initially, after washing, material from each site, unit and level was sorted into gross categories, based on morphological similarity. Immediately separated were species such as *Dromus dromas* and members of the genus *Dysnomia*, that are easily distinguished from other species. The rest were sorted into categories according to gross morphological features such as (1) those with elliptical shape; (2) those with a generalized round, smooth shell; (3) those with pustules or other shell sculpture; and (4) unidentifiable. It was hoped that this initial sorting would help to cut down on identification errors by allowing, across all sites, concentration on one suite of types at a time. Since proficiency at species identification tends to improve with practice, the early units, once all shells were identified, examined again to insure consistency.

Identification

Identifications were made with the help of several sources (Burch 1975; Clarke 1981; Parmalee 1967; LaRocque 1967) and with the comparative collection. Species were confirmed and problematic specimens identified by Dr. J.B. Sickel of Murray State University, who also supplied a number of the identifications and specimens for the comparative collection.

Several factors made difficult the identification of unionacean remains from archaeological sites. First, biologists classify taxa on the basis of attributes of the soft parts, and in some instances the glochidia, as well as by shell morphology. Many of the criteria for identification are therefore simply not available to the archaeologist. This fact is most evident at the genus level. Genera are often defined by features of the marsupia and gills. Thus, only in rare instances is it possible to assign only genus to archaeological specimens whose species is not evident. Further, most books on Unionacean bivalves give the nature of the periostracum, the colour and lustre of the nacre, and the beak sculpture as important identifying characteristics. All of these features are generally lacking from archaeological samples.

It is a popular misconception among archaeologists that unionids are easily distinguished by their teeth. While it is true that the pseudocardinal and lateral teeth are valuable for identifying specimens, sound identification can rarely be made on the basis of the teeth alone. Shell outline, beak cavity depth, and shell sculpture are all equally important identifying characteristics. Some or all of these characteristics may be missing or ambiguous. While it is true that correct identification can rarely be made on the basis of the teeth alone, it is also true that without the teeth, identification is virtually impossible.

Shell Taphonomy

Identification was in most cases hampered by the poor state of shell preservation. A large number of cultural and natural processes have been at work throughout the depositional and post-depositional history of the shell accumulations, and are responsible for the varying states of preservation of the shells at these sites. The study of shell taphonomy is relatively new, with very few integrative studies having yet been completed. Although in the early part of the 20th century some interest was taken in the processes by which shell middens were formed on the California coast (Gifford 1916; Uhle 1907), this type of research was abandoned until quite recently (Muckle 1985; Watson and Marquardt 1979).

Taphonomy was originally defined and described in 1940 by Efremov, a vertebrate paleontologist (Olson 1980:6). Since its conception the study has primarily been applied to paleontological research and it is only fairly recently that taphonomy has been applied by archaeologists to their material.

Taphonomy literally means "the laws of burial" (Olson 1980:5). It deals with the various processes affecting animals from their deaths until their possible fossilization (Hill 1978:87). The interests lumped together under the heading of taphonomy are diverse; however, they all aim at better understanding those many factors involved in the methods of deposition and preservation of fossil assemblages (Hill 1978:98). There is a general tendency to assume that fossil assemblages are essentially equivalent to a once living community of animals. However, as many fossil individuals have almost invariably been subjected to a variety of modifying processes between death and fossilization, this is rarely4 if ever the case. Hence, before attempting a paleoecological reconstruction it is necessary to assess the extent of alteration to the material since death (Hill 1978).

Taphonomy lends itself well to archaeological research. The site can be viewed as "the outcome of a complex, interrelated series of human and natural processes which operated until it came under study by the archaeologist" (Gifford 1980:93). In this respect the site is analogous to the fossil assemblage; it is the product of a variety of factors operating both during and after its occupation. The major distinction between paleontological and archaeological assemblages is human involvement.

The effect of hominids on the accumulation of fossil assemblages has been considered (see Hill 1978:91–93); however, in a paleontological assemblage there is generally some question as to whether or not hominids were involved in the accumulation of a particular group of fossils. Much taphonomic research has been devoted to the identification of attributes within assemblages that could not have been produced by any means other than by humans (Brain 1976, 1980, 1981; Bonnichsen 1973, 1979; Morlan 1980). In archaeological assemblages, human involvement is known (or assumed), and the question becomes one of distinguishing between the cultural and natural processes, (or between C- and N-transforms (Schiffer 1973, 1976), that produced the site and the degree to which each process operated throughout the depositional and post-depositional history of the site.

Numerous paleontological studies have examined the taphonomy of bivalve mollusc shell, but these studies have only rarely been related to archaeological material (Koloseike 1969; Muckle 1985). The shell accumulations examined for this study exhibited a range of preservational states which may be due to both chemical and mechanical weathering processes.

Shells are composed primarily of calcium carbonate and are therefore highly suceptible to deterioration by acids. Rain and groundwaters are essentially solutions of carbon dioxide in water, or carbonic acid, which is capable of dissolving limestone (Sienko and Plane 1966:407; Friedman and Sanders 1978:134). Other acids that affect archaeological sites are produced by the decomposition of organic matter and by urine (Koloseike 1969:375; Muller 1979:56). Carbonates released by the decomposing shells during the chemical weathering process raise the pH level of the soil and help to counteract the acidity of percolating groundwaters. This process produces a favourable environment for the preservation of organic remains. Throughout the shell midden there may be differential preservation of shell and other materials depending upon their proximity to acids (Sanger 1981:38). It has been noted (Muller 1979; Schafer 1972) that small and thin particles of shell are likely to be more rapidly dissolved than are larger particles. Thus, depending upon shell size and structure, there will also be differential preservation of particular species. Shells that have sustained fractures may also be expected to be more suceptible to chemical weathering. It is not known what effect chemical fertilizers and pesticides have on the preservation of shells in archaeological sites.

Soils in this area of the Midsouth are notoriously acidic, and this acidity has been blamed for the poor state of preservation of organic remains at many of the sites in the region. The shell accumulations in the study area are relatively small and thin and the release of carbonates by decomposing shells is likely not sufficient to alter soil pH significantly. At the Millikan Site, the matrix in which the shells were found consists predominantly of sand with little or no humic matter or charcoal. Organic humus and charcoal tend to hold water and aggregate (Hughes and Lampert 1977:136). A good percentage of these components is likely to hold acidic water against the shells and allow more time for chemical dissolution to take place. At Millikan, however, the sand provided good drainage, and chemical weathering was less obvious here than at the other sites. Chemical weathering was evident at all sites by the porous and chalky texture of all shells and by their friable nature.

Fracturing of shell may occur as the result of a variety of natural processes, including crushing from the weight of overburden (Allen 1974:85) and abrasion from deposition in an active environment (Chave 1964; Coutts 1969; Driscoll 1967, 1970; Driscoll and Weltin 1973; Muller 1979). A number of cultural processes may also be responsible. These include trampling (Maggs and Speed 1967; Voight 1975; Muckle 1985) and other factors of collection, processing and discard (Shaw 1976). Degree of fracturing is not only dependent upon the nature of the disturbance, but also upon the shell structure (Chave 1964; Currey 1976; Muller 1979). Here again, one may expect there to be differential fragmentation of shell by species. The shells of some unionid species such as *Anodonta* spp., *Lampsilis ventricosa, and Lasmigona complanata* are notorious for their tendency to crack as they dry (van der Schalie 1974).

Separation of the nacreous and prismatic shell layers was the major taphonomic problem encountered at the sites. Young unionid specimens and some genera such as *Anodonta* and *Leptodea* have very thin shells where the nacreous and prismatic layers are of approximately equal thickness. Most of the unionids in the study area have a thin layer of prismatic structure and a very thick nacreous layer. Nacre is a very primitive type of structure, but it is superior to all other shell structures in tensile, compressive and bending strength (Currey 1976:452). Separation of the two layers in the archaeological shells at these sites has led to shells being represented only by the thick, nacreous umbonal region, while the prismatic layer is often completely disintegrated. Shell sculpture is often confined to the prismatic layer of the shell. Thus, separation of the two layers renders many species unidentifiable. It is only those species with either very unique tooth structure, or shell sculpture that involves the nacreous layer, that may be readily identified once the two layers have separated.

The degree of shell fracture was variable at each of the sites. All of the shell concentrations occur in cultivated fields, and the amount of destruction sustained through farming activity is a significant consideration. At Dyke, concentrations were located in the plough zone and the shells were probably reworked annually during cultivation. The shells at Millikan were located at the edge of a field and were likely beyond the limits of regular ploughing. Most of the shells at McKinney were below the plough zone, though the top of the concentration was within reach. Even so, the weight of farm machinery can be expected significantly to increase crushing and compression of the layer.

The Gordon II Site on the Ohio River contained the best preserved shells. In many cases remnants of the periostracum were still present and even the colour of the nacre was at times faintly evident. As at McKinney, the layer was mostly below the plough zone, but the most significant differences were primarily due to the lesser degree of chemical weathering. A number of well-preserved vertebrate and botanical remains were also recovered during the excavations. This state of preservation would suggest that, for reasons presently unknown the soils here were simply not as acidic as those adjacent to the Tennessee and Cumberland rivers. Gordon II is also the most recent of all the sites and as such has been exposed to less weathering.

Right and left shell valves have been observed to behave differently under different kinds of depositional circumstances (Muller 1979; Lever and Tjissen 1968). This difference is mainly due to morphological details of the valves. In heterodont bivalves such as unionids, the right valve has a larger pseudocardinal tooth, making this valve heavier than the left. Thus in an active environment, the valves would be expected to behave differently.

A preference for the aboriginal use of one valve over another has been noted ethnographically by Skinner (1925:137), who found that Sauk Indians preferred to use the left valve of freshwater bivalve shells for removing the kernels from cobs of corn. The reason for this preference is that the left valve fits more comfortably in the right hand. Theoretically, this same preference could apply to any shells used as tools for such activities as scraping, hoeing, or cutting (see Gradwohl 1982). In situations where shells are used as tools, they may be expected to be disposed of in contexts different from those shells that represent food refuse. The disproportionate occurrence in a site of one valve over another could therefore be due to the systematic removal of one valve for tool manufacture.

At the archaeological sites, numerous attempts were made to match pairs of valves. In life the pseudocardinal and lateral teeth are positive–negative images of each other that interlock perfectly. Chemical weathering has the effect of rounding out the jagged edges of the teeth and makes the fit ambiguous at best. When shells may be differentially broken along the posterior and ventral edges, it is even more difficult to assess fit. During excavation, whenever articulated shells were found, they were bagged and labelled separately. When the specimens had been cleaned of surrounding matrix, they rarely proved to be actual articulating shells. Often the two halves were of different species. In only a few cases were both valves of the same individual found together.

The presence of large numbers of paired valves indicates that many shellfish were processed at the same time (Morrison 1942; Warren 1975). The ligamentous, hinge which joins the two shell valves of the living shellfish, is made of organic matter similar to that of the periostracum. This material is pliable when fresh, but becomes brittle once dried. Two reasons suggest why the paired valves of shellfish which are processed in quantity are likely to be found close together in a midden. First, if the ligament is intact at the time of disposal, the valves will be deposited together. Second, the rapid accumulation of material protects the shells below, giving them less opportunity to become separated.

In order to assess the degree and direction of movement of shells over time, Koike (1979) developed a technique for pairing valves in shell midden analysis. Her study involved the excavation and analysis of a small midden in its entirety, an opportunity that rarely presents itself. Her work also rests on the assumption that the valves of all shellfish were together at the time of disposal. This assumption was necessary for her study, though it may be erroneous. Depending upon how much time passed between processing and the final deposition of the shells, the ligament may have had time to dry out and crack - thus causing the valves to separate. There is also ethnographic evidence that, in order to lighten the load for transport, certain groups habitually remove one of the valves of a pair when shellfish are fresh (Meehan 1982).

Nomenclature

The problem of nomenclature of freshwater bivalve molluscs is a very long standing one which dates back to the time of Rafinesque in the early 19th century (Ortmann and Walker 1922; van der Schalie 1952). There is still no system that is agreed upon by all malacologists, and, for the archaeologist who is unfamilliar with the variety of names available for many specimens, the problem of nomenclature can be very confusing. No strict nomenclature was adopted for the present study, but the system follows most closely the work of Ortmann and Walker (1922) and Burch (1975).

No attempt was made to identify specimens to the subspecific level, and, where several species form a "complex" (e.g. *Pleurobema cordatum*), these specimens were most often designated as a single type. Sometimes extremes of a complex or suite of forms were encountered; but as differences were slight, and as intermediate forms were usually difficult to assign to one or another form, specimens were "lumped" rather than "split". Specific problems with identification are noted as they arise in the account of species.

The identification of shellfish remains from archaeological sites can assist biologists in tracing stream confluences and chart the migrations and distributional history of molluscan species throughout an area (van der Schalie 1939b, 1945). In this respect it is important to identify correctly as many species as possible. Often, however, the perceived distinction between forms is in the relative size of the shell, in the degree of inflation or compression and in the number or definition of pustules or other shell sculpture. When dealing with archaeological specimens, separating the various forms and subspecies is extremely difficult and time consuming, and, given the poor state of preservation of many archaeological collections, many species assignments are quite subjective. Often the various forms represent ecophenotypic variants of a species, and the identification of the forms can suggest whether the specimens were recovered from, for instance, a small tributary stream rather than from the main stem of a large river. Since the identification of forms is so subjective, and since the archaeological specimens at hand were in such a poor state of preservation, it was felt that ambiguous identifications may lead to false or misleading biological information. Forms and subspecies were therefore assigned to either a "complex" (e.g. *Pleurobema cordatum pyramidatum* = *Pleurobema cordatum* complex), or to a species *Dysnomia torulosa rangiana* = *Dysnomia torulosa*) designation.

Techniques of Analysis

The vast majority of midden analysis has been done on coastal sites, but the methods researched and developed there are generally thought to apply to freshwater shell deposits as well (Bowdler 1983:135). The freshwater shell midden is quite different from a coastal shell midden, and, as such, requires a different archaeological approach. Many of the standard techniques of coastal shell midden analysis are not valid when applied to interior freshwater river and lake environments.

In terms of sampling, the analysis of these two types of middens is similar. Not much is known about the formation of middens in either context. Both coastal and interior middens can display the same heterogeneous admixture of lenses of shell that are interspersed with lenses of charcoal, sterile soil, humic matter, pits, rocks and features. In both cases, it is ideal that the entire midden be carefully excavated to determine the depositional sequence of events, the placement of dwellings, and other features and changes in the composition of shellfish species. Any of these characteristics can change horizontally and/or vertically in a midden. Because of the size of many shell accumulations and because of frequent constraints on time and money, complete excavation is rarely possible. As a result, sampling procedures must be adopted that will provide the maximum amount of information, with the least amount of work over an often vast and very heterogeneous site. In most cases, column samples are taken; however, unusual lenses of shell should be sampled separately, and, ideally, all excavated shell should be saved.

Standard coastal midden analysis usually involves the analysis of column samples. These samples of midden matrix are first weighed, then dried, and then passed through graduated sieves. The sample within each screen is then sorted into its various components (shell, charcoal, rock, bone, etc.), and the shell component is further sorted into recognizable species. Each species is then weighed to obtain the proportion of each shellfish species in the midden. Meat weights may also be calculated (Meighan et al. 1958; Koloseike 1969, 1970; Bowdler 1983). This calculation is possible in coastal sites because marine shellfish often represent a large number of families with a relatively small number of genera and species in each family. The shell structures of the different animals can be quite different, and, even when found in very small fragments, can retain their integrity (Kobayashi 1969). Genera such as *Haliotis* and *Mytilus* can even retain their colour when found as tiny fragments in archaeological samples (Koloseike 1970: 476–477). Recommendations that samples be identified only to what is retained in a 1 mm or a 1/8 inch screen are due to the constraints of time even though some species may be easily identified from even smaller fragments (Koloseike 1969, 1970; Muckle 1985:83).

By contrast, unionacean bivalves represent a small number of families and a very large number of genera and species, all of which have a very similar shell structure. The various genera and species are therefore not easily identifiable in an advanced state of fragmentation and/or decay. In most archaeological sites all colours of nacre quickly bleach to white. Only in rare instances (i.e. dry cave sites) are the darker shades of purple discernible in archaeological specimens. Thus, tiny fragments of unionacean shell are rarely identifiable. The process of weighing freshwater shellfish remains is practically useless as an analytic tool. At the sites in this study virtually all identifiable shells were broken, most having lost the thinner posterior edge of the shell and often a good portion of the prismatic layer as well. Thus, even for identified remains, the calculation of weights for freshwater shellfish does not serve any practical purpose.

The various proportions of shellfish species in an interior midden analysis represent <u>identified</u> specimens. If one or more species has a greater tendency than the others to fracture into unrecognisable fragments, it runs the risk of being systematically underrepresented. This happens frequently in coastal middens, particularly with thin–shelled, friable specimens such as *Mytilus*; however, subsampling and fine screening generally reveal the presence of

Mytilus fragments and proportions may be calculated by weight (see Wessan 1982).

While the weight method is often used for quantifying shell fragments in column samples, it is also used to establish proportions of whole shells in coastal midden samples. Weights can also be used in conjunction with individual counts in midden analysis.

In zooarchaeological studies there are two main methods of quantifying taxonomic abundance: by number of identified specimens (NISP) and by minimum number of individuals (MNI). NISP is simply the number of bones (or, in this case, shells) of each species of animal that are identified in the assemblage. NISP is the most obvious and easily obtained measurement; however, in studies of vertebrate remains it presents some problems.

Major problems with NISP concern the differential preservation and/or recovery properties of various skeletal elements. In NISP counts, the taxa that are emphasized are those with a larger number of skeletal elements, those with larger and less friable bones, and those in which individuals are brought to the site whole (Grayson 1979, 1981, 1984). MNI was introduced as a way to get around some of the biasing factors that affect vertebrate assemblages by giving a number that represents the minimum number of individual animals necessary to produce that assemblage. This number is obtained by counting all the specimens of each skeletal element for a species, and the highest number becomes the MNI. For example, if an assemblage contained 8 right and 4 left deer femora, NISP would be 12; however, MNI would be only 8, since that is the least number of deer that would be necessary to produce the assemblage.

Yet, MNI is also not without its share of problems. Perhaps the biggest concern is that it only gives a conservative estimate of the number of animals in an assemblage, not the actual number. One method of arriving at a more accurate measure of MNI is the technique of "matching" described by Bokonyi (1970). With this technique, the bones of a species are divided into age groups on the basis of epiphyseal union, size and degenerative evidence. The MNI for a species is the sum of the MNI of all the groups. This total generally provides a higher number than for the regular MNI counts. Although one should be aware of the limitations of MNI (see Grayson 1979, 1984), it is often felt to be a useful measure in the quantification of vertebrate faunas and, in most cases, is preferable to NISP.

It is not unusual to see MNI used in the quantification of shellfish remains (Barber 1982; Klippel, Celmer and Perdue 1978; Murphy 1976; Warren 1975; Wessen 1982); however, when applied to shellfish remains, the estimation and utility of this measure is quite different from when it is applied to the remains of vertebrates. Since bivalve shellfish are composed of a single pair of skeletal elements, they are not subject to many of the factors that bias vertebrate assemblages.

In the study of vertebrate remains, not all analysts trouble to separate left from right skeletal elements their assumption being that the accumulator probably did not have a preference for side (Klein and Cruz-Uribe 1984:26). If this assumption is correct, lefts and rights will be roughly the same in very large samples - whether or not the sample is sided or simply divided in two. For small samples the two procedures can produce very different MNIs.

Right and left valves are easily distinguished in most species of bivalve shellfish, even if only the umbonal region be present. In general, estimates of MNI in shell assemblages are simply the greater number of lefts or rights for each species. Left and right valve counts should be made routinely on at least a sample of each shell assemblage with the purpose of assessing the presence of systematic preference of one valve over another, a preference due to differential disposal or post-depositional behaviour of valves, or to the inability on the part of the analyst to identify one of a pair of valves in a species. This latter factor is a distinct possibility in the identification of unionids where the teeth in each valve can appear to be quite different in an advanced state of decay and may be misidentified as belonging to two separate species.

Theoretically, the matching technique could be used on shellfish assemblages by counting annuli, or by making length or height measurements. The sheer numbers of shells involved in many midden analyses, and the degree of breakage sustained by many of the specimens, would probably make this method impractical for most purposes. The matching technique discribed by Bokonyi (1970) and applied to shellfish differs from the valve pairing technique discribed by Koike (1979) in that with the former technique, it is not necessary to identify discrete pairs.

One of the other problems with vertebrate assemblages that MNI attempts to circumvent is the possibility of counting pieces of a fragmented element as unique elements. In the quantification of shellfish remains this problem is easily avoided by counting only one portion of the shell. With bivalve molluscs the usual procedure is to count only those shells containing the hinge line and teeth. Since unionid shells are rarely identifiable without the umbo, all counts represent umbonal portions. With marine shellfish, which may be identified in smaller fragments, weights and MNI are sometimes used in together (Bowdler 1983).

If one's interest lies in knowing the relative proportions of the various bivalve species in an assemblage, it does not make much difference whether one uses MNI or NISP – the proportions will not change between the two. Although this estimate may be out by a few shells, the amount of additional information that is to be gained by siding, matching and weighing of shell fragments is minimal. If, however, one is interested in comparing bivalves to other classes of molluscs, or to echinoderms and crustaceans, some estimate of MNI will be necessary to account for the differences in skeletal elements between these other types of shellfish.

NISP counts were used in this study for two reasons. First, we are only interested in comparing the proportions of the various shellfish species between sites. Second, this study compares sites in which the shellfish remains have been quantified by other researchers who did not use MNI.

Seasonality

The analysis of growth increments on shells to estimate the season of death of the animal has recently become a popular avenue of enquiry in freshwater shellfish studies (Claassen 1982, 1986; Manzano 1985; Nicholson 1981). An unbroken ventral shell margin is required for this technique. The season of death is estimated by calculating the amount of growth the shell has undergone since the last winter rest period. Unfortunately, the ventral margin is missing on virtually every shell in the assemblages in this study, making seasonality estimates with this technique impossible.

CHAPTER V

ACCOUNT OF SPECIES

Distribution of the Unionidae

The unionid fauna of North America occur in a number of discrete regions. Simpson (1895) divided North America into three regions that were based on the species of river mussels found: The Pacific drainage; the Atlantic region – including the lower St. Lawrence and the rivers of eastern Canada; and the Mississippian region. Of the Mississippian region Simpson states:

> All waters that are carried to the Gulf of Mexico through the Mississippi River are filled with a common assemblage of Naiades, including Unios and Anodontas. In fact, this fauna occupies almost exclusively all the streams emptying into the Gulf...
>
> No equal area on earth has such a diversity of Naiad life or such magnificent shells. Here are found the largest species in the world; here are forms with knobs, pustules, angles, lobes and concentric sculpture. The nacre of many of them is wonderfully rich in tints of silver, pink, purple, salmon or red, and is equaled in beauty by the elegant patterns of external painting in stripes and mottlings and delicate hair lines (Simpson 1895:331–2).

The Mississippian region, also known as the Interior Basin, is world renowned for its unionid fauna. It is estimated that half the world's known species of river snails and freshwater bivalve molluscs are found here (Stansbery 1970:9).

Subsequent researchers have designated several other faunal groups within the Mississippian region. Van der Schalie and van der Schalie (1950) designate three faunal groups within the Mississippian region: 1) Mississippian or Interior Basin (the largest); 2) Ozark, located slightly to the west of the Mississippi River including all rivers that drain the Ozark highlands; and 3) Cumberlandian, (Ortmann 1924b) which is located east of the Mississippi River and which includes the headwaters of the Tennessee and Cumberland rivers. Johnson (1980) gives a narrower definition of the Interior Basin, and, in addition to the

Ozarkian and Cumberlandian regions, designates the Ohioan Region – a region that consists of all the rivers that flow into the Ohio River, excluding the Tennessee and Cumberland rivers. Johnson defines the Mississippian region as the Missouri River, and all rivers that flow into its south side excepting the Osage, Meramec and Gasconade (which are Ozarkian), all the Mississippi River above the Missouri, and all rivers to the west and north of the Ohio.

The major cause of the molluscan provinces has to do with the glacial history of the area. Johnson (1980) explains it thus:

> Prior to the Cretaceous Period the then Cumberland Plateau extended continuously from the Appalacian Mountains southwest into western Texas. The Mississippi River did not exist. What is remarkable about the present unionid faunas on the Ozark Plateau, on both sides of the Ozark Crest and on the Cumberland Plateau, is their similarity, even after the passage of some 200 million years. The maximum Pleistocene glaciation extended southward, west of the Appalacian Mountains, roughly to the present Missouri and Ohio rivers, and to the Pennsylvania-New York boundary in the east. During the Nebraskan glacial stage, which represents the earliest and most southerly extension of the ice sheet, the unionid fauna was eliminated north of this line. With the exception of two species from the Pacific Coastal Region, the Interior Basin (including the Canadian Interior Basin), the St. Lawerence River system, and the Northern Atlantic Slope, have since been repopulated with species from southern refugia (Johnson 1980:78)

That these regions should contain such discrete faunal groups is a matter of considerable interest. Distribution of the Unionidae is accomplished through larval parasitization of fish. Thus, such barriers to the fish host as mountains, deserts, and waterfalls are barriers to the dispersal of unionids. Given this, it is easy to see how the Atlantic and Pacific slopes could produce such distinctive faunas.

The type of host parasitized can have a great effect on unionacean bivalve populations. Unionids that parasitize primarily fish species that are territorial and restricted to areas within a single river will likewise have restricted distributions, and populations within a geographical area may exhibit considerable morphological variation. In contrast, species which parasitize widely ranging hosts, especially anadromous fish, show considerably less morphological divergence between populations located even at opposite ends of their geographic ranges (Kat 1984:202).

Other aspects of the geological history of the area may also be responsible for some of the patterns of mollusc distribution in the Interior Basin. It has been suggested, for example that the Ozarkian and Cumberlandian regions represented land masses which protruded "above the several embayments that engulfed this interior region in geologic time" (van der Schalie and van der Schalie 1950:450). Similarly, post-glacial changes in the drainage of the area, which caused rupture of stream confluences, are thought to have played a significant role in the distributional patterns of mussels (Johnson 1978; van der Schalie 1945).

The rivers of most interest to this study are the Tennessee, Cumberland, and Ohio rivers. Although the Tennessee and Cumberland rivers are excluded from most definitions of the Ohioan faunal region, the lower ends of these rivers are thought to have more in common with the Ohioan region than with the Cumberlandian. According to Johnson (1980:80), the Cumberlandian region may be defined as "The drainages of the Tennessee River system from the headwaters to the vicinity of Muscle Shoals, in Colbert and Lauderdale counties, Alabama; and the Cumberland River system from the headwaters to the vicinity of Clarkesville, Montgomery county, Tennessee". Of these two regions Ortmann (1926) states:

> *The two systems, at some time in the past were separated,* the Ohioan (or whatever was its master stream) having no connection with the Cumberlandian River (Cumberland and Tennessee). Later on, however, the present conditions were established, very probably by the deflection of the Tennessee and Cumberland toward the north and toward the Ohio, and there is no question, that the northward flowing parts of these rivers are of rather modern origin. This union with the Ohio must have brought about a partial mingling of the old faunas and we have introduced the above evidence for the invasion of Ohioan types into the Lower Cumberland and Tennessee (Ortmann 1925, p.375). But, of course, a change could have gone on also in the opposite direction (Ortmann 1926:187; emphasis and reference in the original).

Although Ortmann did not suggest which species may have descended the Tennessee and/or Cumberland and invaded the Ohio drainage, Johnson (1980:79) lists seven possibilities:

Lampsilis abrupta (= *orbiculata*)
Caruncula glans
Plethobasus cicatricosus
Plagiola (=*Dysnomia*) *personata*
Plagiola (=*Dysnomia*) *flexuosa*
Plagiola (=*Dysnomia*) *sampsoni*
Plagiola (=*Dysnomia*) *propinqua*

According to Johnson (1980:79) "Thirty-seven of the 90 species of unionids found in the Tennessee River are Cumberlandian, as are 27 of the 78 found in the Cumberland River. These two assemblages are the largest number of unionid species found anywhere in the world's rivers".

The Mississippian and Ohioan regions likewise have distinctive faunas. Fifty-three species are found in the Mississippian region, and 72 are found in the Ohioan. Of these species, 40 are common to both areas. Eleven of the Mississippian species have penetrated the lower Ohio River at least as far as the Wabash, though only one Cumberlandian species and one Ohioan species occur in the Mississippian region. According to Johnson: "During the Wisconsin glacial stage, the ice sheet in the Mississippian region was much less extensive than in the Ohioan region, and perhaps, the former fauna had achieved a stability that prevented the Ohioan fauna from penetrating it" (Johnson 1980:80). Table 5 lists the species found in the early surveys of the lower Tennessee, Cumberland and Ohio rivers. Details of these surveys appear in the following sections on the three rivers.

The Tennessee River

The headwaters of the Tennessee River are in eastern Tennessee. From there the river runs south and west through the State of Tennessee, dipping into northern Alabama, the northwestern tip of Mississippi, then running north through western Tennessee and into Kentucky where it enters the Ohio River at Paducah. The construction of dams on the

Table 5. Unionid Species Found in the Early Surveys of the Lower Tennessee, Cumberland and Ohio Rivers and Some of their Tributaries.

Species	Ortmann 1925	van der Schalie 1939	Wilson and Clark 1914	Sickel 1982	Ortmann 1926 (Green)	Clench and van der Schalie 1944 (Green)	Clench and van der Schalie 1944 (Salt)	Rosewater 1959 (Salt)	Danglade 1922 (Kentucky)
Cumberlandia monodonta	e								
Amblema plicata	x	x	x	x	x	x	x	x	x
Fusconaia ebena	x		x	x					
Fusconaia flava					x	x	x	x	x
Fusconaia undata			x	x		x			
Fusconaia subrotunda	x	x	x		x	x			x
Quadrula cylindrica	e		x		x				x
Quadrula metanevra	x	x	x	x	x				
Quadrula nodulata				x		x			x
Quadrula pustulosa	x	x	x	x	x	x	x	x	x
Quadrula quadrula	x	x	x	x	e	x	x	x	x
Tritogonia verrusosa	x	x	x	x	x	x	x	x	x
Megalonaias gigantea	x	x	x	x	x	x	x	x	x
Cyclonaias tuberculata	x	x	x		x	x			x
Elliptio crassidens	x	x	x	x	x	x			
Elliptio dilatata	x	x	x	x	x	x	x	x	
Hemistens lata	e				x				
Plethobasus cooperianus	x	x	x		e				
Plethobasus cyphyus	x	x	x		e				
Pleurobema clava	e				x	x			x
Pleurobema cordatum cpx.	x	x	x	x	x	x			x
Alasmidonta calceolis					x			x	x
Alasmidonta marginata	e				x				x
Arcidens confragosus				x	e				
Lasmigona complanata	e		x	x		x	x	x	x
Sasmigona costata	e				x	x	x	x	x
Strophitus rugosus	e		x	x	x			x	x
Actinonaias carinata	e		x		x	x	x	x	x
Carunculina moesta					e	x		x	x
Dysnomia flexuosa					e				
Dysnomia torulosa	e				x				x
Dysnomia triquetra	e				x	x		x	x
Dysnomia sulcata	e				x				
Dysnomia personata	e								

Species	Ortmann 1925	van der Schalie 1939	Wilson and Clark 1914	Sickel 1982	Ortmann 1926 (Green)	Clench and van der Schalie 1944 (Green)	Clench and van der Schalie 1944 (Salt)	Rosewater 1959 (Salt)	Danglade 1922 (Kentucky)
Plagiola lineolata	x		x	x	e	x			
Lampsilis fasciola	e				x				x
Lampsilis orbiculata	x	x	x						
Lampsilis ovata	x		x		x	x	x	x	x
Lampsilis r. siliquoidea					x	x	x	x	x
Lampsilis teres	x	x	x		x	x	x	x	x
Leptodea fragilis	e		x	x					
Leptodea leptodon	e								
Ligumia recta	x	x	x	x	x	x			x
Obovaria olivaria	x	x	x						
Obovaria retusa	x	x	x		x				
Obovaria subrotunda	e				x	x	x		x
Proptera alata	x	x	x	x	x	x	x	x	x
Proptera laevissima	e		x						
Truncilla truncata	x	x	x		x	x	x	x	x
Truncilla donaciformis	e	x		x	e			x	x
Villosa favalis					e				
Villosa lienosa					x	x		x	
Villosa nebulosa					x				
Villosa ortmanni					x	x			
Cyprogena stegaria	e				x	x	x		x
Obliquaria reflexa	x	x	x	x	x	x		x	x
Dromus dromas			x*						
Ptychobranchus fasciolaris	x				x	x	x	x	x

e = species that were expected but not found

* Although D. dromas was found by Wilson and Clark (1914) at a single station just below Clarkesville on the Cumberland River, by all accounts this is an unusual occurrance, and this species is not commonly listed as being present in the lower Cumberland.

Tennessee River has led to a virtually continuous series of impoundments along its entire length, with a concomitant decrease in the species of Unionacean bivalves that once inhabited it. One area in particular, Mussel Shoals ("Muscle" Shoals) in northern Alabama, is world renowned for the number of species and the abundance of mussels that once lived there. In this section of the river, a fall of some 134 feet in a distance of 37 miles had produced a series of rapids which created an ideal mussel habitat (Webb 1939). Although the Tennessee is considered to be a large river habitat, the presence of shoals in this section had the effect of rejuvenating the river by producing a region of shallow riffles. In this region one found many mussel species that are commonly restricted to creeks and small rivers, as well as species that are common to larger river habitats (van der Schalie 1939a). Here too one found the greatest mix of Ohioan and Cumberlandian forms. According to Ortmann (1925):

> ...considering the whole Tennessee drainage *we have in the lowermost parts (Dixie), a rather pure Ohio, (or Interior Basin) fauna; in the region of Mussel Shoals (probably somewhat below), Cumberlandian types begin to appear; farther up, the latter become more and more prevalent, and the Ohio types disappear,* but nevertheless they constitute a certain percentage of the fauna at least as far as the Knoxville region. This decrease of Ohio elements continues farther up from Knoxville. *On the other hand, the percentage of the Cumberlandian forms correspondingly increases from the lower to the upper Tennessee* which, however, is not so much due to an increase in the number of these types, but is largely brought about by the decrease alone of that element (Ortmann 1925:369; emphasis in original).

Ortmann's study of the lower Tennessee only went as far downstream as Dixie, at the confluence of the Tennessee and Duck rivers. At Dixie he collected 25 species, all of which are Ohioan, and he listed 26 others which, according to their general description, should have been found. A subsequent study, undertaken by van der Schalie (1939a), was based on collections made by M.M. Ellis in 1931 from as far downstream as Paducah, Kentucky. This study listed 25 species that "may now be more conclusively considered as belonging to the naiad fauna of the 'Interior Basin' in the Lower Tennessee River" (van der Schalie 1939a:456). This list is similar to Ortmann's (1925) with the addition/omission of three species (see Table 5). Van der Schalie disregards Ortmann's suggestion that 26 other species could potentially be inhabiting the lower Tennessee; he suggests instead that ecological conditions would restrict the actual number of species. He states (1939:453) "the *large river* habitats found in the Lower Tennessee consequently restrict the potential fifty–one species to about half that number, that is, to those which find a large–river environment suitable to their existence"

Ortmann (1925) and van der Schalie (1939a) are the only useful guides to the mussel fauna of the lower Tennessee before impoundment. Subsequent work by Scruggs (1960), Bates (1962), Isom (1969) and Sickel and Chandler (1982) have dealt primarily with the effects of impoundment. Decline in mussels stocks is seen to be due to over–harvesting by commercial musselers, and to increasing silt content (Isom 1969). Impoundment has eliminated shoals and shallow water habitats from most of the Tennessee River. As a result, only those species which can survive in large river conditions (i.e., deep, slow–moving silt–laden water) are found at present. Such conditions have promoted the virtual extinction of much of the Cumberlandian fauna from the Tennessee River. The impoundment of the shoal areas in Colbert and Lauderdale counties in north Alabama effectively eliminated this unique mussel habitat. Its destruction was foreseen by Ortmann (1924a) and has been lamented ever since.

Currently in the lower Tennessee, below Kentucky Dam (TRM 22.4), most of the mussels are located between TRM 9.6 and TRM 22. While mussels have been taken as far downstream as TRM 2, most of the substrate between TRM 2 and TRM 9.6 is shifting sand and is, therefore, not suitable for unionid habitation (Isom 1969:412). Since no archaeological sites containing shell have been recorded further downstream than the Dyke Site at TRM 17, these conditions have probably not changed much over the past several thousand years. Dyke is currently adjacent to major mussel beds which were evidently thriving at the time the site was occupied.

There are several studies that compare the present mussel fauna to that of prehistoric middens on the Tennessee River. The first study of this kind was undertaken by Morrison (1942) on seven sites in the Pickwick Basin in northern Alabama. These sites are primarily Archaic in age (ca. 7000–5000 BP), although later occupations also occur. They were located in the shoals area of the Tennessee River in Colbert and Lauderdale counties. Morrison's results indicate that the Colbert Shoals, located just downstream from the Mussel Shoals, once maintained a fauna virtually identical to that of the Mussel Shoals, and suggests that there has been a slight but general upstream retreat of the typical "shoals fauna" (Morrison 1942:382).

The Widows Creek Site, also in Northern Alabama at TRM 408, is a large shell midden spanning Middle Archaic through Late Woodland time periods (ca. 5000 BC - AD 1000). In 1973, excavations by the University of Tennessee, Chattanooga produced samples of unionid shells totalling almost 60,000 identifiable valves. The samples were analysed by Warren (1975), whose analysis indicates a marked decrease in Cumberlandian elements between prehistoric midden samples and late historic collections. Deterioration of river conditions and the destruction of mussel habitats has been blamed for this decrease. Cumberlandian species accounted for 46% of Warren's 51 identified species.

An analysis of 28 middens in the Chickamauga Reservoir, on the Upper Tennessee River (TRM 495–528) was undertaken by Parmalee, Klippel and Bogan (1982). The middens in this study, being primarily Late Woodland (AD 600–1000) and Mississippian (AD 1000–1600) in age, were later than those in the previous two studies. Results of this study showed that of the species present in the middens, 28 are not currently found in the impounded river. However, five species which were not previously known from the river have become established in the reservoir. One of the most interesting aspects of this study is the absence of Archaic period shell mounds from this section of the river. This will be discussed in some detail later.

While Morrison (1942), Warren (1975) and Parmalee, Klippel and Bogan (1982) conducted the major studies comparing past and present mussel fauna in the Tennessee River, there have been other archaeological projects on the Tennessee in which the analysis of shellfish played a more minor role (e.g., Parmalee 1966; Clench 1974). One such site, the Eva Site, is of particular interest because it represents the closest shell midden to the Dyke Site on the Tennessee River and also because it is the farthest downstream location known for an Archaic shell midden site on the Tennessee. Eva is located in Benton County, Tennessee. Although analysis of the shellfish was not included in the site report (Lewis and Lewis 1961), the only small sample of shell that was saved was tabulated by Parmalee and Bogan (1977).

The Cumberland River

The headwaters of the Cumberland River are in eastern Kentucky. The river flows southwest into northern, then western Tennessee. Once in western Tennessee, the Cumberland flows north again into Kentucky where it empties into the Ohio River at Smithland, some 11 km upstream from the confluence of the Ohio and the Tennessee.

The Cumberland is a much smaller river than the Tennessee and has not been subject to as much intensive research into its mussel fauna. There are only two major studies of the fauna of the Cumberland River, neither of which was extended as far downstream as the study area. In 1911 the entire river and its tributaries were surveyed down to CRM 36 by Wilson and Clark (1912, 1914) and, in 1947–1949, Neel and Allen (1964) examined the upper Cumberland. These are the only two studies that investigated the unimpounded river. In 1981 Sickel (1982) evaluated the present status of the mussel fauna. The prehistoric mussel fauna from the sites on the lower Cumberland is also reported elsewhere (Casey 1986). In 1979 Parmalee, Klippel and Bogan (1980) surveyed the middle Cumberland for a project which included study of extant mussel populations. Their survey consisted of brailing the river and investigating commercial musselers cull heaps. In order to chart temporal changes in the mussel fauna, they subsequently surveyed and tested two Woodland sites, Plunkett Creek and Rome Island, on the banks of the Cumberland.

The Robinson Site, located 50 miles upstream from Nashville in the middle Cumberland at CRM 319, is an Archaic shell mound investigated by Morse (1967). The presence of this site on the Cumberland is interesting since the Cumberland River is not one of the major loci of Archaic shell mound sites. Unfortunately, there is no account of the species found at this site.

The Ohio River

The Ohio River originates in Pennsylvania, from whence it flows first south then west. It forms the southern borders of the states of Ohio, Indiana and Illinois, the western border of West Virginia and the northern border of Kentucky. It enters the Mississippi at Cairo, Illinois approximately 50 miles downstream from the confluence of the Tennessee and Ohio. As with the Tennessee and Cumberland rivers, most studies of the river mussels have concentrated on the upper reaches of the river (Ortmann 1909, 1912, 1919; Taylor 1980), though Ohio River mussels have also been included in surveys of the states of Ohio (La Rocque 1967), Indiana (Call 1897, 1900; Daniels 1903, 1915; Clench and van der Schalie 1944) and Illinois (Parmalee 1967). There have also been numerous surveys of the tributaries of the Ohio. On the lower reaches of this river these include the Wabash (Call 1897; Clark 1976; Meyer 1974), Green (Ortmann 1926; Goodrich and van der Schalie 1944; Isom 1974), Tradewater and Salt (Clench and van der Schalie 1944; Rosewater 1959), Kentucky (Danglade 1922), Licking and Big Sandy (Ortmann 1913) rivers.

Ohioan fauna is found in many of the tributaries of the Ohio River. Primary tributaries for this fauna are the Green, Salt and Kentucky rivers on the south side of the Ohio. The Tradewater, Licking and Big Sandy rivers do not contain such an abundance of fauna. This suggests that the former rivers were refugia for Ohioan species during the Wisconsin glaciation, and that the latter rivers became repopulated postglacially. Due to the paucity of mussel surveys from the lower Ohio River, Table 5 lists the species found in early surveys of these three tributaries.

On the upper Ohio studies of the molluscan fauna have been undertaken on several sites in eastern Ohio (Taylor and Spurlock 1982), and West Virginia (Parodiz 1955; Stansbery 1977). Taylor and Spurlock (1982) indicated that recent alterations in river conditions have produced a mollusc fauna completely different from that which existed during occupation of the aboriginal sites, or during Ortmann's survey in 1921.

There are many archaeological sites dating to all time periods in the lower Ohio Valley (Maxwell 1952; Morgan 1952). The collection of shellfish does not appear to have been a dominant activity in this area, and such shell accumulations as do occur have generally been unanalysed. One exception is the Angel Site, a large Mississippian site on the Ohio River in western Indiana. Excavations were undertaken here between 1939 and 1959 and the collected mussels were analysed by Parmalee (1960).

Account of Species

In this section the shells recovered from the sites at Dyke, Gordon II, 15McN51, McKinney, Millikan, and Iuka are compared with the past and present mussel fauna in the area, and with shells recovered from other archaeological sites. Comparisons of past and present mussel faunas are important as indicators of how river environments have changed over the intervening time span. Comparisons of archaeological sites provide interesting information about available species and cultural use of the resource.

Since the terms used depend upon the preference of the investigator, the nomenclature of many species is difficult to sort out. A partial synonomy is included here as an aid to untangling the nomenclatural knot. This synonomy differs from those found in biological treatises because the latter are concerned with original descriptions and designations of the molluscan species. This synonomy gives species names as they occur in the sources used in this report. The synonomy should serve as a useful guide for other archaeologists interested in the area who may not realize, for example, that the term *Dysnomia* (used here) is equivalent to *Epioblasma*, as used by Stansbery (1970) and Parmalee, Klippel and Bogan (1980); and is also the same as *Plagiola*, as used by Johnson (1980) and Parmalee, Klippel and Bogan (1982). The species names that will be used here are indicated with an asterisk (*). Names below each asterisked designation are other names by which the species is also known. The "form" designation used here is defined by Stansbery (1962):

> The term "form" is used...to recognise populations of uncertain taxonomic status. The evidence at the present time indicates that many of these morphologically distinguishable populations are probably ecoforms, some are most likely subspecies, and a few may be distinct species. The information upon which such decisions should be based is not yet available and it seems best at present to withold judgement thus recognising the questionable status of these forms (Stansbery 1962: cited in Warren 1975:56).

The sites discussed are indicated in Figure 6, and the frequency data referred to in the following compendium is summarized in Table 6. The species are reported systematically in the order given by Burch (1975) by family, subfamily, tribe, and in the case of Lampsilini, by marsupial characteristics of the gills. Genera are arranged alphabetically within these categories. Tribal and marsupial designations are not noted in this list.

superfamily: UNIONACEA
family:MARGARITIFERIDAE
subfamily:CUMBERLANDIIDAE

Cumberlandia monodonta (Say 1819)
Margaritana monodonta (Call 1900)
Common Name: Spectacle Case.

Figure 6: The Locations of the Shell–Bearing Archaeological Sites Discussed.

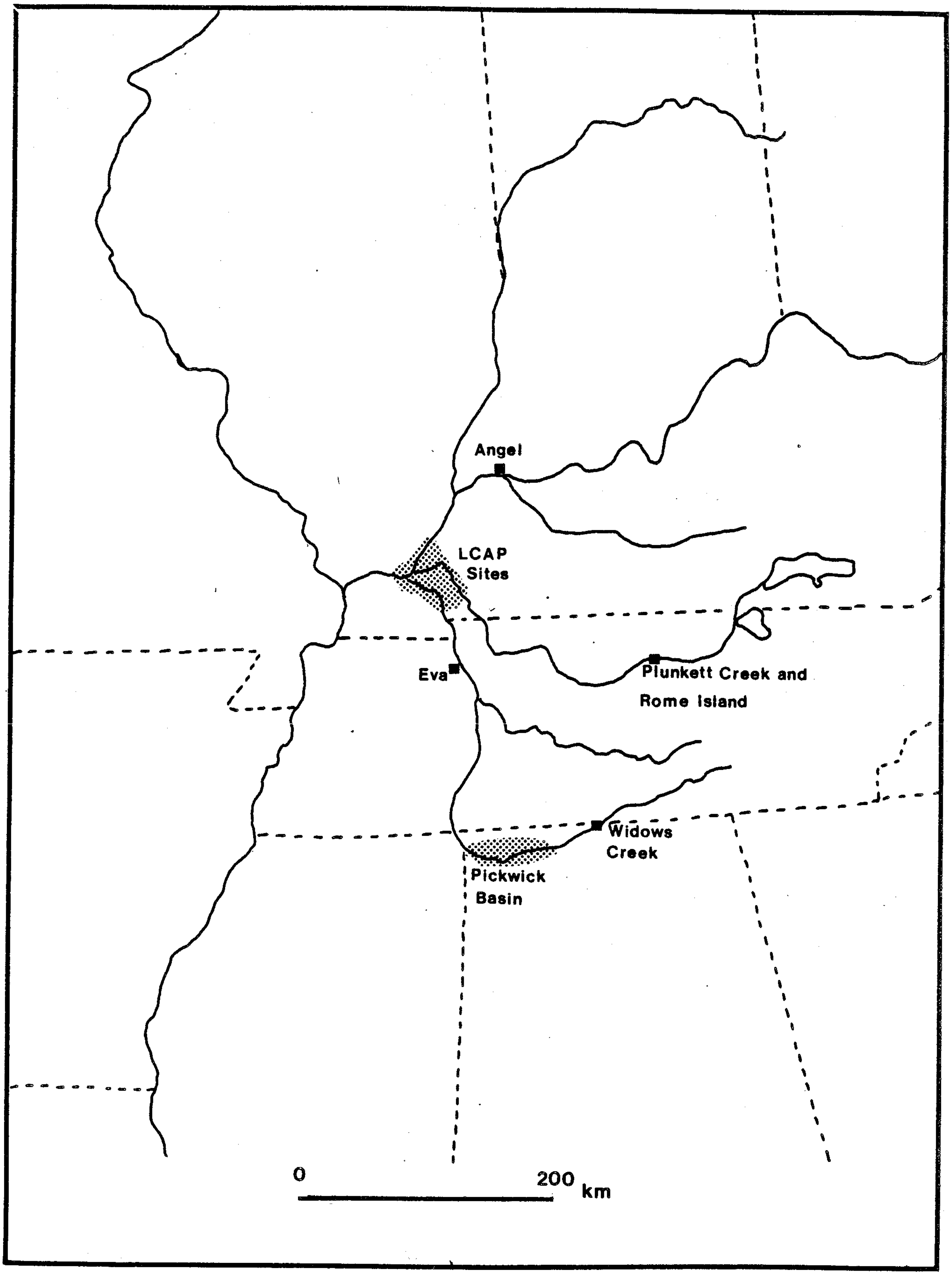

Angel
LCAP Sites
Eva
Plunkett Creek and Rome Island
Widows Creek
Pickwick Basin
0
200 km

Table 6. Proportions and Raw Counts (in parenteheses) for Unionids at 12 Archaeological Sites.

SPECIES	McKINNEY	MILLIKAN	IUKA	PLUNKETT CREEK	ROME ISLAND	15McN51	GORDON II	ANGEL	DYKE	EVA	PICKWICK BASIN	WIDOWS CREEK^1
Amblema plicata	.3	1.0	1.9	.3	1.3	5.0	.8	.1		4.4	.3	.27
	(14)	(15)	(6)	(2)	(11)	(2)	(5)	(55)		(8)	(97)	(146)
Fusconaia ebena	2.0	5.0	7.2			46.3	43.0	26.4	.7			
	(100)	(78)	(23)			(19)	(256)	(1466)	(4)			
Fusconaia subrotunda				2.8	1.5						.2	1.97
				(20)	(12)						(78)	(1129)
Fusconaia undata					.1							
					(1)							
Fusconaia appressa											1.5	.17
											(472)	(70)
Fusconaia edgariana											.8	.6
											(244)	(317)
Fusconaia plena											.7	
											(217)	
Fusconaia cordata											.2	
											(63)	
Fusconaia tumescens											0.0	0.04
											(10)	(17)

SPECIES	McKINNEY	MILLIKAN	IUKA	PLUNKETT CREEK	ROME ISLAND	15McN51	GORDON II	ANGEL	DYKE	EVA	PICKWICK BASIN	WIDOWS CREEK [1]
Quadrula cylindrica	1.1 (55)			.7 (5)	.4 (3)		.3 (2)	.1 (5)		.5 (1)	.5 (161)	.25 (111)
Quadrula intermedia											.6 (177)	.14 (63)
Quadrula metanevra	1.6 (77)	.8 (12)	1.2 (4)	.4 (3)	1.1 (9)		.5 (3)	2.0 (113)	.2 (1)		.2 (56)	1.1 (599)
Quadrula nodulata			.3 (1)				2.7 (16)					
Quadrula pustulosa	3.6 (179)	0.0 (1)	2.8 (9)	.1 (7)	1.2 (10)	7.3 (3)	2.3 (14)	.1 (3)	2.2 (12)	1.6 (3)	.4 (121)	.61 (334)
Quadrula quadrula	0.0 (2)							.3 (13)	.2 (1)	.5 (1)		
Quadrula tuberosa											0.0 (15)	
Quadrula biangulata											.5 (160)	
Megalonaias gigantea								.2 (12)				

SPECIES	McKINNEY	MILLIKAN	IUKA	PLUNKETT CREEK	ROME ISLAND	15McN51	GORDON II	ANGEL	DYKE	EVA	PICKWICK BASIN	WIDOWS CREEK[1]
Tritogonia verrucosa	0.0 (2)						.3 (2)	.1 (4)				
Cyclonaias tuberculata	3.9 (194)		6.9 (22)	3.5 (25)	3.1 (26)	19.5 (8)	4.0 (24)	7.6 (424)	9.2 (49)	5.5 (10)	19.6 (6264)	6.26 (3723)
Elliptio crassidens	.5 (27)	2.2 (35)		2.9 (21)	2.9 (24)		1.7 (10)	7.4 (411)	1.7 (9)		.3 (95)	1.41 (827)
Elliptio dilatata	1.7 (85)	4.1 (63)	8.7 (28)	21.7 (155)	21.2 (175)		7.4 (44)	10.6 (586)	46.0 (245)	4.9 (9)	20.1 (6435)	27.31 (16692)
Lexingtonia dolabelloides				.6 (4)	2.3 (19)					.5 (1)	1.5 (373)	2.14 (1253)
Plethobasus cicatricosus	.7 (33)	.7 (11)		.3 (2)	.1 (1)		1.0 (6)	1.9 (105)			0.0 (12)	.8 (446)
Plethobasus cooperianus				.4 (3)	.8 (7)					2.2 (4)		1.49 (845)
Plethobasus cyphyus												

SPECIES	McKINNEY	MILLIKAN	IUKA	PLUNKETT CREEK	ROME ISLAND	15McN51	GORDON II	ANGEL	DYKE	EVA	PICKWICK BASIN	WIDOWS CREEK[1]
Pleurobema clava	19.9	1.5	4.4	5.4	4.2		.7		8.8	1.6	3.4	1.95
	(979)	(24)	(14)	(39)	(35)		(4)		(47)	(3)	(1099)	(1114)
Pleurobema cordatum complex	15.4	46.2	43.0	6.9	6.9	2.4	25.0	50.1	3.4	13.7	.1	10.41
	(759)	(716)	(138)	(49)	(57)	(1)	(149)	(2782)	(18)	(25)	(46)	(6455)
Pleurobema holstense											.8	.13
											(257)	(60)
Pleurobema spp.				2.2	7.9							
				(16)	(66)							
Alasmidonta calceolus											0.0	
											(1)	
Alasmidonta marginata											0.0	
											(1)	
Anodonta grandis											0.0	0.0
											(16)	(1)
Lasmigona costata				.1				0.0			0.0	
				(1)				(2)			(1)	

SPECIES	McKINNEY	MILLIKAN	IUKA	PLUNKETT CREEK	ROME ISLAND	15McN51	GORDON II	ANGEL	DYKE	EVA	PICKWICK BASIN	WIDOWS CREEK[1]
Strophitus rugosus											0.0 (1)	
Actinonaias carinata								0.0 (2)			.9 (288)	7.88 (4802)
Actinonaias ligamentina				11.5 (82)	15.7 (130)					4.4 (8)		
Actinonaias pectorosa												0.0 (1)
Carunculina moesta											.2 (51)	.08 (38)
Dysnomia arcaeformis	5.9 (292)	1.2 (19)	3.4 (11)	1.5 (11)	3.3 (27)				1.2 (8)	1.6 (3)	3.2 (1025)	.52 (262)
Dysnomia biemarginata											.1 (20)	.01 (2)
Dysnomia brevidens				.6 (4)	.5 (4)					.5 (1)	.3 (110)	.2 (95)

SPECIES	McKINNEY	MILLIKAN	IUKA	PLUNKETT CREEK	ROME ISLAND	15McN51	GORDON II	ANGEL	DYKE	EVA	PICKWICK BASIN	WIDOWS CREEK
Dysnomia florentina				.3 (2)	.1 (1)						1.0 (358)	
Dysnomia capsaeformis				.3 (2)	.2 (2)						1.9 (594)	.21 (110)
Dysnomia haysiana				.1 (1)	.2 (2)						.8 (249)	.24 (111)
Dysnomia torulosa complex	11.6 (569)	4.4 (69)	1.9 (6)	7.4 (53)	2.5 (21)			1.2 (63)	4.9 (26)	20.2 (37)	22.0 (7066)	5.68 (1853)
Dysnomia flexuosa	3.4 (194)	1.5 (24)	.6 (2)	1.1 (8)	1.5 (12)			.2 (12)	2.6 (14)	.5 (1)	1.2 (390)	.76 (288)
Dysnomia personata											.1 (24)	
Dysnomia sampsoni								.2 (13)				
Dysnomia triquetra								0.0 (2)				.01 (4)

SPECIES	McKINNEY	MILLIKAN	IUKA	PLUNKETT CREEK	ROME ISLAND	15McN51	GORDON II	ANGEL	DYKE	EVA	PICKWICK BASIN	WIDOWS CREEK[1]
Plagiola lineolata	1.5 (74)	4.6 (71)	.9 (3)			2.4 (1)	1.5 (9)	.7 (38)	.6 (3)	2.7 (5)	0.0 (5)	0.0 (1)
Lampsilis fasciola				.8 (6)	.1 (1)							.09 (39)
Lampsilis orbiculata	.8 (38)	.3 (5)	1.9 (6)		.1 (1)			.3 (14)	1.1 (6)			
Lampsilis ovata				1.7 (12)	1.1 (9)			.9 (51)		1.0 (2)	.7 (238)	.64 (357)
Lampsilis teres							.3 (2)					
Lampsilis virescens											.2 (59)	
Conradilla caelata											.5 (155)	.13 (61)
Leptodea fragilis												0.0 (1)

SPECIES	McKINNEY	MILLIKAN	IUKA	PLUNKETT CREEK	ROME ISLAND	15McN51	GORDON II	ANGEL	DYKE	EVA	PICKWICK BASIN	WIDOWS CREEK[1]
Ligumia recta	0.0		.3	.4	.1	5.0	.3	1.5				.02
	(2)		(1)	(3)	(1)	(2)	(2)	(82)				(8)
Obovaria olivaria	.9		1.9				.5	.3	.7			
	(43)		(3)				(3)	(16)	(4)			
Obovaria retusa	10.2	14.6	8.1	.4	.8	5.0	6.6	3.0	2.6	4.9	.1	2.71
	(502)	(227)	(26)	(3)	(7)	(2)	(38)	(160)	(14)	(9)	(34)	(1617)
Obovaria subrotunda	7.4	4.6	2.8	.4	.6			.7	.2	7.1	.2	.8
	(365)	(71)	(6)	(3)	(5)			(40)	(1)	(13)	(66)	(437)
Proptera alata				.1	.1		.2	.1			0.0	
				(1)	(1)		(1)	(6)			(2)	
Villosa iris				.1								
				(1)								
Villosa taeniata				.8	1.4						2.3	.06
				(6)	(12)						(748)	(24)
Villosa fabalis												0.0
												(1)
Villosa vanuxemensis											0.0	0.0
											(1)	(1)

SPECIES	McKINNEY	MILLIKAN	IUKA	PLUNKETT CREEK	ROME ISLAND	15McN51	GORDON II	ANGEL	DYKE	EVA	PICKWICK BASIN	WIDOWS CREEK[1]
<u>Truncilla truncata</u>	0.0 (1)											
<u>Cyprogena stegaria</u>	3.8 (186)	1.7 (27)	1.2 (4)	.7 (5)	.6 (5)			.5 (29)	.4 (2)	6.5 (12)	2.0 (658)	.39 (187)
<u>Obliquaria reflexa</u>	.3 (16)			.1 (1)		2.4 (1)		0.0 (2)				.01 (3)
<u>Dromus dromas</u>	2.4 (125)	5.2 (81)	2.8 (9)	20.6 (147)	13.4 (111)				13.1 (70)	14.7 (27)	9.6 (3075)	22.38 (14142)
<u>Ptychobranchus fasciolaris</u>		.2 (3)		1.7 (12)	2.1 (17)		.3 (2)				.1 (40)	.78 (435)
<u>Ptychobranchus subtentum</u>											.9 (288)	.16 (78)
TOTAL	4913	1552	322	715	827	39	596	6537	534	183	31987	59502

1. raw counts are NISP, proportions are %MNI (from Warren 1975)

Cumberlandia monodonta is found in the Tennessee, Cumberland and Ohio rivers. It is most commonly found in shallow, swift water, deeply buried in gravel or under slabs of stone. A preference for burrowing probably explains its absence from the archaeological sites (Morrison 1942:353).

family: UNIONIDAE
subfamily:AMBLEMINAE

******Amblema plicata* (Say 1817)
Amblema costata (Rafinesque 1820)
Amblema peruviana (Lamark)
Common Name: Three ridge

Amblema plicata and *Amblema costata* are distinguished from each other by the more quadrate and compressed shape of the latter. The species name *peruviana* is often given to large river forms (La Rocque 1967:132; Goodrich and van der Schalie 1944:306). Since intergrades of this suite are often difficult to tell apart in archaeological material, the name *plicata* is used in this thesis to denote all species of *Amblema*.

In the lower Tennessee River, this genus is reported by Ortmann (1925), van der Schalie (1939a) and Morrison (1942). It constitutes 4.4% of the assemblage (8 valves) at the Eva Site and occurs in negligible numbers at Widows Creek and in the Pickwick Basin sample (.3% at each). It was not present at the Dyke Site. *Amblema plicata* has also been found living in the Cumberland River, though it contributes less than 2% to any of the archaeological assemblages here. This genus is reported from the Ohio River and is common in one of its several forms in most rivers, streams and lakes throughout the Mississippi River system (Parmalee 1967:26-27). *Amblema plicata* is found in small numbers at 15McN51 and Gordon II. Fifty five specimens were found at the Angel Site, but these accounted for less than 1% of the assemblage total. The infrequency with which this ubiquitous species occurs in archaeological sites may be due in part to the utility of the shell as a tool. Implements fashioned from *A. plicata* valves are known from many sites in the southeastern United States (Baker 1930; Matteson 1953; Parmalee et al 1972). At the Carrier Mills

Archaeological District in southern Illinois, a possible ceremonial or ritual purpose may be attributable to this species. Here, *Amblema plicata* occurred only with burials and was the only unionid species recovered (Jefferies and Butler 1982).

**Fusconaia ebena* (Lea 1831)
Fusconaia ebenus (Lea 1831)
Common name: Ebony shell

This species prefers large rivers and is most commonly found on mud, gravel or sand bottoms in 1-3 feet (or more) of swift water. It is an Interior Basin species common in the Ohio and Mississippi rivers and in the lower ends of the Tennessee and Cumberland. Although this species was found in the lower Tennessee River in collections made by Ortmann (1925), van der Schalie (1939a) and Morrison (1942), it occurs at only one archaeological site on the lower reaches of this river. The Dyke Site contained four valves of *F. ebena*, amounting to .7% of the assemblage. Morrison (1942:353) suggests that, due to its deeper water habitat, *F. ebena* was not collected for food by prehistoric inhabitants. *Fusconaia ebena* was absent from the upper Cumberland River, but quite common in the lower (Wilson and Clark 1914:62). Its presence in the archaeological sites on this river reflects its reported distribution. It was not found at either site on the middle Cumberland, but was recovered at all three sites on the lower Cumberland, though not in very great numbers.

F. ebena is currently very common in the lower Ohio River (Miller, Payne and Siemsen 1986:16). At the two LCAP sites on this river, *F. ebena* was the most common species, forming 46.3% and 43% of the assemblages at 15McN51 and Gordon II, respectively. However, at 15McN51 this amounts to only 19 valves. At the Angel Site *F. ebena* was the second most common species and accounted for 26.4% (1466 valves) of the assemblage.

**Fusconaia appressa* (Barnes 1893)
**Fusconaia cordata*
**Fusconaia edgariana*
**Fusconaia plena*
**Fusconaia subrotunda*
**Fusconaia tumescens* (=*barnsiana*)

Several other species of *Fusconaia* have been found in the Tennessee River, both as live specimens and in the archaeological sites. Morrison (1942) found *Fusconaia undata* in the shoals area of the Tennessee River but did not find it in any of the mounds in the Pickwick Basin. Neither was it found on the lower reaches of this river. As with *F. ebena*, Morrison (1942) suggests that the absence of *F. undata* from the mounds indicates a preference for deeper water, and hence indicates the prehistoric inhabitant's inability to procure this species. *F. undata* was found on the Cumberland, though only as a few specimens in the upper portion of the river (Neel and Allen 1964:454). It was also found in the lower reaches by Wilson and Clark (1914), and, more recently, by Sickel (1982). This species does not occur in any of the lower Cumberland archaeological sites, and on the middle Cumberland was represented by a single valve at Rome Island.

Fusconaia subrotunda is the most frequently occurring species of this genus. Goodrich and van der Schalie (1944) have reported it live on the lower Tennessee. An Interior Basin form, it contributes about 2% of the assemblage at Widows Creek and only .2% at the Pickwick Basin sites. As this species is another that prefers deeper water, Morrison (1942:354) attributes its presence in the sites to periods of extremely low water. *F. subrotunda* is reported from the upper Cumberland by Neel and Allen (1964:434), but is not reported from the lower Cumberland, nor is it found in any of the archaeological sites along the Cumberland. Both *F. subrotunda* and *F. undata* are well known from the Ohio River, though neither species was identified at either 15McN51 or Gordon II. *F. subrotunda* apparently bears some resemblance to *F. ebena* (Goodrich and van der Schalie 1944:307).

Other species of *Fusconaia* are primarily Cumberlandian types that constitute a very small percentage of the collections from the Pickwick Basin and Widows Creek Sites, but which are not found in the lower Cumberland River or the Ohio.

**Quadrula cylindrica* (Say 1819)
forms *cylindrica* and *strigillata*
Common name: Rabbits foot

This highly distinctive shell was present at most of the sites but was nowhere abundant. It is an Ohioan species which appears not to have been very common in any of the three rivers. It is not mentioned by van der Schalie (1939a) for the Tennessee, but was one of the species Ortmann (1925) expected to be living in the river although he never actually found it. Today its occasional appearance in musseler's cull heaps attests to its presence in the lower Tennessee. Neel and Allen (1964:434) report *Q. cylindrica* as being rare in the upper Cumberland and it was not found in the lower Cumberland by Wilson and Clark (1914). Because no other shell looks like *Q. cylindrica*, recovery and identification of this species where it exists has a high probability. While most sources only discuss *Q. cylindrica* proper, Stansbery (1970:17) recognizes two forms: the large river form *cylindrica*, and the headwater form *strigillata*. The preferred habitat of this species is swift water on bars of gravel or shingle (La Rocque 1967:134).

**Quadrula metanevra* (Rafinesque 1820)
Common name: Monkey face

This species is abundant and widespread in the lower Tennessee and Ohio drainages, though rarer in the upper Tennessee (Ortmann 1918:541). Though Wilson and Clark (1914) considered it to be a rare species for the Cumberland, Neel and Allen (1964:434) reported that *Q. metanevra* is extremely abundant in the main stream. *Q. metanevra* is apparently common in the lower Ohio River (Parmalee 1967:39). It occurred at most sites, but in very small numbers. It was most abundant at Widows Creek and Angel, comprising 1.1% (599 valves) and 2% (113 valves) of the samples, respectively.

**Quadrula nodulata* (Rafinesque 1820)
Common name: Warty back

Q. nodulata is found in all three rivers. It prefers large rivers and is usually found on a mud bottom. A single valve of this species was recovered at Iuka, but it was absent from all other sites on the Tennessee and Cumberland rivers. At Gordon II on the Ohio, a total of 16 valves (2.7%) of this species were found.

**Quadrula pustulosa* (Lea 1831)
Quadrula pustulosa pernodosa
Common name: White wartyback, Pimpleback

Q. pustulosa is the most common and widespread of all members of this genus and it is found in a wide range of habitats. Accordingly, it is the most frequently occurring *Quadrula* species archaeologically, but it is not particularly abundant at any given site. Although Morrison (1942) refers to the subspecies *pernodosa*, it is not mentioned commonly in the literature.

**Quadrula quadrula* (Rafinesque 1920)
Quadrula quadrula fragosa
Quadrula fragosa (Conrad 1836)
Common name: Maple leaf

Of all *Quadrula* species, this is perhaps the most variable (Burch 1975:40). Its preference for mud bottoms in six or more feet of water probably explains its virtual absence from archaeological sites. Two specimens were found at McKinney and one at Dyke.

**Quadrula intermedia* (Conrad 1836)
**Quadrula tuberosa*
**Quadrula sparsa*

This group is found in the upper Tennessee (Ortmann 1925:336) and was reported for the upper Cumberland by Wilson and Clark (1914:59), but not by Neel and Allen (1964). They are considered to be typical Cumberlandian species and therefore one can expect to find them neither in the lower reaches of these rivers nor in the Ohio. Morrison (1942) considers these three to be separate species, though Ortmann (1925) considered *tuberosa* only to be a more swollen form of *intermedia*. Warren (1975) and Morrison (1942) found members of this group in the shoals area, though in very small numbers.

**Quadrula biangulata* (Morrison 1942)

This was reported as a new species by Morrison who found small numbers of it in all seven mounds in the Pickwick Basin. It is not mentioned in other literature, and, as

Morrison reported that it strongly resembles *Q. intermedia*, it is probably considered to be a variation of that species.

**Tritogonia verrucosa* (Rafinesque 1820)
Quadrula verrucosa (Rafinesque 1820)
Quadrula tritogonia (Rafinesque 1820)
Common names: Buckhorn; Pistol grip

Though it is missing from the upper reaches of the Tennessee, Ortmann (1925) reported that this Ohioan species was abundant throughout the Interior Basin, including the lower Tennessee and Cumberland rivers. Neel and Allen (1964) found *Tritogonia verrucosa* to be abundant in the upper Cumberland, and, in the river as a whole, Wilson and Clark (1914:57) described it as being "not rare". It also occurs in the Ohio (Parmalee 1967:43).

Baker (1928:102) describes *T. verrucosa* as being found in both deep and shallow water, and on bottoms of sand or mud. When found in riffles this species is not buried, even though it may be quite deeply buried when it occurs in mud. Given the abundance and apparent ubiquity of this species, it is surprising that *T. verrucosa* is absent from virtually all the archaeological shell assemblages. Two valves of this species were recovered from Gordon II, 13 from Angel, and two from McKinney. Morrison (1942) attributes this absence to the tendency of *T. verrucosa* to be deeply buried in mud and, while this may explain its absence from the lower ends of the rivers, where mud habitats are frequent, it does not indicate why this species may be absent from sites in the shoals area where riffle habitats abound.

**Megalonaias gigantea* (Barnes 1823)
Quadrula heros (Say 1829)
Common name: Washboard

This extremely large mussel is currently abundant in the Ohio and in the lower Tennessee and Cumberland rivers where it lives in quiet places in deep water, on mud or gravel bottoms. It is not found in the upper Tennessee or Cumberland rivers and is generally absent from smaller streams and headwaters. Presently, this species is quite common in the middle Cumberland. Parmalee, Klippel and Bogan (1980) suggest that this is a recent phenomenon and is a direct result of the impoundments which alter the river conditions in such a way as to benefit this animal.

M. gigantea was found only at the Angel Site (12 valves, .2%). Its apparent absence from most sites may be due to it being inaccessable in deep water. The valves of this species are the heaviest of any of the unionids in North America, and, as such, they were useful prehistorically for the manufacture of tools. *M. gigantea* hoes were frequently used by Mississippian farmers. One hundred and seventeen hoes were recovered from the Aztalan Site (Wisconsin) alone (Kuhm 1937). Although from its deep water habitat this species may have been difficult for prehistoric peoples to obtain, it is likely that once it was procured its large valves may have had practical value and were therefore separated from the rest of the food refuse.

subfamily: UNIONINAE

**Cyclonaias tuberculata* (Rafinesque 1820)
form *granifera*
Common names: Purple warty back; Purple pimple back

Cyclonaias tuberculata is commonly found on a mud bottom in water that ranges in depth from 10 cm to two metres (La Rocque 1967:151), though it has also been reported from shallow riffle areas in coarse gravel. The name *granifera* is often used to identify specimens found in large rivers (Baker 1928; Ortmann 1925), while the term *tuberculata* refers to small stream and headwater forms. It is apparent that, when using a system developed by Ball (1922), the two forms can be easily distinguished by measuring relative shell obesity. Given the badly fragmented nature of the shells from the LCAP sites, metric determinations were not possible and, as a result, all forms were referred to as *C. tuberculata*. The two forms are considered to be synonomous by Goodrich and van der Schalie (1944:306) and by van der Schalie and van der Schalie (1950) who report that *tuberculata* and *granifera* are merely ecological variants.

Cyclonaias tuberculata is found throughout the Tennessee, Cumberland and Ohio river systems (Parmalee 1967:27). It is frequent at all sites and comprised between 5.5% and 9.2% of the assemblages at the sites on the Tennessee River. On the Cumberland River this species did not comprise such a large proportion archaeologically, but neither was it particularly uncommon. On the middle Cumberland it represented over 3% of the assemblages at both Plunkett Creek and Rome Island. On the lower Cumberland *C. tuberculata* was absent from Millikan, but comprised over 4% (194 valves) of the assemblage at McKinney, and almost 7% (22 valves) at Iuka. The absence of this species from the Millikan Site is interesting since Millikan is close to the other two sites. It is sometimes possible to confuse specimens of *C. tuberculata* with those of some of the *Quadrulas*, particularly *Q. pustulosa*, since the two can look quite similar in archaeological samples when the postero-ventral margin is missing and the purple nacre of *C. tuberculata* is bleached to white. Few *Quadrulas* of any sort were found at Millikan, however, so the absence is likely a real one and not a preservational or identification error. On the Ohio, eight specimens of *C. tuberculata* were found at 15McN51, and represented almost 20% of the assemblage. Twenty-four specimens (4%) were found at Gordon II and 424 (7.6%) at Angel.

**Elliptio crassidens* (Lamarck 1819)
Common name: Elephant ear

Elliptio crassidens is known throughout the Tennessee, Cumberland and Ohio River systems. It was not common at most of the sites and this may be due to its preference for deep water. It was most common at the Angel Site where it contributed to 7.4% of the assemblage (411 valves). It was also fairly common at the middle Cumberland sites and at Millikan where it contributed between 2-3% of the assemblage at each site. Morrison (1942:358) suggests that the occurrence of this species in any abundance in archaeological sites it is probably due to periods of extremely low water. The only shell artifact found at any of the sites in the LCAP study area, a left valve of *E. crassidens*, found at Gordon II, had denticulate fractures on its ventral margin.

**Elliptio dilatata* (Rafinesque 1920)
Elliptio dilatatus
Common name: Lady finger; Spike

Elliptio dilatata is a fairly common species in all rivers in the southeastern United States. It is very tolerant of habitat conditions and inhabits virtually any size of river or stream and sometimes even lakes. It is found in many sorts of bottom and water conditions and is truely ubiquitous. On the Tennessee, *E. dilatata* was the most abundant species at Dyke (46%) and Widows Creek (27.3%). In the Pickwick Basin, *E. dilatata* was second in abundance only to the *Dysnomia torulosa* complex, contributing 20% of the total assemblage. On the middle Cumberland *E. dilatata* was also the most abundant species, contributing over 21% at the assemblages from both Plunkett Creek and Rome Island. On the lower Cumberland, comparatively few specimens of this species were recovered. On the Ohio River *E. dilatata* was not identified at 15McN51, though it constituted 7.4% (44 valves) at Gordon II, and 10% (586 valves) at Angel.

The size of the specimens of *E. dilatata* recovered at all sites was extremely small. At Widows Creek, Warren (1975:66) suggests that this could be due to "an artificially restricted local carrying capacity due to intensive aboriginal collection". This theory is possibly true for the sites where it is evident that *E. dilatata* was the most frequently taken species. However, the fact that shells are still small at sites where it was not frequent may indicate that *E. dilatata* is more susceptible to those other factors that can stunt the growth of shellfish.

**Hemistena lata* (Rafinesque 1920)
Lastena lata
Common name: Cracking Pearly mussel

By all accounts this is a rare mussel. Wilson and Clark (1914:55) point out that this apparent rarity may be due to its habits since it burrows deeply into a gravel substrate and as a result it is generally more difficult to locate. *Hemistena lata* can only be taken by hand from sand and gravel bars, usually in areas of swift current. This species is known from the Ohio, Cumberland and upper Tennessee, a distribution which makes its place of origin difficult to pinpoint (Ortmann 1925). It was not found at any of the archaeological sites.

**Lexingtonia dolabelloides* (Lea 1840)
Common name: Slab-sided mussel

This is a Cumberlandian species that has only been reported from the upper Tennessee River system. As regards the archaeological sites, it was present at Eva, at Widows Creek and in the Pickwick Basin on the Tennessee. It was also present at Plunkett Creek and Rome Island on the middle Cumberland River. At these two sites it comprised .6% (21 valves) and 2.3% (19 valves) of the assemblages respectively.

**Plethobasus cicatricosus* (Say 1829)
Plethobasus cicatricoides
form *detectus* (Frierson 1911)
Common name: White warty back

This appears to be a rare species, as it is not mentioned in many of the reports of unionids in the area. Not much is known about its ecology, though La Rocque notes that

> Judging by its distribution, this is a species of larger rivers, but so far I have yet seen no exact data for this situation....Its range is similarly unknown, though it has been reported from the Ohio (La Rocque 1967:153).

Plethobasus cicatricosus is one of the species Johnson (1980) suggests may have invaded the Ohioan region from the Cumberlandian. It was reported by Stansbery (1964) for the Tennessee River near the impounded Mussel Shoals area, and was also found (though sparingly) at some of the sites in the Chickamauga Reservoir on the upper Tennessee (Parmalee, Klippel and Bogan 1982:85). This species constituted less than 1% of the assemblage at Widows Creek,, and was not recovered at any of the other sites further down on the Tennessee.

On the Cumberland River *P. cicatricosus* has not been reported in any of the surveys except most recently by Sickel (1982), a record based on a single valve. Archaeologically, on the Cumberland River this species was found only at McKinney and Millikan, where it formed 1% or less of the assemblages. On the Ohio, *P. cicatricosus* formed 1% (6 valves) of the assemblage at Gordon II, and 1.9% (105 valves) at Angel.

**Plethobasus cooperianus* (Lea 1834)
Common name: Orange-footed pimple back

The historic range of this Ohioan species includes the lower Tennessee, Cumberland and Ohio rivers. It has been reported in the lower Tennessee by both Ortmann (1925) and van der Schalie (1939), though it was considered to be quite rare. Archaeologically it was recovered from both Eva (2.2%) and Widows Creek (1.4%).

Plethobasus cooperianus was found in the Cumberland by Wilson and Clark (1914), and recently was recovered only as a single shell valve by Sickel (1982). On the middle Cumberland it constituted only .4% (3 valves) of the assemblage at Plunkett Creek, and .8% (7 valves) at Rome Island. Its absence from the sites in the LCAP area may be due to my inability to recognize this species in archaeological materials. Miller et al. state that

> Superficially this species resembles *Q. pustulosa*, but the latter species is usually smaller and has fewer and relatively larger tubercles which tend to be laterally rather than radially extended. In addition, *Q. pustulosa* exhibits white nacre and young species have green rays, whereas in *P. cooperianus*, the rays are obscure and narrow. The most definitive characteristic in *P. cooperianus* is the bright orange viscera, which can be seen in live specimens by gently prying the valves apart (Miller et al. 1986:14).

If this species occurred in any of the LCAP sites, then it would likely have been identified as *Q. pustulosa* or *C. tuberculata*, given that (1) most archaeological specimens are characteristically smaller than modern specimens; (2) *Q. pustulosa* is currently one of the most common species in the lower Tennessee, Cumberland and Ohio rivers; (3) the number of tubercles is highly variable in modern specimens of *Q. pustulosa*; and (4) the most diagnostic features of *P. cooperianus* are missing archaeologically.

While Morrison did not recover any specimens of *P. cooperianus* from any of the mounds on the Pickwick Basin, he feels that misidentification was unlikely

> It is possible, but highly improbable that any specimens escaped my notice in the thousands of mussel shells referred to as *granifera* (*Cyclonaias tuberculata*), as this species may be distinguished by other characteristics as well as by the difference in colour of nacre. It could not be confused with *pernodosa* (*Q. pustulosa*) as found in this region, not being as high as that species (Morrison 1942:357; parentheses mine).

P. cooperianus is currently considered to be a rare and endangered species (Stansbery 1970:13).

**Plethobasus cyphyus* (Rafinesque 1820)
**Plethobasus cyphyus compertus* (Frierson)
Common names: Bullhead; Sheepnose

P. cyphyus was considered a rare species in all three rivers (Ortmann 1925; Neel and Allen 1964; Goodrich and van der Schalie 1944). It is an Interior Basin form, and is thought to have originated in the Ohio River, although this is not positively known (Ortmann 1925:338). Though it has occasionally been found in riffles on a coarse gravel substrate, this species is usually considered to be a large river species and is most frequently found on mud bottoms in rapidly flowing water at depths of 3–6 feet (Baker 1928:112).

P. cyphyus was rarely found in the archaeological sites. On the Cumberland it occured only at Rome Island (*n*=2). On the Ohio, similar proportions of this species were found at Angel and Gordon II, where *P. cyphyus* contributed .7% of the assemblage at both sites (4 valves and 38 valves respectively). At 15McN51, two valves were recovered and formed deceptively significant proportion of this small assemblage. At Widows Creek on the Tennessee, this species contributed only .1% of the assemblage. Although Morrison (1942) noted a few individuals at the mounds in the Pickwick Basin, the actual numbers of specimens were omitted from his tables (Tables 3 and 4; pages 350–351). The nacre of *P. cyphyus* is extremely hard (Wilson and Clark 1914), a fact noted by Morrison (1942:357) who commented on the excellent preservation of this species in the Pickwick Basin mounds.

**Pleurobema clava* (Lamarck 1819)
Common name: Club Shell

P. clava is found most frequently in small streams and creeks (LaRocque 1967; Ortmann 1925; van der Schalie and van der Schalie 1950; Wilson and Clark 1914) but it also inhabits small to medium-sized rivers (Parmalee 1967). This species prefers shallow, swift-running water and a clean substrate of rock or sand.

P. clava was one of the species Ortmann (1925) expected to occur in the lower Tennessee, but it was not found in any of the surveys of that river. This species contributes only 1-2% of the assemblage at Eva and Widows Creek, but makes up 3.4% (1099 valves) in the Pickwick Basin, and 8.8% (47 valves) at the Dyke Site. It was not found below Burnside, Kentucky on the upper Cumberland in the early studies of the river. Wilson and Clark (1914:57) state "We have usually found this species most abundant in small streams, and this may explain its absence from the greater part of the Cumberland". Although Ortmann (1925) thought the presence of *P. clava* in the Cumberland was doubtful, archaeological sites on this river show this species to have been reasonably abundant. On the middle Cumberland it made up 5.5% (39 valves), and 4.2% (35 valves) of the assemblages at Plunkett Creek and Rome Island, respectively. On the lower Cumberland, the assemblages at Iuka and Millikan contained 4.4% (15 valves) and 1.5% (24 valves). At McKinney, however, *P. clava* was the most commonly occurring species, contributing 851 valves or over 19% of the assemblage. The great abundance of this species in the lower end of the Cumberland suggests a bar or shoals area that provided a shallow riffle habitat adjacent to the McKinney Site. An intermittent stream just to the north of the site may have produced a gravel bar at its confluence with the Cumberland, and therefore provided an unusually clean, shallow habitat in this relatively large river.

In the Ohio, *P. clava* is currently restricted to several small disjunct headwater populations (Stansbery 1970:13). The lower end of the Ohio was probably not a good habitat for this species, though four specimens recovered from Gordon II attest to its former presence.

The *Pleurobema cordatum* complex
**Pleurobema cordatum* (Rafinesque 1820)
form *cordatum* (Rafinesque 1820)
form *catillus* (Conrad 1834)
form *coccinium* (Conrad 1834)
form *plenum* (Lea 1840)
form *pyramidatum* (Lea 1840) (= form *rubrum*) (Rafinesque 1820)
form *sintoxia* (Rafinesque 1820)
Common name: Pig toe; Ohio River pig toe

The debate over this complex is primarily one of whether the varieties of this genus should be differentiated in terms of species (Morrison 1942; Stansbery 1967; Ortmann and Walker 1922), subspecies of *cordatum* (Neel and Allen 1967; Ortmann 1925; Parmalee 1967), or forms (Burch 1975; Goodrich and van der Schalie 1944; van der Schalie and van der Schalie 1950; Warren 1975). Goodrich and van der Schalie note that

> Much confusion formerly existed concerning the relationships of this species and various forms of it which have in the past been recognised as distinct species. The late Dr. Ortmann has studied the group carefully and has shown that *cordatum* tends to vary in two directions. On the one hand, it becomes higher with an increasingly shortened posterior end. In this direction we get a series of forms that are named progressively as the specimens get higher in this order: true *cordatum*, then *cordatum catillus* (Call, plate 59), then *cordatum plenum*, and finally the highest forms are called *cordatum pyramidatum*. This series comprising the main species and its forms are associated with streams of comparatively large size. On the other hand, when *cordatum* (the typical form) loses its sinus, becomes rounded and tends to assume an elongated posterior end then the name *cordatum coccineum* (see Call, plate 56) is applied. This form differs ecologically from the true *cordatum* and the higher forms in that it inhabits streams which are considerably smaller, getting well into the headwaters of the larger rivers. Distributionally, it is of interest to note that the true *cordatum* and the high forms are largely restricted to the big rivers in the southern portion of the state [of Indiana], such as the Ohio, White and Wabash. *P. cordatum coccineum*, however, is found throughout the state and continues northward into the Maumee, St. Joseph and Kankakee rivers (Goodrich and van der Schalie 1944:309).

The virtual identicality of the soft parts of these animals (Ortmann 1911:340) indicates that the complex represents a single species with subspecies or varieties. However, in reporting instances of several varieties of the *P. cordatum* complex coexisting on a single riffle without intermediate specimens, Stansbery (1967) suggests reproductive isolation.

In the archaeological material, four possible varieties of this complex were found at the LCAP sites on the lower Tennessee, Cumberland and Ohio rivers. These varieties were particularly apparent on the Cumberland where specimens were more numerous. Intermediate varieties were frequent, and the high degree of intergradation, in addition to the generally poor condition of many of the specimens, made ambiguous positive assignments to any category beyond *P. cordatum.*

P. cordatum in its various forms is frequent in most rivers and streams throughout the southeastern and midwestern United States. This frequency indicates the species' tolerance for a wide range of conditions. It is one of the few species to survive the changing river conditions of these rivers, and it is currently one of the most abundant species in the lower reaches. *P. cordatum* is also one of the most important commercial mussel species (Scruggs 1960).

It is evident that this complex was important prehistorically. It contributed a large proportion of the assemblage at most of the archaeological sites. On the Tennessee it represented 10.4% and 13.7% of the assemblages at Widows Creek and Eva, though only 3.4% at Dyke. Surprisingly few members of the complex were recovered from the Pickwick Basin sites, and these comprised less than 1% of the assemblage total. On the middle Cumberland, members of the *Pleurobema* complex and unidentified *Pleurobema* spp. accounted for over 9% of the assemblage at Plunkett Creek and almost 15% at Rome Island. On the lower Cumberland, the *P. cordatum* complex is the most commonly occuring type at Iuka and Millikan, with 43% (138 valves) and 46.2% (716 valves), respectively. At McKinney almost 17% (753 valves) of the assemblage was made up of this complex, second in abundance only to *P. clava.*

On the Ohio, however, only one valve was identified at 15McN51, though more were certainly present in the unidentified remains from this site. Members of *Pleurobema* and

Fusconaia can be indistinguishable in an advanced state of decay, and in this particular site preservation was poor. Probably a large proportion of the unidentified valves were members of either of these two genera. At Gordon II and Angel, members of this complex were the most commonly occurring type, making up 25% (149 valves) and 50.1% (2782 valves) at these two sites, respectively.

**Pleurobema oviforme* (Conrad 1834)
Pleurobema oviforme holstensis
Pleurobema holstense (Lea)
Common Name: Tennessee Clubshell

This species is variously grouped with *P. clava* (Warren 1975:69) or with *P. cordatum* (Neel and Allen 1967:483). Its similarity to *P. clava* suggests that it cannot easily be grouped with the *P. cordatum* complex. However, it also does not belong with *P. clava* proper. Warren (1975) and Morrison (1942) found that, although it comprised .5% or less in each of the two assemblages, *P. oviforme* is readily distinguishable from *P. clava* in their archaeological specimens. *P. oviforme* is considered to be a Cumberlandian species, and the various forms have been reported from the upper Tennessee and Cumberland rivers. The species does not occur at any of the middle or lower Cumberland sites, nor does it appear in the Ohio River or adjacent sites.

**Alasmidonta calceolus* (Lea 1830)
Alasmidonta minor
**Alasmidonta marginata* (Say 1818)
Alasmidonta truncata
Alasmidonta (Decurambis) marginata (Say 1819)
Common name: Elk toe

Both *Alasmidonta calciolis* and *Alasmidonta marginata* prefer smaller streams and headwaters, though Neel and Allen (1964) found *A. marginata* to be more common in the main stem of the Cumberland than in its tributaries. They are widely distributed in the smaller tributary streams of the Tennessee, Cumberland and Ohio rivers, and inhabit a gravel/sand substrate in swift water from a few inches to one metre deep. Though widely distributed, neither species is particularly common. Their small size, combined with the burrowing habit of *A. calciolis*, suggests why this species is virtually absent from the shell middens. Morrison (1942) found a single valve of each in the Pickwick Basin mounds.

Genus: *Anodonta* (Lamarck 1799)

Members of the genus *Anodonta* are primarily thin-shelled, edentulis individuals that prefer lakes, ponds, sloughs and the still, ponded areas of creeks. They are not expected to occur in the main channels of larger rivers such as the Tennessee, Cumberland and Ohio. A total of 16 specimens of *Anodonta grandis* (Say 1929) were recovered from the archaeological sites in the Pickwick Basin, and a single fragment was found at Widows Creek. Warren (1975) suggests that the occurrance of *A. grandis* at the Widows Creek Site was either accidental or indicative of muddy bank pooling.

**Arcidens confragosus* (Say 1829)
Common name: Rock Pocketbook

This species is currently found in the lower Cumberland River (Sickel 1982) but it also occurs in other medium-sized to large rivers. *A. confragosus* is tolerant of quiet water as well as current and is usually found in shallow water on a bottom of sand and mud (Parmalee 1967:52). This species has not been reported from the lower Tennessee River and was not found at any of the archaeological sites.

**Lasmigona complanata* (Barnes 1823)
Lasmigona (Pterosyna) complanata
Common name: White heel splitter

Lasmigona complanata is widely distributed in the Interior Basin where it lives on a mud substrate in quiet water, a few centimetres to one metre deep and in all sizes of streams and creeks (LaRocque 1967:191). It is reported by Wilson and Clark (1914) as being very rare in the Cumberland, and in their study it was represented by only a few thin-shelled specimens. In the Tennessee River system Ortmann (1925, 1924b) found it only in the Duck River, though he expected that it existed in the lower Tennessee, below the mouth of the Duck. Ortmann suggests that *L. complanata* is a migrant from the lower Ohio. Although undoubtedly in the area, this species was not present at any of the sites.

**Lasmigona costata* (Rafinesque 1820)
Lasmigona (Lasmigona) costata
Symphynota costata
Common name: Fluted shell

This species is rare in large rivers but more common in tributaries – where it is usually found in sand and gravel and in a good current. Though its origin is obscure, *L. costata* is distributed all over the Interior Basin, primarily in the Ohio drainage, as well as in the Cumberland and upper Tennessee. A single valve of this species was found in the archaeological material from the Pickwick Basin.

**Strophitus rugosus*
Strophitus edentulus (Lea)
Strophitus undulatus (Say 1817)
Common name: Squaw foot

Strophitus rugosus is a common species all over the Interior Basin where it is found in small to large streams and in lakes. This wide distribution makes its centre of origin obscure. It is common in the Cumberland and in the upper Tennessee, but Ortmann (1925:345) reported that it is rather rare in the lower Tennessee. It is frequently found in tributary streams of these rivers. *S. rugosus* was found archaeologically only as a single valve in the Pickwick Basin. The small, fragile shell and variable shape of this mussel make it very difficult to recover.

**Actinonaias carinata* (Barnes 1823)
Actinonaias ligamentina
Lampsilis ligamentina
form *gibba*
form *orbis*
Common name: Mucket

The mucket is a species that prefers large–to medium–sized rivers, but may be found in small streams as well. It prefers a coarse sand–gravel substrate in water varying in depth from a few inches to 3–4 feet (Parmalee 1967:56). In the Tennessee River this species was reported as uncommon by Morrison (1942), who refered to the form *orbis* which is more compressed and orbicular in outline. However, the species was present in most of the sites on the Tennessee where it comprised 7.9% (4802 valves) of the assemblage at Widows Creek, .9% (288 valves) at Pickwick, and 4.4% (8 valves) at Eva.

The Ohio River form of *A. carinata* has been called *gibba*, but this form is not differentiated by most researchers. The form *gibba* has been mentioned as being quite common on the Cumberland River by Neel and Allen (1964:442) who describe it as a "shortened, compressed form", strictly Cumberlandian in origin. They note that specimens resembling the form *gibba* have been found on the Ohio River, but they state that these specimens are merely *A. carinata*. Furthermore, this species was quite common at the archaeological sites on the middle Cumberland, forming 11.5% and 15.7% of the assemblages at Plunkett Creek and Rome Island, respectively. On the Ohio River, only two valves were found at the Angel Site.

In archaeological specimens, this thick, heavy shell can be easily mistaken for male specimens of *Lampsilis orbiculata*. The absence of this species from the six LCAP sites are probably due to their having been identified as *L. orbiculata*. Warren (1975) also reports a single valve of *Actinonaias pecterosa* at Widows Creek.

**Carunculina moesta* (Lea 1841)
form *cylindrella*
form *corunculus*

This Cumberlandian species is generally distributed in the tributaries of the lower Tennessee (Ortmann 1925). The form *cylindrella* denotes a variety found in tributaries of the Tennessee River such as the Paint Rock River, Alabama. A few specimens of this species were found in the Pickwick Basin sites and at Widows Creek.

In the Cumberland, Neel and Allen (1964) report *Carunculina moesta* from the main stem of the upper parts of the river, but Wilson and Clark (1914) found it only in the tributaries. It was not found at any of the archaeological sites on the middle or lower Cumberland. Although various members of the genus *Carunculina* are found in the Ohio River (LaRocque 1967; Parmalee 1967), none was recovered in the two archaeological sites on the lower Ohio.

**Conradilla caelata* (Conrad)
Common name: Birdwing Pearlymussel

This rare Cumberlandian mollusc is found in the Tennessee River, but not in the Cumberland (Ortmann 1925:353). Though it is rare, it occurs at the Widows Creek Site and in the archaeological sites in the Pickwick Basin. This species is sometimes synonomized with *Lemiox rimosus* [Rafinesque 1820] (Burch 1975), but there are arguments against doing so (Ortmann 1925; Ortmann and Walker 1922).

Dysnomia (=*Epioblasma* =*Plagiola*) (Agassiz 1852)

Of all the genera of Unionidae, *Dysnomia* shows the greatest degree of sexual dimorphism. There are several arguments as to which generic designation has precedence over the others (see Johnson 1978:240, Bogan and Parmalee 1983:3; Ortmann and Walker 1922:71; van der Schalie 1973:49), but the genus *Dysnomia* is used here since it is the name that appears most frequently in the literature.

According to Johnson (1978), all but one of the 16 species of *Dysnomia* were found in the Tennessee River and all but two occured in the Cumberland. These latter two are listed as *D. torulosa* and *D. sampsoni*, though the former has been found in shell middens on the middle Cumberland (Parmalee, Klippel and Bogan 1980) as well as on the lower Cumberland in this study.

**Dysnomia flexuosa* (Rafinesque 1820)
Dysnomia flexuosa lewisi
Dysnomia lewisi (Walker 1910)
Dysnomia flexuosa F. *lewisi*
Dysnomia flexuosa F. *flexuosa*
Dysnomia stewardsoni (Lea 1852)

Plagiola (=*Epioblasma*) *flexuosa* (Rafinesque)
Common names: Leaf Shell (*flexuosa*); Fork Shell (*lewisi*).

This complex consists of the forms *flexuosa/stewardsoni/lewisi.* There seems to be little agreement as to whether *lewisi* is a subspecies of *flexuosa* (Morrison 1942), a form of *flexuosa* (Warren 1975), or a separate species in its own right (Stansbery 1970; Parmalee, Klippel and Bogan 1980). Differences in shell morphology are minute, and have mainly to do with variations in size, thickness and inflation (Johnson 1978). Such differences are at best ambiguous in archaeological specimens. *Dysnomia stewardsoni* was a rare species (now considered extinct) that has never been found in great numbers (Johnson 1978), though has been recognized archaeologically by Morrison (1942) and by Warren (1975). In the archaeological assemblages it comprises 1.1% at Pickwick Basin and .23% at Widows Creek. Johnson (1978:286) refers to *D. stewardsoni* (Lea) and *flexuosa* as being "clearly sibling species". As regards shell shape, primary differences between the two are that the former is smaller, with the male more quadrate, and the radial furrow of both sexes less defined. As with *lewisi*, such differences would be difficult to determine in the LCAP material; thus the *Dysnomia flexuosa/lewisi/stewardsoni* complex is considered here as *D. flexuosa.* Problems differentiating the members of this complex have been noted by Parmalee, Klippel and Bogan (1980). *Dysnomia flexuosa* has been found both on muddy bottoms in deep water (Call 1900) and in shallow riffles in big rivers (Stansbery 1970). Due to impoundment and dredging, the latter habitat has virtually disappeared from local rivers. With it the mussel fauna that prefers these conditions has also vanished. Stansbery (1970) lists as extinct all three members of the *D. flexuosa* complex.

The origin of this species has also been questioned. Warren (1975) lists the origin of *flexuosa* as Interior Basin and *lewisi* as Cumberlandian. Johnson (1978) lists the range of *flexuosa* as the Tennessee and Cumberland River systems, and also the lower Wabash and Ohio, and considers *stewardsoni* as being restricted to the Tennessee and Cumberland rivers.

In a later publication (Johnson 1980), he lists *flexuosa* as one of seven Cumberlandian species to have invaded the Ohio drainage. It seems then, that the origin of the *D. flexuosa* complex must be Cumberlandian. As with many *Dysnomia* species, *flexuosa* exhibits a great degree of ecophenotypic variation, and, as has been noted, is generally smaller in shallow riffles of the Tennessee and Cumberland, but grows to much larger sizes in the Ohio.

Ortmann (1925) neither found, nor expected to find, *D. flexuosa* in the lower Tennessee. This species was also not reported by van der Schalie (1939a). Farther up this river the complex accounts for only 1.2% and 1.1% of the assemblages in the Pickwick Basin and at Widows Creek, respectively. At Eva it comprises .5%; however, at Dyke the complex accounts for fully 2.6% of the assemblage.

In the upper Cumberland, two specimens of *D. lewisi* were reported by Neel and Allen (1964), while specimens of *D. flexuosa* were not found. Parmalee, Klippel and Bogan (1980) report all members of the complex at the Plunket Creek Shelter (1.1%) and at Rome Island Shelter (1.5%) on the middle Cumberland. On the lower Cumberland, *D. flexuosa* was not reported by Wilson and Clark (1914) and was found only as a single shell valve by Sickel (1982). At Iuka, Millikan and McKinney, *D. flexuosa* occurs as .6%, 1.5% and 3.7% of the assemblages, respectively. On the Ohio, 12 valves are reported from the Angel Site (.2%) by Parmalee (1960).

**Dysnomia torulosa* (Rafinesque 1820)
Plagiola torulosa
Dysnomia torulosa torulosa (Rafinesque 1820)
Dysnomia torulosa rangiana (Lea 1839)
Dysnomia torulosa cincinnatiensis (Lea)
Dysnomia torulosa gubernaculum (Reeve 1865)
Dysnomia torulosa propinqua (Lea 1857)
Dysnomia propinqua (Lea 1857)
Common name: Tubercled-blossom Pearly mussel

D. torulosa is another species exhibiting a high degree of ecophenotypic variation (Johnson 1978). This is manifested in the shell in the greater or lesser number of tubercles and in the degree of shell inflation (Ortmann 1918). As with the *flexuosa* complex, there is some argument as to whether *propinqua* is a subspecies (Ortmann 1925; Parmalee and Bogan 1977) or a true species (Morrison 1942; Johnson 1978). Any of the *torulosa* forms are difficult to tell apart in the archaeological samples, although *propinqua* has been so distinguished from *torulosa* proper by Morrison (1942), Parmalee and Bogan (1977) and Warren (1975). Parmalee, Klippel and Bogan (1980) point out the difficulties of separating members of this complex (including *sulcata*) and have lumped all similar members together.

Dysnomia torulosa is considered to be Ohioan in origin and, though no living specimens have been reported from the lower Tennessee, it was one of the species that Ortmann (1925) predicted should occur. In the Tennessee, it has been reported only from Mussel Shoals (Ortmann 1925).

At Widows Creek the complex as a whole accounts for 3.5% of the assemblage. However, in the Pickwick Basin Morrison (1942:365) reported that *D. torulosa* was "One of the most characteristic, and most important from the standpoint of food supply, of the mussels found in these shell mounds....This section of the Tennessee River evidently affords optimum habitat requirements for *torulosa*...." *D. torulosa* and *D. propinqua* together comprise 22% of the specimens in the Pickwick Basin sample. The complex was also important at the Eva Site, and accounted for 20.7% of the assemblage. At Dyke, *D. torulosa* constituted 4.9% of the assemblage.

There is some question as to whether the complex ever occurred in the Cumberland River during the historic period. Neel and Allen (1964) found a single specimen of *D. sulcata* in the upper Cumberland, but make no mention of *D. torulosa*. *Dysnomia torulosa* was not recorded by Wilson and Clark (1912), and Johnson (1978) regards as spurious the only mention of this species in this river. Parmalee, Klippel and Bogan (1980) have established its presence in the middle Cumberland archaeologically, at both the Plunket Creek

(7.4%) and Rome Island (2.5%) shelters. On the lower Cumberland, *D. torulosa* appears to have been an important resource at McKinney (11.6%, 517 valves), though less so at Millikan (4.4%) and Iuka (1.9%). Three valves of *D. sulcata* were recovered from the Angel Site on the Ohio River.

**Dysnomia arcaeformis* (Lea 1831)
Common name: Sugar spoon

This species was neither reported nor expected from the lower Tennessee or Cumberland rivers. It is considered to be a true Cumberlandian form, its range usually being restricted to the upper reaches of these two rivers. Johnson (1978) lists *arcaeformis* as being the least abundant and least widely distributed species of *Dysnomia. Dysnomia arcaeformis* is present at all of the following sites on the Tennessee, A total of 272 valves (.52%) are reported from Widows Creek, 1025 valves (3.2%) for the Pickwick Basin, three valves (1.6%) at Eva and eight valves (1.2%) at the Dyke Site. Wilson and Clark (1914) found this species to occur rarely throughout the Cumberland, but it was not mentioned for the upper Cumberland by Neel and Allen (1964). Parmalee, Klippel and Bogan (1980) recovered 11 valves (1.5% of the total) at Plunkett Creek and 27 valves (3.3%) at Rome Island. At McKinney, Iuka and Millikan on the lower Cumberland, *D. arcaeformis* comprises 5.9%, 3.4% and 1.2%, respectively. The greatest number of valves (292) occurs at McKinney. The presence of this species at Dyke, Millikan, Iuka and McKinney is the first known record for its occurrence in the lower reaches of these two rivers (Sickel and Casey, in preparation). Specimens from these sites were first identified by Dr. J. B. Sickel and were subsequently confirmed by Dr. P.W. Parmalee.

**Dysnomia biemarginata* (Lea 1857)
**Dysnomia brevidens* (Lea 1834)
**Dysnomia capsaeformis* (Lea 1834)
**Dysnomia florentina* (Lea 1857)
**Dysnomia haysiana* (Lea 1833)
**Dysnomia sampsoni* (Lea 1861)
**Dysnomia triquetra* (Rafinesque 1820)

The other species of *Dysnomia* are Cumberlandian forms, and did not occur in any of the sites in the LCAP study area. At sites in nearby areas, they each accounted for less than 1.0% of the assemblages.

**Plagiola lineolata* (Rafinesque 1820)
Plagiola securis
Common name: Butterfly

This species is common throughout the Interior Basin. It was considered as such in the Cumberland (Wilson and Clark 1914), though less so in the Tennessee (Ortmann 1925). Ortmann (1925) considers it to be an Ohioan form rather than a Cumberlandian one and therefore suggests its migration into the Tennessee and Cumberland from the Ohio River.

This species is virtually absent from the shell mounds on the Tennessee River. Although it constitutes 2.7% of the assemblage at Eva, this only amounts to five shells. Three valves were found at Dyke, a single valve at Widows Creek, and one valve each at two of the mounds in the Pickwick Basin. On the Cumberland it is absent at Plunkett Creek and Rome Island, but it does occur at the lower Cumberland sites: .7% at McKinney; .9% at Iuka; and 4.6% at Millikan – where it numbers 71 valves. Parmalee (1967) considers *P. lineolata* to be moderately common on the Ohio River. Valves were found at 15McN51 (1 valve, or 2.4%), Gordon II (9 valves, or 1.5%) and Angel (38 valves, or .7%). Along with its habit of burrowing, this species' preference for deep water has been posited as the cause for its comparative absence in shell mounds (Warren 1975; Morrison 1942).

**Lampsilis teres* (Rafinesque 1820)
Lampsilis anodontoides (Lea 1831)
Lampsilis fallasciola
Lampsilis anodontoides fallasciola (Smith 1899)
Common names: Yellow sandshell; Slough sandshell

This species is widely distributed in the Interior Basin and is well known from the lower Tennessee, Cumberland and Ohio rivers. It prefers large rivers, deep water and sand/gravel bottoms. Ortmann (1925) suggests that *L. anodontoides fallasciola* is the mud form of *L. anodontoides* proper. Morrison (1942) notes that although these species are known from the Tennessee River, their deep water preference probably accounts for their absence at Pickwick Mounds.

**Lampsilis fasciola* (Rafinesque 1820)
Common name: Wavy-rayed Lamp Mussel

This common Interior Basin form is present in all three river systems. It increases in abundance towards the headwaters and is also frequently found in smaller tributaries (Neel and Allen 1964; Ortmann 1925). This species, found only at Widows Creek, Plunkett Creek and Rome Island, is not common archaeologically. It accounted for less than 1.0% of these assemblages. *L. fasciola* is usually found on relatively solid sand/gravel bottoms in shallow, swift water. That it is also a burrowing form, may explain its archaeological absence (van der Schalie 1939a).

**Lampsilis orbiculata (Hildreth 1924)*
Lampsilis abrupta (Say 1831)
Common Name: Pink mucket

Lampsilis orbiculata is present in the Ohio and Cumberland rivers (Johnson 1978) and in the lower Tennessee (Ortmann 1925). It prefers deep water in large rivers. This species was rare in all sites. Several valves contributed 1.1% to the assemblage at Dyke, but it is otherwise absent at Tennessee River sites. However, Morrison (1942) notes that live specimens occur in the vicinity of Pickwick Basin. On the middle Cumberland a single valve was recovered at Rome Island. For the lower Cumberland, 38 specimens (.9%) occur at McKinney, five (.3%) at Millikan and six (1.9%) at Iuka. Specimens of this species were originally identified by Dr. J.B. Sickel. According to Parmalee (pers. comm. 1986) however, it is difficult if not impossible to separate the males of *L. orbiculata* from *Actinonaias ligamentina* in archaeological specimens. On the Ohio River this species occurs only at Angel, where it constitutes .3% of the assemblage (14 valves).

**Lampsilis ovata* (Say 1817)
Lampsilis ventricosa

Lampsilis ovata ventricosa (Barnes 1823)
Common name: Pocketbook

Lampsilis ovata is common in many of the small streams and large rivers of the southeastern United States. *Lampsilis ventricosa* is restricted to headwaters. Intergrades have been noted between the two (Ortmann 1925). *Lampsilis ovata* is common in the Tennessee, Cumberland and Ohio rivers.

At the archaeological sites, *L. ovata* is rare. Morrison (1942) suggests that this may be due its burrowing behavior. He also notes that the flesh of older individuals tends to be tough, and, possibly is only used as fish bait. The shell is large and ovate and has frequently been found modified into cups and bowls in archaeological deposits (Parmalee et al 1972). On the Ohio River 51 specimens were collected from the Angel Site (.9%).

**Leptodea fragilis* (Rafinesque 1820)
**Leptodea leptodon* (Rafinesque 1820)
Common name: Fragile paper shell

Both of these species are widely distributed over eastern North America, including the Cumberland River and the upper and lower Tennessee. They commonly occur on muddy bottoms, but may also be found in a gravel substrate. Of the two, *fragilis* is more common, inhabiting bars in large rivers. Though widely distributed, *L. leptodon*, is very rare. No center of origin is recognized for either species.

A single fragment of *L. fragilis* was found at Widows Creek; however, it is absent from all other sites. Because of the thin and fragile nature of the shell of this species, it is unlikely that it would be recovered archaeologically.

**Liguma recta* (Lamarck 1819)
Liguma recta latissima (Rafinesque 1820)
Lampsilis recta
Common Names: Black sand shell; Long John

According to LaRoque (1967) *L. recta* refers to the lake variety of this species while *latissima* is the river form. *L. recta* is found in large and small rivers and lakes throughout the Interior Basin and throughout the Tennessee and the Cumberland rivers. It prefers a sand/gravel substrate and a good current. In lakes it is found in areas with pounding surf. Wilson and Clark (1914) found the species to be common throughout the Cumberland River, but nowhere abundant. Neel and Allen (1964) reported it to be very abundant in the upper Cumberland. It is reported from Mussel Shoals by Morrison (1942) and for the lower Tennessee by Ortmann (1925) and van der Schalie (1939a).

The species is rare archaeologically. A total of three valves were recovered from the Iuka and McKinney sites on the lower Cumberland River, and a total of four valves were found at the two sites on the middle Cumberland. Eight valves occur at Widows Creek. On the Ohio, 82 valves occur at the Angel Site, though only two valves occur at Gordon II and 15McN51.

*_Modionidus conradicus_ (Lea 1834)
Common name: Cumberland Moccasin

Ortmann (1925) reports that this is one of the most characteristic of the Cumberlandian types, occurring commonly in the small streams and headwaters of both the Cumberland and the Tennessee rivers. Although Neel and Allen (1964) found this species to be plentiful just below the falls in the main stem of the Cumberland, Wilson and Clark (1914) found it mainly in the small tributaries of this river. *Medionidus conradicus* was not found at any of the archaeological sites in the area.

*_Obovaria olivaria_ (Rafinesque 1820)
Common name: Hickory Nut

According to Ortmann (1925), this species occured in the Tennessee only at Mussel Shoals (rare) and at Dixie (abundant). The species was found at the Dyke Site on the Tennessee, though as less than 1.0% of the assemblage. Wilson and Clark (1914) noted the rarity of *O. olivaria* from the Cumberland, where it occured with a frequency of 1.0% at Millikan and 1.9% at Iuka. On the Ohio, Ortmann (1919) lists the species as common, though only three valves were found at Gordon II and 16 at Angel. *O. olivaria* seems to prefer larger rivers where it is found on a sand/gravel substrate in deep water. However, it is not unknown from smaller rivers (Baker 1928).

**Obovaria retusa* (Lamarck 1819)
Common names: Golf stick; Ring pink;
Ram's horn pink; Pink pigtoe; Rosebud

This species is found mainly in large rivers, though it does penetrate into headwaters (LaRocque 1967). It is most abundant in the Ohio (Ortmann 1925), but is also known from the Cumberland (Wilson and Clark 1914; Neel and Allen 1964) and from the Tennessee (Ortmann 1925) rivers. It is not considered common in these latter two rivers (Ortmann 1918, 1924, 1925).

O. retusa is uncommon in the mounds of the Pickwick Basin. However, it does constitute 2.7% (1617 valves) of the assemblage at Widow's Creek, 2.6% at Dyke, and 4.9% (9 valves) at Eva. On the middle Cumberland, it contributes less than 1.0% at both Plunkett Creek and Rome Island. In the LCAP study area, however, *O. retusa* is quite common archaeologically, contributing almost 10% at McKinney. At Millikan it was the second more common species (14.6%). On the Ohio, 38 valves (6.6%) were recovered at Gordon II, two valves at 15McN51 and 160 valves (3%) at Angel.

Living populations of this species are noted for the Tennessee (Stansbery 1970) and Cumberland rivers (Parmalee and Klippel 1982); however, these do not appear to be reproducing and are expected to die out. A modern shell recovered by the author at the head of Cumberland Island, indicates that this species may still exist in the lower Ohio River.

**Obovaria subrotunda* (Rafinesque 1820)
form *subrotunda*

form *lens* (Lea 1830)
Obovaria subrotunda parva
Obovaria subrotunda globula
Obovaria subrotunda leibii (Lea 1862)
Common name: Round Hickory Nut

Several forms are referable to *O. subrotunda*. The form *subrotunda* (= *globula*) inhabits large rivers and the lower ends of small rivers, while the form *lens* is of the headwater variety. *O. subrotunda parva* is synonymous with *O. subrotunda liebii*, the latter being a lake variety.

Morrison (1942) and Warren (1975) recognized two forms in their collections, though when combined their number accounted for less than 1.0% at either site. In the lower Tennessee only one form is noted from Dyke, and few individuals were found. *O. subrotunda* accounts for 7.1% of the Eva assemblage (13 valves). It is not mentioned as being present in the lower portions of the Cumberland River (Wilson and Clark 1914), but is apparently abundant in the upper reaches of this river (Neel and Allen 1964). The species is not common from the middle Cumberland archaeological sites, but is so for the lower Cumberland. The species contibuted between 2.8 and 6.0% of these assemblages, with the most valves (267) recovered from McKinney. *Obovaria subrotunda* was recovered only from the Angel Site on the Ohio, where it constituted .7% of the assemblage (40 valves) (Parmalee 1960). It should be noted that we can expect archaeological recovery of this species to be good. Even in an advanced state of decay, *O. subrotunda* is readily identified by its almost circular shape and by its centrally located umbos.

**Proptera alata* (Say 1817)
F. *megaptera* (Rafinesque 1820)
Lampsilis alata (Say 1817)
Potamilus alatus (Say 1817)
Common names: Pink heel splitter, Pancake,
Pink hatchet back, Purple heel splitter

According to LaRocque (1967) the form *megaptera* is the river form, and, when compared with *alata*, the lake form, is distinguished by a larger and less inflated shell. It occurs in the Tennessee, Cumberland and Ohio rivers and inhabits a variety of depths and bottom types, though generally it prefers a good current. This is a relatively thin shelled species and would not be expected to be preserved in archaeological deposits. However, it was recovered in very small numbers from the Pickwick Basin and middle Cumberland sites and two of the sites on the Ohio River.

**Proptera laevissima*
Lampsilis laevissima
Leptodea laevissima
Potamilus laevissima (Lea 1830)
Common name: Paper shell

This species is found in all three of the rivers considered here, but is not common in any of them. It prefers larger rivers with sand/mud bottoms and good currents. Though this species may be common on sand bars, deeper water (three to six feet or more) is also a preferred habitat. Its very thin shell is likely a primary reason for its absence from the archaeological sites.

**Truncilla truncata* (Rafinesque 1820)
**Truncilla donaciformis* (Lea 1828)
Common name: Deertoe; Fawnsfoot

These species are reported as being uncommon in the Cumberland (Neel and Allen 1964; Wilson and Clark 1914) and in the upper Tennessee. They are apparently abundant in the lower Tennessee (Ortmann 1925). With the exception of a single valve recovered at McKinney, these forms are absent archaeologically.

Genus *Villosa* (=*Micromya* =*Eurynia*) (Frierson 1927)
**Villosa fabalis* (Lea 1831)
**Villosa iris* (Lea 1830)
**Villosa trabalis* (Conrad 1834)
**Villosa taeniata* (Conrad 1834)
Villosa picta
Villosa punctata (Lea 1865)
**Villosa vannuxemensis* (Lea 1838)
Common names: Rainbow; Creek shell

Members of this genus primarily inhabit shallow, swift, clear waters with a sand and gravel bottom. Most species are present in small streams and headwaters rather than in main streams of larger rivers. As such they are sparsely represented in the archaeological sites.

**Cyprogena stegaria* (Rafinesque 1820)
Cyprogena irrorata (Lea 1829)
Common name: Fan shell

Johnson (1980) reports that this species is abundant throughout the Tennessee, Cumberland and Ohio River systems, in both the Cumberlandian and Ohioan regions. Neither Ortmann (1925) nor van der Schalie (1939a) report its presence in the lower Tennessee, though it does occur at Mussel Shoals and in the upper regions of this river. *C. stegaria* prefers swift, shallow waters and gravel bottoms (Ortmann 1919).

This mollusc is noted in moderate abundance at the Pickwick Basin sites (Morrison 1942). It is also frequent at the Eva Site (6.5%), though it comprises only .4% at both Widow's Creek and the Dyke Site.

On the Cumberland *C. stegaria* was infrequent for the middle river sites, and, on the lower Cumberland comprised 1.7% (Millikan), 1.2% (Iuka), and 4.1% (McKinney) of LCAP assemblages. Historically, neither Wilson and Clark (1914) nor Sickel (1982) recorded the form for the lower Cumberland. Its occurrence in the upper Cumberland is also rare (Wilson and Clark 1914; Neel and Allen 1964). Parmalee (1967) reports that although *C. stegaria* has not been found alive in the Ohio, its occurrence in shell middens here attests to its previous presence. Of the lower Ohio sites studied here, this species occurs only at the Angel Site, where 29 valves (.5%) were recovered.

**Obliquaria reflexa* (Rafinesque 1820)
Common names: Three horn; Three–horned warty back

This species is generally found in larger rivers (Ortmann 1925). It occurs at few archaeological sites in the area, but in very small numbers. A maximum of 16 valves (.4%)

were found at the McKinney Site. Its rarity in prehistoric deposits likely reflects its preference for deep waters and muddy bottoms (Morrison (1942).

***Dromus dromas* (Lea 1834)
F. *dromas*
F. *caperotus* (Lea)
Common names:Camel shell; Dromedary shell

D. dromas is considered a true Cumberlandian form, abundant in the upper Cumberland and Tennessee, but unknown outside of this region. Ortmann (1925) mentions a reference by Call to the occurrence of this species in the Green and Salt rivers in Kentucky, although Ortmann considered this doubtful. Interestingly, this species is abundant archaeologically. On the Tennessee, *D. dromas* comprises at least 10% of all sites reviewed; it was the most common species at Widows Creek (22.4%, 14,142 valves). It occurred with the second highest frequency at Dyke (13.1%), which is surprising because this species has not been previously known to occur this far down the stream. A similar distribution is noted on the Cumberland. The middle Cumberland sites of Plunkett Creek and Rome Island contained 20.6% and 13.4%, respectively. In the LCAP area, a reduced occurrence is noted: 2.7% at McKinney, 5.2% at Millikan and 2.8% at Iuka. This still indicates the existence of a viable population locally. In keeping with its true Cumberlandian nature, no specimens are reported for Ohio River sites.

The two forms of this species represent large river (*dromas*) and small river or stream (*caperatus*) varieties. The former is distinguished by large lateral bumps and an inflated shell, while the latter is more compressed and possesses smaller bumps (Wilson and Clark 1914). The majority of specimens recovered from the lower Cumberland and Tennessee sites were of the *dromas* variety. The two forms intergrade (Wilson and Clark 1914) and they are generally considered to be a single species.

D. dromas is a very distinctive mussel, even when considerably decayed. Specimens from the LCAP study area were confirmed by P.W. Parmalee. The great abundance of this form in archaeological deposits suggests either that it was extremely abundant prehistorically or that it was consciously selected as a favored resource.

***Ptychobranchus fasciolaris*
Ptychobranchus fasciolare (Rafinesque 1820)
Ptychobranchus phaseolus F. *subtentum* (Say 1825)
Common name: Kidney shell

This species is widely distributed, but is seldom found in large numbers. It occurs in the rivers and tributaries of the Tennessee, Cumberland and Ohio drainages. It is absent in the lower Mississippi River, though it is known from the Ozark and Alabama drainages. This distribution 89led Ortmann (1925) to suggest that it is a Cumberlandian migrant to the Ohio. Although it is frequently found in rapids, buried deeply in sand and gravel (van der Schalie 1938, cited in LaRocque 1967), it has also been found in sandy mud and sluggish water (Ortmann 1925). Coupled with its burrowing habit, its rarity likely accounts for its archaeological distribution. While *P. fasciolaris* occurs at most sites, it does so in very low frequencies, i.e., less than 1.0%.

Summary and Discussion

Table 7 summarizes the certain environmental information that indicates the preferred habitat for each mussel species. These data were taken from a variety of sources (Baker 1928; Bogan and Parmalee 1983; Call 1900; Clarke 1981; Matteson 1959; Murray and Leonard 1962; Johnson 1978, 1980; La Rocque 1967; Neel and Allen 1964; Ortmann 1918, 1925; Parmalee 1967; Parmalee Klippel and Bogan 1980; Stern 1983; van der Schalie 1939a, 1981; van der Schalie and van der Schalie 1950; Warren 1975; Wilson and Clark 1912, 1914) and were synthesized to produce the table.

Table 7. Summary of Environmental Requirements for Unionid Species

SPECIES	BODY	DEPTH	CURRENT	BOTTOM
Cumberlandia monodonta	LR-MR	S	S	GR
Amblema plicata	All	S-D	S-W	All
Fusconaia ebena	LR	D	S	MSG
Fusconaia undata	LR	D		M
Fusconaia cordata		S	S	
Fusconaia edgariana	LR-Sst	S	S-M	RGS
Fusconaia plena		S	S	
Fusconaia subrotunda	LR	D	S-M	RGS
Fusconaia trmescens		S	S	
Quadrula cylindrica	LR-Sst	S	S	GR
Quadrula metanevra	LR-MR	D	S-M	M(SG)
Quadrula nodulata	LR-MR	S-D	M(W)	M(S)
Quadrula pustulosa	SR-SR	S-D	M-S	SMG
Quadrula quadrula	LR-MR	D	S(M)	M(SG)
Tritogonia verrucosa	LR-SR	S-D	S	SM
Megalonaias gigantea	LR	D	W	MG
Cyclonaias tuberculata	LR-SR	S-D	S-M	GM
Elliptio crassidens	LR-MR	D	S-M	SG
Elliptio dilatata	All	S-D	S-W	SGM
Hemistena lata		S	S	G
Lexingtonia dolabelliodes		S	S	GS
Plethobasus cicatricosus	LR	S		
Plethobasus cooperianus	LR			GS
Plethobasus cyphyus	LR-MR	D	S	M(RSG)
Pleurobema clava	Sst	S	S	RS
Pleurobema cordatum cpx.	LR-SR	S-D	S-W	SGM
Alasmidonta calceolis		S	S	GS
Alasmidonta marginata		S	S	GS
Arcedens confragosus	LR-MR	S-M	S	SM
Anodonta spp.	MR,p,lk	S-D	W	M
Lasmigonia complanata	All	S	W	M
Lasmigonia costata			S	SG
Strophitus rugosus	Mst-Sst	S-M	W	SG
Actinonaias carinata	LR-SR	S	S	SG
Carunculina moesta		S	S	GS
Conradilla caelata	SR-Sst	S	S	RGS
Dysnomia arcaeformis	LR-MR			SG
Dysnomia biemarginata	SR-MR			
Dysnomia brevidens	LR-MR			
Dysnomia capsaeformis	SR-Sst			
Dysnomia flexuosa	LR-SR	S/D?		G(S)
Dysnomia haysiana	LR-Mst			
Dysnomia torulosa cpx.	LR-MR	S-M	S	G(S)
Dysnomia triquetra	LR-MR	S-D	S	
Plagiola lineolata	LR-MR	D	S-M	S-G

SPECIES	BODY	DEPTH	CURRENT	BOTTOM
Lampsilis teres	LR-SR	S-W	S-W	SM
Lampsilis fasciola	SR-Sst	S-D	S	SG
Lampsilis orgiculata	LR	D(S)	S	D
Lampsilis ovata	LR	D(S)	S-M	SG(M)
Leptodea fragilis	LR-Sst	S-D	S-W	MS
Ligumia recta	LR-MR(lk)	S	S-M	SGM
Obovaria olivaria	LR(MR)	M-D	S-M	SG
Obovaria retusa	LR(MR)	D	S	SG
Obovaria subrotunda	LR(MR)	S	S-M	S(G)
Proptera alata	LR(MR)	S-D	S	S(G)
Proptera laevissima		S	S	SM
Truncilla truncata	LR-SR	D		SM
Truncilla donaciformis	LR	S-M		SM
Villosa spp.	Mst-Sst	S	S-M	SGM
Cyprogena stegaria	LR-MR	S	S-M	SG
Obliquaria reflexa	LR-MR	S-D	S-W	MSG
Dromus dromas	LR-MR	S	S	GS
Ptychobranchus fasciolaris	SR-LR	M	S	SG

KEY:

BODY: R = river, st = stream, lk = lake, p = pond, L,M,S = large, medium, small.
DEPTH: SMD = shallow, moderate, deep; ? indicates conflicting reports.
CURRENT: S,M,W = swift, moderate, weak
BOTTOM: M,S,G,R = mud, sand, gravel, rock

NB. Column codes are listed in order of preference; parentheses indicate conditions other then usual in which the species have been found.

Diversity

It is difficult to assess the adequacy of the samples at the 12 sites because the sample sizes are so different. The relative presence or absence of low abundance species, for example, could be a function of the sample size. One way of accounting for differences in sample sizes between sites is to construct a diversity index. There are several ways of measuring diversity (see Styles 1981; Grayson 1984). With the technique used here, the number of identified specimens (NISP) is plotted against the number of identified species (NTAXA) for each site. The expectation is that as sample size increases, NTAXA will also increase to a certain point after which the number of new taxa being found will fall off and only rare species will be recovered with a larger sample size. Figure 7 plots LogNISP and NTAXA on a graph with the regression line indicated. Table 8 lists these figures and gives the predicted number of taxa (PTAXA) (i.e. the number of taxa expected given the sample size) and the residual. From these figures, the standard error of prediction was calculated and the standardized residual is listed in the final column. Sites indicated (*) are those that show a significant difference in the observed from the predicted number of taxa.

According to this index, the McKinney, Millikan and Dyke Sites have significantly fewer species than would be expected given the size of the samples. Plunkett Creek and Rome Island have significantly more species. In theory, if NTAXA is less than PTAXA, truly low diversity is indicated relative to all the samples being compared. When NTAXA is equal to PTAXA, it can be expected that only the rare taxa will be missing from the sample. When NTAXA is greater than PTAXA, this indicates truly high relative diversity. The high species diversity at Plunkett Creek and Rome Island may indicate one of two things. First, the sites may have been located near areas of extensive natural habitats for shellfish. A shoal or sand/gravel bar immediately adjacent to the site may have contained a large variety of mussel species many of which are represented at the sites. An alternative explanation is that the prehistoric site inhabitants may have either been extremely adept at retrieving mussels

Figure 7: Graph plotting LogNISP and NTAXA for Twelve Archaeological Sites.

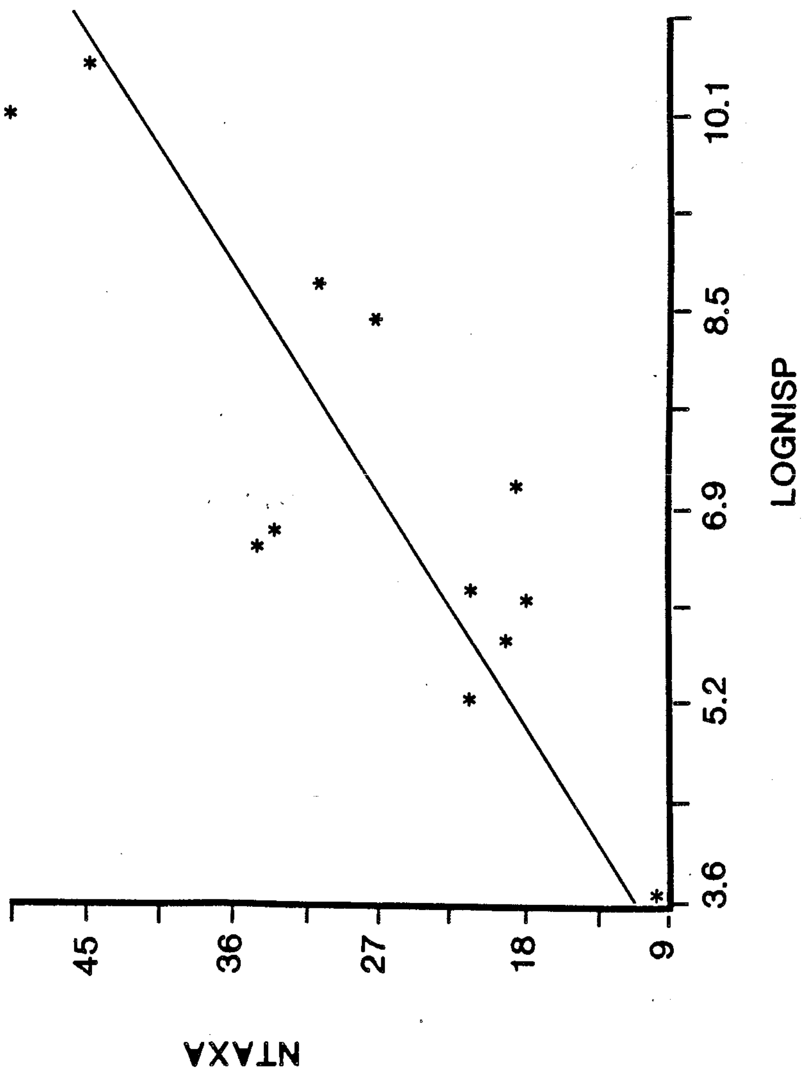

NTAXA
45
36
27
18
9
3.6
5.2
6.9
8.5
10.1
LOGNISP

Table 8. Summary Statistics for the Measurement of Species Diversity from Twelve Sites.

SITE	NISP	LOGNISP	NTAXA	PTAXA	RESIDUAL	STD.RESID
McKINNEY	4913	8.4	26	33	-7.5	-3.2*
MILLIKEN	1552	7.3	19	28	-9.0	-4.6*
IUKA	322	5.7	20	20	-.4	-0.1
PLUNKETT CREEK	715	6.5	35	24	10.6	5.2*
ROME ISLAND	827	6.7	34	25	8.9	4.4*
15McN51	39	3.6	9	10	-1.2	-0.3
GORDON II	596	6.3	21	23	-2.4	-1.1
ANGEL	6537	8.7	30	34	-4.9	-2.0
DYKE	534	6.2	18	22	-4.9	-2.2 *
EVA	183	5.2	21	17	3.2	1.1
PICKWICK BASIN	31987	10.3	50	42	7.3	2.0
WIDOWS CREEK	59502	10.9	46	45	.3	.0

from a number of habitats, or that species from other areas were being brought onto the site.

At McKinney, Millikan and Dyke, where significantly fewer species occur, low diversity is indicated. This suggests that sample sizes at these sites are sufficiently large that if more species had occurred in the sites, they should have been recovered. Therefore, reasons as to why the species diversity at these sites is so low will likely have to be sought in the cultural and environmental factors contributing to the creation of the deposit.

Although the diversity index has been used successfully in a number of studies (ie: Bobrowsky 1982; Bobrowsky and Gatus 1984; Grayson 1984) there are several problems with this technique which restrict its validity in the context of the present analysis. One of the main problems with this statistic is that it makes the assumption that all samples are drawn from a common population. Mussel species, however, are not evenly distributed throughout the river valleys. Particularly in the Tennessee and Cumberland rivers, the species composition changes drastically from the mid-sections of the rivers to their mouths. Thus the low species diversity indicated at most of the sites on the lower ends of these rivers could simply be an indication of the fewer available species.

Another problem with the diversity index is that it does not consider the fact that different investigators may assign taxa in different ways; nor does it allow for preservational differences between samples. Given the poor state of preservation at the LCAP sites, and the concomitant ambiguity of the subspecies and forms, taxa at these sites were "lumped" rather than "split". The samples from Plunkett Creek and Rome Island may have been in a better state of preservation and hence could be identified more accurately thereby producing a larger number of taxa.

The Potential vs the Exploited Resource

Although the diversity index does indicate which samples are significant in terms of the relative number of species recovered from the sites, it does not explain why this may be so. It is therefore useful to measure species diversity against a known index of which species are to be expected from different parts of the rivers. While such a comparison does not overcome the problems described above, it does provide a different perspective on species diversity.

Tables 9, 10 and 11 list the mussel species that have been found in the lower Tennessee, Cumberland and Ohio rivers but were not found in the archaeological sites. These tables also include a number of ecological, cultural, and analytical circumstances which may have contributed to the absence of these species from the archaeological collections. The species listed for the Tennessee and Ohio rivers (Tables 9 and 11) are a bit misleading and require a brief explanation.

Included as being absent from the Tennessee River are the 26 species of mussels which Ortmann (1925) expected to have occurred in the lower Tennessee, though they were never actually found by him. These species are noted in Table 9. In the list of conditions it is evident that most of these species are species that prefer small stream habitats, and van der Schalie (1939a) was correct in his supposition that most of these species probably never occurred in the lower Tennessee. (A few of Ortmann's expected species were found in the archaeological sites, however, and these are listed on Table 12).

The majority of the data on living shellfish populations in the lower Ohio River was taken from surveys of some of the smaller tributaries that enter the lower reaches of this river. The large number of creek and stream species that are indicated as being potential resource species in the Ohio reflect the nature of the rivers on which the surveys were done. It is doubtful that any of these creek and stream species ever occurred in the Ohio

Table 9. Potentially Available Unionid Species That Were Absent From the LCAP sites on the Tennessee River and Conditions Which May Have Influenced This Absence.

Species	Uncommon	Small Stream	Deep, Muddy	Burrowing	Friable Shell	Small	Possible Curation	Possible Misidentification	Expected But Not Found in Early Surveys
Cumberlandia monodonta	x			x	x				x
Amblema plicata							x		
Quadrula cylindrica	x								x
Tritogonia verrucosa			x						
Megalonaias gigantea			x				x		
Hemistena lata	x			x	x				x
Plethobasus cooperianus	x							x	
Plethobasus cyphyus	x		x						
Alasmidonta marginata	x	x							x
Lasmigona complanata	x		x						x
Lasmigona costata	x	x							x
Strophitus rugosus	x	x			x	x			
Dysnomia personata			x						x
Dysnomia triquetra				x					x
Lampsilis fasciola		x		x					x
Lampsilis ovata				x			x		
Lampsilis teres			x						x
Leptodea fragilis			x		x	x			
Ligumia recta			x						
Proptera alata			x		x				
Proptera laevissima			x		x				x
Truncilla truncata			x			x			x
Truncilla donaciformis			x			x			x
Obliquaria reflexa			x						

Table 10. Potentially Available Unionid Species That Were Absent From the LCAP Sites on the Cumberland River and Conditions Which May Have Influenced This Absence.

Species	Uncommon	Small Stream	Deep, Muddy	Burrowing	Friable Shell	Small	Possible Curation	Possible Misidentification	Expected But Not Found in Early Surveys
Cumberlandia monodonta	x			x	x				
Fusconaia subrotunda	x		x					x	
Fusconaia undata			x						
Megalonaias gigantea			x				x		
Plethobasus cooperianus	x							x	
Plethobasus cyphyus	x		x						
Arcidens confragosus									
Lasmigona complanata	x		x						
Lampsilis ovata				x			x		
Lampsilis teres			x						
Leptodea fragilis			x		x	x			
Proptera alata			x		x				
Proptera laevissima			x		x				
Truncilla donaciformis			x			x			

Table 11. Potentially Available Unionid Species That Were Absent From the LCAP Sites on the Ohio River and Conditions Which May Have Influenced This Absence.

Species	Uncommon	Small Stream	Deep, Muddy	Burrowing	Friable Shell	Small	Possible Curation	Possible Misidentification	Expected But Not Found in Early Surveys
Fusconaia flava		x	x						
Fusconaia subrotunda	x		x					x	
Fusconaia undata			x						
Megalonaias gigantea			x				x		
Hemistena lata	x			x	x				
Plethobasus cooperianus	x							x	x
Alasmidonta calceolis	x	x		x	x	x			
Alasmidonta marginata	x	x							
Arcidens confragosus									x
Lasmigona complanata	x		x						
Lasmigona costata	x	x							
Strophitus rugosus	x	x			x	x			
Actinonaias carinata							x		
Carunculina moesta		x							
Dysnomia flexuosa									x
Dysnomia torulosa									x
Dysnomia triquetra				x					
Lampsilis fasciola		x		x					
Lampsilis orbiculata			x					x	
Lampsilis ovata				x			x		
Lampsilis radiata siliquoidea									
Lampsilis teres			x						
Leptodea fragilis			x		x	x			
Truncilla truncata			x			x			
Truncilla donaciformis			x			x			
Villosa spp.		x							
Cyprogena stegaria	x								

Table 12. Species that were found but not expected in the Archaeological Sites.

Species	Tennessee River	Cumberland River	Ohio River
Plethobasus cicatricosus		x	x
Pleurobema clava	x(t)*	x	
Dysnomia arcaeformis	x	x	
flexuosa	x	x	
torulosa	x(t)	x	
Obovaria olivaria			x
subrotunda	x(t)	x	
Dromus dromas	x	x	
Cyprogena stegaria	x(t)		

*(t) - indicates species which Ortmann (1925) expected to occur in the Tennessee River, though they were never actually found live.

River proper. In addition, there are a number of species in Table 11, which Ortmann (1926) expected to occur in the Green River, but never actually found. If these species were not found in any of the other surveys they are noted.

When the creek and stream species in the Ohio, and those species which Ortmann expected but did not find on the Tennessee and Ohio rivers are deleted from the list, there are eight species missing from the archaeological sites on the Tennessee River, 13 from the Ohio, and 14 from the Cumberland. With a few exceptions, these missing species are those that are either uncommon, or due to their habitat preferences, would have been difficult for prehistoric peoples to procure.

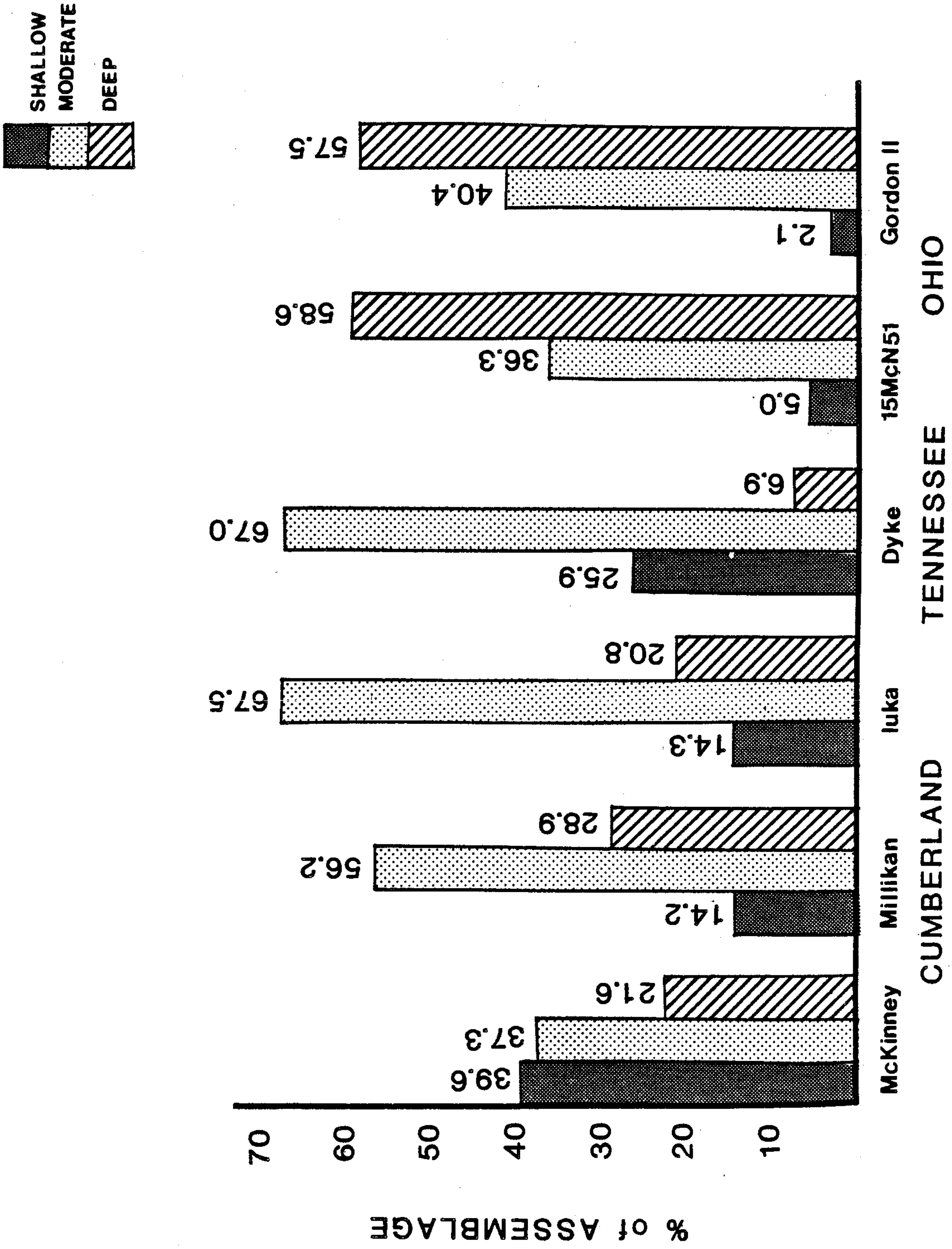
It is difficult to explain the absence of ***Arcidens confragosus*** from the sites on the Cumberland and Ohio rivers, ***Actinonaias carinata*** on the Tennessee and Ohio, and ***Dysnomia flexuosa, Dysnomia torulosa*** and ***Lampsilis radiata siliquoidea*** on the Ohio. None of these species inhabit particularly deep water, and all have been reported as being reasonably abundant on the rivers indicated. A possible explanation might be that these species were not locally abundant in the immediate vicinity of the sites.

Table 12 lists the species of mussels that were found at the sites but had not been previously reported from the lower ends of the rivers. Primarily, these species appear to indicate a loss of shallow-water or shoal habitats in the lower ends of these rivers between the time the sites were occupied and the present.

Cultural Aspects of the Species Composition at the Sites

Figure 8 compares the preferred water depth of the species at each of the six LCAP sites. Water depth is compared here since it is the variable that will, more than any other, affect the ease with which the various species may be obtained. Depth increments are arbitrary. Shallow water is considered here to be anything less than one metre deep. One

Figure 8: Histogram Comparing the Proportions of the Unionid Species at Six Archaeological Sites by Preferred Water Depth.


SHALLOW
MODERATE
DEEP
% of ASSEMBLAGE
70
60
50
40
30
20
10
39.6
37.3
21.6
14.2
56.2
28.9
14.3
67.5
20.8
25.9
67.0
6.9
5.0
36.3
58.6
2.1
40.4
57.5
McKinney
Millikan
Iuka
Dyke
15McN51
Gordon II
CUMBERLAND
TENNESSEE
OHIO

metre is approximately "waist height," and it is presumed that when found at depths of 1 m or less, shellfish can easily be collected by wading. However, depths of considerably less than one metre would be necessary before small children could partake in shellfishing activities. The "moderate" category includes species that prefer 1 - 1.5 m of water. At this depth shellfishing would be more difficult, and virtually all children would have to be excluded from the collecting group. This category also includes species that are more tolerant of various water conditions, and that can occur at all depths. Deep water species prefer depths of 1.5 m or more, and, under such conditions would be most difficult to obtain.

The results show distinct differences in the types of shellfish procured in each of the three rivers. Although the species of shellfish at all of the LCAP sites are virtually the same, the proportions the various species contribute to the assemblages are quite different. On all three rivers a significant proportion of the site consists of the moderate or tolerant species. These large numbers are primarily due to the *P. cordatum* complex and/or *E. dilatata*, which are common at all sites and inhabit a variety of depths.

The Iuka and Millikan Sites on the Cumberland River show very similar patterns with moderate/tolerant species making up well over 50% of the assemblage in each. Deep water species comprise the next largest percentage. The situation at McKinney is somewhat different, with shallow water species being slightly more abundant than moderate/tolerant species. This apparent difference is entirely due to the large numbers of *P. clava* at the McKinney Site. *P. clava* accounts for almost 20% of the Mckinney assemblage, and this inflates the value for shallow water species. Otherwise the values for deep water species are very similar, and amount to between 20-29% of the total.

The species habitat profile for this section of the Cumberland depicts a rather typical array of species types for the lower end of a medium to large-sized river. Here, from deep to shallow water, are a number of habitats that support a variety of unionid life. It is unfortunate that the early river surveys did not penetrate to the lower reaches of the Cumberland, since it is not known when the fauna of this region changed. Today the dredging and damming activities have eliminated shoal habitats, which, according to the mussels found in the archaeological sites, were once a feature of the lower end of this river.

When the lower Cumberland sites are compared to the sites on the middle Cumberland, it appears that very similar species were being collected in both places. While on the middle Cumberland more creek species (i.e. *Villosa*) were being collected, on the lower Cumberland more deep water species are evident. On the Middle Cumberland there are also more species of *Dysnomia*, and other species of Cumberlandian origin are found here as well. This result is consistent with the general observation that Cumberlandian elements increase in number as one progresses upstream on the Tennessee and Cumberland rivers.

At the Dyke Site, again, moderate/tolerant shellfish species make up the majority of the site assemblage; however shallow water species account for almost 26% of the total while deep water species follow with less than 7%. Although early river surveys do not mention the occurrence of shallows on the lower Tennessee, such areas are evident by the species indicated here. The sample at Dyke roughly parallels the species reported by van der Schalie (1939a) but with a few exceptions. Three species of *Dysnomia* were found at Dyke representing 8.7% of the total assemblage. There were also relatively large proportions of *D. dromas* (13%) and *P. clava* (8.8%), none of which in any of the surveys was apparently expected to occur this far down the Tennessee. Several notable species that were reported by van der Schalie (1939a), and that are known to be currently abundant in the lower Tennessee River are *M. gigantea, P. alata,* and *A. plicata.* I have already discussed the possibility of *M. gigantea* and *A. plicata* being used by the prehistoric site occupants as tools; however, the relative absence of deep water shellfish in general at this site indicates that these animals were probably not being sought by the prehistoric inhabitants. Culturally, this assemblage suggests that the inhabitants did not habitually take shellfish; it suggests rather that on rare occasions they collected the shellfish from a shallow bar adjacent to the site.

The number of species types diminishes toward the mouth of the Tennessee. This reduction is contrary to the situation on many rivers where the lower end is expected to provide the greatest number of habitats, and therefore is expected to support the greatest number of species. The intrusion of the shoals in northern Alabama produced an unusual situation on the Tennessee, since it is here that the majority of the shellfish species occur. The species compositions at the Pickwick and Widows Creek Sites reflect this. The sites in the shoals area contain many more species of mussels and considerably more specimens than the sites farther down the river at Eva and Dyke. The Pickwick and Widows Creek occupants were obviously presented with a resource that included a variety of easily obtainable species. Notable too is the composition of Cumberlandian and Ohioan elements on the Tennessee and Cumberland rivers. While Cumberlandian elements certainly increase upstream, the appearance of *D. dromas* and *D. arcaeformis* from the lower reaches of these rivers indicates that Cumberlandian elements may not have been quite as restricted in the past as the early surveys would indicate.

One finds a considerably different situation on the Ohio River. At both 15McN51 and Gordon II deep water species account for most of the site assemblage. These species are followed in number by moderate/tolerant varieties, with shallow water species accounting for 5%, or less, at either site. These results are basically consistent with what one should expect from this river environment. On the Ohio River, the species compositions at the archaeological sites indicate a paucity of shallow water habitats. As compared to the upper ends, the lower ends of large rivers tend to contain more silt, and tend to be deeper and slower moving. Although shallow water habitats are primarily restricted to sand and gravel bars, the shores of a number of small islands along this stretch of the Ohio River may have once maintained populations of mussels. To reach these islands the inhabitants would probably have required the use of a boat, and they may not have considered it worthwhile expending such effort to obtain the shellfish, or to transport them back to the habitation site. There is no evidence of prehistoric shell accumulations on these islands; however, the migration of the islands and shifts in the river's course may have eliminated such sites as may once have occurred. The conditions on the lower Ohio evidently have not changed much since the sites were occupied. The sporadic use of shellfish evident at the Gordon II Site probably indicates the lack of readily available species close to the site. Shellfishing activities were undoubtedly restricted to periods of extremely low water. The Ohio River sites are in a good position to undertake investigations concerning Ortmann's (1925) suggestion that Cumberlandian species may have descended the Tennessee and Cumberland rivers and establish themselves in the Ohio. The recovery of ***D. dromas*** and ***D. arcaeformis*** from the extreme lower ends of the Tennessee and Cumberland rivers would seem to make these two species likely candidates for penetration of the Ohio River. These two species prefer shallow riffle habitats and such conditions are not in evidence on this stretch of the river. Sites farther upriver - where more riffles and shoals occur may contain evidence for the migrations of Cumberlandian species; however, to date, with the exception of the seven species mentioned by Johnson (1980), no such species have been found. A comparison of the LCAP lower Ohio assemblages with the assemblage from the Angel Site indicates that virtually the same river conditions prevail in both areas.

CHAPTER VI

SHELLFISH EXPLOITATION IN THE LOWER TENNESSEE AND OHIO DRAINAGES

Overview

The prehistory of the southeastern United States can be placed in four broad time periods: Paleo-Indian, Archaic, Woodland and Mississippian. Although we know little about the Paleo-Indian period, we do know that over much of North America this time period is characterized by the presence of fluted points, by a highly mobile lifestyle and by exploitation of a rather narrow range of food resources.

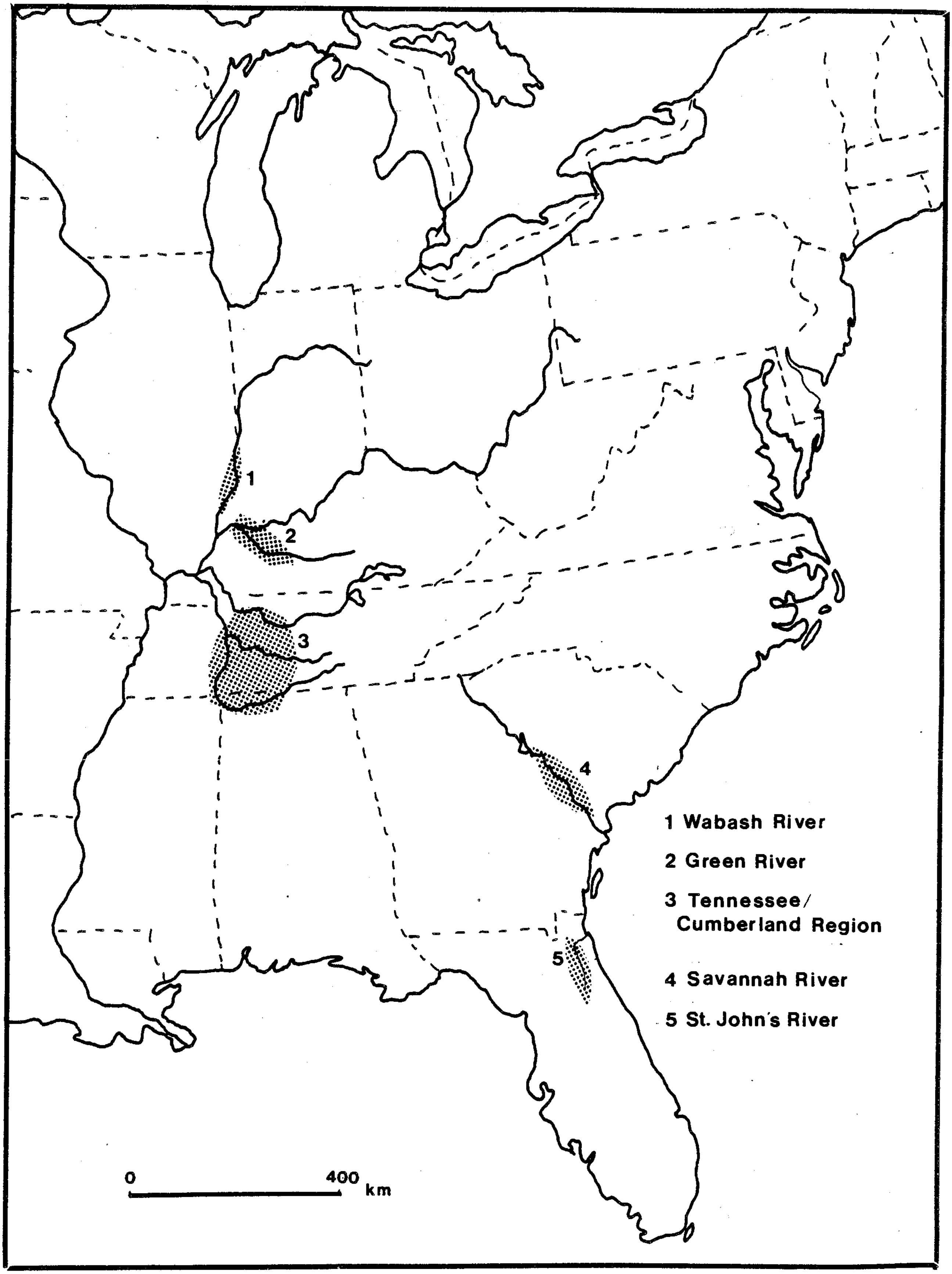
The Archaic period represents a shift in focus from the Paleo-Indian way of life to a more diverse economy, consisting of a variety of plants, small vertebrates, fish and aquatic invertebrates. During this period shell middens first appear in the southeast. Although in some areas of the Southeast, the first fibre-tempered pottery appears in the Late Archaic (Reid 1984), the transition between the Archaic and Woodland is marked by the appearance of ceramics that are tempered with grit, grog and sand. During the Woodland Period the first domesticates occur, though recent evidence suggests domesticated plants also have their origin in the Archaic (Marquardt and Watson 1983). There is evidence also for the advent of villages and ceremonialism. During the Mississippian period sites further diversify as ceremonial centers, fortified villages, hamlets and farmsteads; pottery is tempered with shell, and a variety of painted, decorated and effigy vessels appear late in the period. The economy is largely agricultural, though wild resources are still extensively exploited.

The Shell Mound Archaic

The focus that has become known as the Shell Mound Archaic occurs in the Late Archaic, from 2500 to 500 B.C. (though it could have originated as early as 4-5000 B.C. (see Morse 1967). Huge accumulations of river mussel shells characterize the Shell Mound Archaic at sites along the banks of some of the major southeastern rivers and their tributaries. The distribution of these sites is quite distinctive (Fig. 9). Shell Mound Archaic sites occur primarily on the Tennessee River in northern Alabama (Webb 1939; Webb and DeJarnette 1942), the lower Tennessee and Cumberland rivers in Tennessee (Morse 1967; Lewis and Lewis 1961; Bowen 1976), the Green River in western Kentucky (Moore 1916; Webb 1950a, 1950b, 1974; Marquardt and Watson 1983; Marquardt 1985), and the Wabash River in southeastern Illinois and southwestern Indiana (Winters 1967, 1969). There are other occurrences of Archaic freshwater shell midden sites along the Savannah River in Georgia (Stoltman 1974), Archaic shellmounds consisting primarily of gastropod shells along the St. Johns River in Florida (Wyman 1868, 1875; Cumbaa 1976) and lenses of shell occurring at isolated Archaic sites such as the Modoc Rock Shelter (Fowler 1959) and at Koster, both in Illinois (Hill 1975). Although Conaty (1985:36) states "In spite of sharing a wide variety of artifact types, shellmound sites from any given area can be differentiated from shellmound sites in other areas", Morse (1967) defines the Shell Mound Archaic on the basis of artifact assemblages. In his estimation, a Shell Mound Archaic site need not contain any shell.

Not all Late Archaic sites in the southeast contain shellfish remains. While all of these sites possess traits in common, the presence or absence of shell indicates different ecological orientations. Researchers investigating late Archaic subsistence and settlement systems have found that shellmound and non-shellmound sites in an area are frequently complementary and represent different aspects of the subsistence system (Conaty 1985, Bowen 1976). Such investigations have been undertaken on the Green River Drainage in McLean county (Fowler

Figure 9: The Distribution of Shellmound Archaic Sites in the Eastern United States.



1
2
3
4
5
1 Wabash River
2 Green River
3 Tennessee/ Cumberland Region
4 Savannah River
5 St. John's River
0
400 km

1959), on the Wabash (Winters 1969), and in the Tennessee River Valley in northern Alabama (Jenkins 1974), west-central Tennessee (Bowen 1976) and on the Duck River (Bowen 1979).

Theories concerning the origin and development of Shell Mound Archaic sites fall into three broad categories.

Cultural Evolution

Jeffries Wyman is credited with being the first to investigate the freshwater shellmounds of the St. Johns River region of Florida. In his estimation:

> ...it seems certain, that until the bow and arrow, the trap or net were invented, the animal food must of necessity been derived from such species as could most easily be obtained, and among these the shell-fish and more sluggish reptiles would first attract attention (Wyman 1868:458).

Considering the early date of his investigations, Wyman is perhaps to be forgiven for his simplistic notion of Archaic subsistence strategies. A similar opinion was echoed almost a century later by Caldwell (1958), who suggests that the Archaic peoples were initially tundra-adapted groups who slowly, over millenia, became acquainted with the forest environment. He suggests that the Shell Mound Archaic manifestations of the southeast indicate areas of lesser achievement in hunting skill. Webb and DeJarnette (1942) also see the Archaic as a time of cultural evolution. In the strata of Shell Mound Archaic sites they see a progression of tool types and cultural achievements. In the lowest levels they report:

> Doubtless the shellfish were eaten and their extraction from the shell accomplished by the aid of, perhaps, stone hammers and bone splinters, but nothing appears to indicate the intentional manufacture of artifacts in the lower 2 feet of shell, save one artifact, a section of bone having a hole drilled through it. This may have been a "shaft straightener" and may suggest that at this period most "tools" were made of wood or bone (Webb and DeJarnette 1942:264-5).

All of these hypotheses intimate that the inhabitants of Archaic Shell Mound sites exploited freshwater molluscs because they were unable to capture any sort of moving prey. This suggestion implies an incredible lack of sophistication on the part of these early populations. As Winters notes:

> All too frequently the Archaic peoples, who were greatly diversified culturally through space and time, are treated as though they were a homogenous array of hunters and gatherers, and as though they were *idiots savants* capable only of changing styles of artifacts, producing an occasional nicely ground piece of stone, continuously foraging for a precarious and uncertain subsistence, and in general doing little beyond surviving as noble and unspoiled primitives (Winters 1968:191).

Climatic and Environmental Change

Various theories have been proposed under this heading. Lewis and Lewis (1961) suggest that during the altithermal a drying trend effectively eliminated forests, their attendent fauna, and other food resources. During this time Archaic peoples were forced to search the river valleys for food, and thus became reliant upon easily obtained and abundant shellfish. The precipitation which followed the altithermal raised water levels and silt burden in the rivers. This change rendered the shellfish resource inaccessible, and thus explains the decline of shellfish remains in the upper levels of many Shell Mound sites.

Two additional theories which attempt to explain the sudden development of Shell Mound sites concern glacial retreat around 15,000 B.P. The first suggests that meltwater created excessive silting of all southeastern rivers. This effectively eliminated shellfish populations. The appearance of Shell Mound sites indicates a time when conditions stabilized, and streams were once again able to support thriving unionid fauna. The second suggests that the occurrence of freshwater shellmounds in the southeast coincides with the stabilization of sea levels. Prior to this time, stream gradients were too steep to support naiad life (Winters 1969).

There seem to be as many theories for the purpose of Shell Mound Archaic sites as there are for their development. Morse (1967) notes that these sites are most frequently associated with deer bones; and he suggests from this that they represent winter camps where Archaic peoples exploited the 'yarding' behavior of deer. During winter, deer move down into protected valleys and, as Morse argues, Archaic peoples camping in these valleys, consumed shellfish as a 'back-up' resource - either as a suppliment when deer were scarce, or for variety. Because this argument implies that shellfish were more commonly consumed in winter - rather than in summer or fall - it therefore contradicts the findings of most investigators. Subsequent research (see especially Claassen 1986; Manzano 1985) has shown that, in the Southeast, freshwater shellfish were rarely procured during the winter. Morse further suggests that also represented at the shellmound sites are other winter activities, such as trade and ritual behaviour. Evidence for these activities may be indicated by the presence of exotic goods (primarily marine shell and copper) and by the variety of burials.

Trade and Exchange

The focus of Shell Mound Archaic sites as centers of trade has been discussed by several authors (Bender 1985; Fitting and Brose 1970; Goad 1980; Marquardt 1985; Winters 1968; Wright and Zeder 1977). During the Middle and Late Archaic, trade items such as galena, copper, marine shell, bauxite, and various stone types, appear to have been traded over vast distances. It has been suggested that the Shell Mound Archaic cultures of the mid-south occur at the interface of the exchange zones of two important commodities: copper from the Great Lakes region and marine shell from the Florida Atlantic/Gulf coasts (Bender 1985; Fitting and Brose 1970; Goad 1980; Marquardt 1985; Marquardt and Watson 1983; Winters 1968; Wright and Zeder 1977). It is postulated that groups in this area, particularly in the Green River and the western Tennessee region, exploited their position as 'middlemen' between these two networks (Bender 1985; Goad 1980; Winters 1968).

Evidence of trade implies more than a simple exchange of commodities. In addition to tradeable items, trade requires organization and implies the existance of criteria of value and measure (Renfrew 1975). Exchange systems play an important and complex role within a culture. Renfrew (1969) discusses four ways in which trade can work within a culture system:

1. as a source of wealth to the trader and the community, since efficient or favorable exchange encourages the production of surplus;
2. toward specialized and hence more efficient production;
3. to promote contact between communities and, through personal interaction, to promote the exchange of ideas;
4. to create new demand for commodities, and ultimately, to stimulate their production.

As Bender (1985) points out, exchange is central to human adaptation. In particular, contact between groups has far-reaching implications. According to Harris:

> Hunter-gatherers achieve their lability on the structural level by intermarriages between neighbouring bands. The resultant network of kin ties facilitates visiting throughout the year. Bands reinforce their intergroup solidarity by making joint encampments and by engaging in common ceremonial activities in seasons when resources are abundant (Harris 1979:80).

In terms of subsistence, expanded alliances can facilitate increased flexibility and cooperation in the utilization of resources, and permit exchanges to help overcome deficiencies in one area or surpluses in another.

An increased network of contacts also creates social differentiation by delayed returns, and this leads to the concept of debt. Alliance and exchange systems institutionalize debt, and therefore inequality, by controlling access either to social or ritual knowledge, or to valued material items. Even if there are only a limited number of resources, this control can be achieved if services are substituted for products (Bender 1985). Thus exchange systems are highly politicized institutions. Archaeological information suggests that many changes in social structure were taking place during the Late Archaic, and these changes may indicate the existence of trade alliances which produced increased contact between neighbouring groups (Bender 1985).

The Shell Mound sites of the Southeast have been postulated as aggregation loci for the purpose of trade between two major trading networks from the north and south (Bender 1985). The Archaic peoples in the Southeast are presumed to have acted as middlemen in these transactions. No commodity has yet been identified with which they may have been uniquely dealing. The possibility exists that perishable goods or other items, such as information or spouses – which are difficult to discern archaeologically – may have been the items of exchange.

Numerous scholars have studied the characteristics of aggregation among hunter-gatherers (Bicchieri 1972; Conkey 1980; Gorman 1972; Hayden 1981; Jochim 1976; Lee and DeVore 1968; Testart 1982; Winterhalder 1981a). The specifics of how and why aggregation occurs are not pertinent here; however, several points need to be made. First, it is evident that large groups of people require much more effort to feed and shelter (Lee 1979). Because resources in the immediate area are often quickly depleted by a large group, it is necessary that aggregation phases either be of short duration or result in intensification of subsistence activites. Second, although large groups tend to be socially unstable, they frequently find stability and cohesion in sacred ceremonies and rituals (Lee 1979).

Intensification of subsistence activities during the Late Archaic is evident. This intensification appears to have occurred through the increased use of resources such as shellfish and hickory nuts. Given the larger numbers of available personnel, these resources would have been more easily accessible during aggregation phases (Bender 1985).

The ceremonial aspects of aggregation are also evident in the Late Archaic sites – both in the increased elaboration of burials and in the high numbers of ceremonial artifacts. It has been noted (Conkey 1980) that ecological factors can promote aggregation, and that such factors may in part explain the location of these trading centers or points of aggregation if, in fact, this is what the Archaic Shell Mounds represent. Shellfish are most easily accessible at periods of low water when they may be picked up by hand from shoals and riffles. Furthermore, shellfish occur most frequently at shallow places along a river, and such locations are more likely to be selected as points of crossing by both people and animals.

Along the rivers, campsites adjacent to shellfish habitats would be logical stopping points for bands on seasonal migration, and the shellfish would provide an abundant food resource.

The Importance of Freshwater Shellfish in the Archaic

In their description of the prehistory of the eastern United States, Ford and Willey (1941) state:

> A common feature of nearly all of these (Archaic) sites is the fact that they are located at points where an abundant supply of shellfish was available and the occupation areas are marked by large accumulations of discarded shells. The economic value of these stations appears to have been so obvious that many of them continued to be occupied throughout the cultural stages which succeeded the Archaic (Ford and Willey 1941:332).

The implication is that Archaic sites normally contain shell, and that those that do not must somehow be explained. In fact, Shell Mound Archaic sites represent a particular type of feature and are produced in response to a specific set of social and environmental conditions.

The fact is that the amount of shellfish present in Archaic shell mounds is highly variable. According to Winters:

> Our own experience with midwestern shell middens has been that such shell middens consist only in small part of actual shell accumulations which occur as lenses in the conglomeration of black soil, rock and other midden debris...[O]ne is left with the total impression that while the quantity of shell varied in the middens, at no site was there simply a dense homogenous mass of river mussels (Winters 1968:183).

Similar statements are made by Webb in many of his reports of shell mound sites (see Winters 1968:183 for citations). In their survey, Lewis and Kneberg (1959) report Archaic sites with variable amounts of shell debris. However, because shell tends to be the most visible matrix component, the amount of shell in middens can easily be misleading (Meighan 1969). A midden containing only 30% shell by weight will appear to be almost pure shell; other components (e.g., rocks, soil) have a greater density and smaller volume. Understandably, photographs can be particularly misleading. It is probable that Archaic shell midden sites have obtained their reputation from being the most visible type of archaeological deposit in the southeast, and from their excellent preservational qualities. Returning to the statement by Ford and Willey (1941), it is certainly true that Archaic shell middens are located at points where shellfish were abundant and available. The rivers flowing by many Archaic sites continued, until recently, to support large quantities of mussels. It is no surprise, for example, that the largest and greatest number of Archaic shell mounds sites occur along the Tennessee River in Lauderdale and Colbert counties in northern Alabama, since it is here that the famous shoals area, which supported the greatest number and density of species of freshwater mussels in the world, was located.

To summarize, Caldwell (1958) takes perhaps the most reasonable perspective as regards the actual place of Shell Mound Archaic manifestations in the southeastern United States:

> For the east as a whole it is much more usual to find Archaic sites without associated shell mounds. It is evident now that the shellfish exploitation described for the Lauderdale, Indian Knoll, Savannah River and St. Johns foci has been overemphasized in the literature. A fairer picture of the Archaic would regard the shell mound peoples as practicing a specialized economy in the areas where the supplies were abundant (Caldwell 1958:12).

The Archaic Culture in the Lower Tennessee, Cumberland and Ohio Region

Within the lower Tennessee, Cumberland and Ohio area the earliest documented human occupations date to the Early Archaic (ca. 8200–8500 B.P.) (Nance 1986a, 1986b). Two deeply stratified, multi-component sites provide most of the data. The Morrisroe Site (15LV156) is located on the right bank of the Tennessee River at TRM 13, in Livingston county, Kentucky. The Whalen site (15LY48) is located on the right bank of the Cumberland River at CRM 24, in Lyon County, Kentucky. Excavations at these two sites document the Archaic in this region over the period 8000–8500 B.P. to 2500–3000 B.P. (Conaty 1985; Conaty and Nance 1983; Nance 1981, 1982, 1984a, 1984b, 1986a, 1986b; Nance and Conaty 1982).

The indicated settlement pattern suggests that populations were highly mobile during the Early Archaic. During the Middle Archaic, groups repeatedly and intensively inhabited flood-plain sites, possibly in response to effects of the hypsithermal, which probably concentrated many of the plant resources and their attendant fauna in the river valleys. As the climatic events of this period passed, and resources again established themselves in the uplands, a return to greater mobility occurred in the Late Archaic (Conaty 1985). This sequence is similar to that suggested for the Eva Site (Lewis and Lewis 1961), by water the nearest Archaic shell midden to Morrisroe. At Eva, however, the stratum representing the Three Mile Phase (a late Middle Archaic component) is characterized by a large concentration of mussel shell. The question remains as to why there is no evidence for the prehistoric use of freshwater shellfish during the Archaic in the lower Tennessee, Cumberland and Ohio region.

One possible explanation for this lack of evidence is that mussels did not establish themselves in the lower reaches of the Tennessee and Cumberland rivers as early as they did further upriver. At the onset of the Holocene, the Ohio and other streams entering into it from the north acted as sluiceways for the water that was discharged from the great icesheets of the midwestern states (Alexander and Prior 1968; Leach 1981; Nance 1984b; Ray 1965; Shaw 1915; Thornbury 1950). The glacial melt and sediments clogged the Ohio, and, in turn, affected north-flowing streams, such as the Tennessee and Cumberland, by raising their base levels and effectively ponding them (Finch et al. 1964; Leach 1981, 1982; Leach and Jackson 1986; Nance 1984b; Olive 1964). It is estimated that these conditions cleared about 15,000 years ago. However, the possibility remains that the effects of this event could have rendered the lower Tennessee, Cumberland and Ohio uninhabitable for mussels for a considerable time after this period. Specifically, the freed rivers would be running through silt deposits laid down during the ponding stage. Such fine-grained particles in suspension, and on river bottoms, are highly detrimental to the survival of molluscs. Further, only a small rise in the level of the Ohio River would be required to change significantly conditions in the lower Tennessee and Cumberland Rivers. Such a rise would cause the rivers to back up, and would therefore create deeper water and slower currents. Both effects would be harmful to mussel propagation. An additional point worth considering is that, although some mussel species may survive the rising river levels, such an event would likely render these species inaccessible to humans.

Recent investigation at the Whalen Site (Nance, Casey and Leach in preparation) provides evidence that shellfish may have been established in the lower Cumberland at least as early as 6100 to 5100 BC. The Whalen Site consists of upper and lower midden zones, which are separated by a culturally sterile level. The midden zones have been radiocarbon dated to about 5100 and 6100 years BC, respectively. Recovered within this sterile zone, which consists of sandy clay-silts, were a number of mussel shell valve impressions.

The impressions appear to consist only of the periostracum, occasionally with a little of the calcium carbonate layer preserved. For a number of reasons, the impressions do not resemble an archaeological assemblage. First, associated cultural indicators (artifacts, carbon) are much reduced in abundance in levels yielding the shell impressions. Second, the shells are not as concentrated, as would be expected, in a archaeological deposit. Finally, the fact that the periostracum is preserved rather than the inorganic portion, suggests an unusual set of taphonomic circumstances, for example, the existence of an anaerobic environment. Further, the deposit would also have had to have been sufficiently acidic to dissolve the calcium carbonate shell. Entire shell beds have been known to become entirely buried with sudden mud and silt deposition during freshets (Smith 1899). Riverbank slumping could have produced the same effect.

The occurrence of these mussels strongly suggests that the lower Cumberland, at least, was capable of supporting a mussel population during the Middle Archaic. The fact that a natural deposit of mussels occurs between two cultural layers suggests that the river may have undergone some rather extreme shifts in its bed. Investigations to establish the true nature of the depositional process are ongoing.

A second possibility for the non-occurrence of shellfish at Archaic sites in this area concerns the seasonal scheduling of subsistence activities. If the site occupants inhabited the site only during winter and spring, shell absence could indicate inaccessibility due to seasonal high water levels. This hypothesis agrees with Morse (1967), who suggested that river valleys were popular winter sites for Archaic groups who arranged their schedules around the yarding behavior of deer. Unfortunately, few seasonal indicators are evident at either Morrisroe or Whalen. That the most frequently recovered botanical remains are hickory nuts indicates a late summer/fall occupation. The extreme durability of these nut shells suggests that they are probably over-represented in the archaeological record, and they are thus difficult to evaluate as seasonal indicators. The possibility also exists that they were stored and/or transported. In addition, it should be noted that the presence of fall indicators does not preclude winter occupation.

A third possibility is that the lower ends of the Tennessee, Cumberland and Ohio rivers only sustained those mussel species which had a preference for deep water, and which therefore, were not easily gathered by Archaic groups. However, since archaeological evidence suggests that they were adept at gathering a wide variety of foods, it is unlikely that these people did not possess the technology required to retrieve mussels from deep water. Because the activity would likely require large numbers of people and equipment, it is possible that they simply found it unworthwhile.

The history of shellfish gathering in this region strongly suggests that the resource was never a popular dietary element. The evidence presented here for the Mississippian period indicates that the Mississippian people in this area rarely took shellfish, and, even then only took them during periods of low water, presumably when the shellfish could not be ignored. Although it is unlikely that the local Archaic populations avoided shellfish, it is obvious that mussels were not exploited to the same extent in this region that they were in the major shell mound areas of the mid-south. As previously noted, reasons for this lack of resource utilization are numerous. Included among them are seasonality and scheduling, aspects of geologic history, accessibility, and a possibly a lack of large aggregations which would make intensification of low-return resources necessary. Although mussels may not have been avoided as a resource by the Archaic peoples of the lower Tennessee, Cumberland and Ohio region, it is nonetheless true that evidence of their occasional use has not survived in the archaeological record.

CHAPTER VII

SUMMARY AND CONCLUSIONS

Because of their preservational properties and their frequently large size, cultural accumulations of shellfish remains have provided a unique type of archaeological site. Techniques for investigating these features have changed throughout the years in response to the growing number of concerns adopted by the discipline of archaeology. Central to most inquiries into shell midden deposits is the place of shellfish in the diet and in the ecology of prehistoric peoples. This thesis explores the questions surrounding a particular type of shell midden - that is, those middens which consist of freshwater shellfish.

The focus of the research was on the extreme lower ends of the Tennessee, Cumberland and Ohio rivers in western Kentucky. Freshwater shellfish accumulations at six Mississippian sites, located on the banks of these rivers, were examined and compared with prehistoric shellfish assemblages from middens dating to various time periods farther up the rivers.

Results indicate that a wide variety of shellfish species were procured by the prehistoric inhabitants from the rivers immediately adjacent to the sites. The ecological requirements of these species indicate that in prehistoric times, the lower ends of the Tennessee and Cumberland rivers contained significantly more shallows, probably in the form of shoals and bars, than at present. The assemblage from the Ohio River indicates that deep water conditions predominated prehistorically as they do now. The recovery of significant numbers of shellfish species that are known to prefer deeper water habitats suggests that these shellfish were collected at these sites during periods of low water. Given the small size of the accumulations at these sites, it is probable that the shellfish were collected occasionally during extremely dry seasons, perhaps in response to a reduction in the availability or abundance of other food resources. More likely, it was because the shellfish resource had become so accessible and easily obtainable.

Shellfishing activity in the southeastern United States reached its peak during the Late Archaic when large shell mounds appeared in specific areas of the Southeast, primarily on the Tennessee River in northern Alabama, the Green River in west-central Kentucky, and on the Wabash and Savannah rivers. There are many hypotheses relating to how and why these features came about; however, it is suggested that the importance of shellfish at these Shellmound Archaic sites has been somewhat over-emphasized in the literature. Recent investigators (Winters 1968; Goad 1980; Bender 1984, 1985) have postulated that some of these Archaic sites functioned as centres of exchange at the interface between trading networks from the north and south. The occurrence of shellfish could represent a response to the periodic aggregation and the resulting intensification of subsistence activities - in this case, attention to labour-intensive resources such as shellfish.

Freshwater shellfish were probably never a major resource for the Archaic peoples. Their overrepresentation in the archaeological record may have more to do with the large numbers of shellfish that are required to produce even a relatively small meal, with their high visibility in the midden matrix, and with the fact that shells often preserve well. The large mounds of shells in evidence in some regions of the southeast are probably due to the repeated seasonal occupation of these sites by successive small groups and/or to the use of these locations by large groups during aggregation phases. These shellmounds most frequently occur on riverbanks which are adjacent to shoals and from which shellfish could easily have been obtained during periods of low water. Such areas often provide excellent locations for fording large rivers and are therefore natural sites for camps and/or other forms of aggregation. It is no coincidence that the most extensive and greatest number of freshwater shellmounds in the world occur on the Tennessee River adjacent to the Mussel Shoals in northern Alabama; since it is here that the greatest concentrations of specimens and species of freshwater shellfish in the world once occurred. It is evident that Archaic shellmound sites in the Southeast are the exception rather than the rule. These sites can most simply be considered a response to specific ecological conditions during a small portion of the seasonal round. It is also evident that the later Woodland and Mississippian periods saw a reduction in the exploitation of shellfish. Shell remains continue to occur in midden matrix at some sites during these later time periods, but nowhere do they produce the extremes of depth and number of the Archaic shell midden sites.

Finally, an unforeseen result of this research was derived from comparisons of archaeological shellmounds along these rivers with lists compiled by early researchers who investigated modern distributions of unionid species throughout the eastern United States. This comparison has revealed the presence of several species not previously known to occur in the lower ends of these rivers, and thus has extended our knowledge of their past distributional ranges.

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