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A Descriptive Survey of Freshwater Unionidae Bivalves in Five Creeks Located in West Central Georgia

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A DESCRIPTIVE SURVEY OF FRESHWATER
UNIONIDAE BIVALVES IN FIVE CREEKS
LOCATED IN WEST CENTRAL GEORGIA

Rufus Carson Stringfellow



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Columbus State University

The School of Science

The Graduate Program in Environmental Science

A Descriptive Survey of Freshwater Unionidae Bivalves in Five Creeks
Located in West Central Georgia

A Thesis in

Environmental Science

by

Rufus Carson Stringfellow

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Master of Science

June 1997

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Sept 3-20-97

I have submitted this thesis in partial fulfillment of the requirements for the degree of Master of Science.

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ABSTRACT

A descriptive survey of the West Georgia, Chattahoochee River drainage unionid bivalve fauna inhabiting Mountain Oak, Mulberry, Standing Boy, and Upatoi Creeks has been completed. The survey is intended to determine whether Unionidae populations remain extant in this portion of the Chattahoochee River drainage, and to estimate the abundance and distribution of species encountered. Accessibility sampling was employed; sites selected to be surveyed were usually located at a road bridge or some landmark easily identifiable for geographical positioning. Collecting methods included the use of a small rake in sandy or silty substrate, visual detection of siphons or trails in the soft sediment, manual probing in rocky substrates, and collection of shells from dead individuals on sand bars and overwash areas. Results from this survey were 494 specimens collected between August 1995, and the end of October 1996. Twelve Unionidae species and the Asiatic clam, *Corbicula fluminea*, comprised this collection. Each stream sampled contained Unionidae species; some species clearly inhabited restricted locations (ex. *Elliptio arctata*) and others (ex. *Elliptio complanata*) were widely distributed, reflecting eurytopic adaptations. The most common native Unionidae species encountered were *Elliptio complanata* and *Villosa lienosa*. Based on the best data available at this time, there is a range extension into the Chattahoochee River System of one species, *Anodonta peggyae* Johnson, 1965. Factors that appear to limit the distribution and abundance of Unionidae species include heavy siltation caused by anthropogenic stream-side activities, impoundments, and absence of specific habitat types or environmental conditions.

TABLE OF CONTENTS

| | |
|--|------|
| ABSTRACT..... | iii |
| LIST OF FIGURES..... | v |
| LIST OF TABLES..... | vii |
| LIST OF MAPS..... | viii |
| I. INTRODUCTION AND NATURE OF STUDY..... | 1 |
| II. METHODS AND MATERIALS..... | 6 |
| III. DESCRIPTION OF STUDY AREA..... | 8 |
| IV. RESULTS..... | 9 |
| V. SPECIES ENCOUNTERED..... | 11 |
| VI. DISCUSSION..... | 43 |
| VII. DISCUSSION OF THE ASIATIC CLAM..... | 53 |
| VIII. CONCLUSION..... | 54 |
| LITERATURE CITED..... | 57 |
| APPENDICES | |
| A. Study Area and Distribution Maps..... | 60 |
| B. Locations of Collection Sites..... | 73 |

LIST OF FIGURES

| Figure | Page |
|---|------|
| 1 Location map of study area, West Central Georgia..... | 3 |
| 2 Morphology of freshwater mussel shell illustrating terminology..... | 10 |
| 3 Photograph of <i>Anodonta imbecilis</i> , left valve, external view..... | 14 |
| 4 Photograph of <i>Anodonta imbecilis</i> , left valve, external view and right valve, internal view..... | 14 |
| 5 Photograph of <i>Anodonta peggyae</i> , left valve, external view..... | 17 |
| 6 Photograph of <i>Anodonta peggyae</i> , left valve, external view and right valve, internal view..... | 17 |
| 7 Photograph of <i>Anodonta grandis</i> , left valve, external view..... | 19 |
| 8 Photograph of <i>Anodonta grandis</i> , left valve, external view and right valve, internal view..... | 19 |
| 9 Photograph of <i>Villosa lienosa</i> , left valve, external view (female)..... | 22 |
| 10 Photograph of <i>Villosa lienosa</i> , left valve, external view and right valve, internal view (female)..... | 22 |
| 11 Photograph of <i>Villosa lienosa</i> , left valve, external view (male)..... | 23 |
| 12 Photograph of <i>Villosa lienosa</i> , left valve, external view and right valve, internal view (male)..... | 23 |
| 13 Photograph of <i>Villosa vibex</i> , left valve, external view (female)..... | 26 |
| 14 Photograph of <i>Villosa vibex</i> , left valve, external view and right valve, internal view (female)..... | 26 |
| 15 Photograph of <i>Villosa vibex</i> , left valve, external view (male)..... | 27 |
| 16 Photograph of <i>Villosa vibex</i> , left valve, external view and right valve, internal view (male)..... | 27 |
| 17 Photograph of <i>Villosa sp.</i> , left valve, external view..... | 28 |

| | | |
|----|---|----|
| 18 | Photograph of <i>Villosa sp.</i> , left valve, external view and right valve, internal view..... | 28 |
| 19 | Photograph of <i>Elliptio complanata</i> , left valve, external view..... | 31 |
| 20 | Photograph of <i>Elliptio complanata</i> , left valve, external view and right valve, internal view..... | 31 |
| 21 | Photograph of <i>Elliptio icterina</i> , left valve, external view..... | 34 |
| 22 | Photograph of <i>Elliptio icterina</i> , left valve, external view and right valve, internal view..... | 34 |
| 23 | Photograph of <i>Elliptio arctata</i> , left valve, external view..... | 37 |
| 24 | Photograph of <i>Elliptio arctata</i> , left valve, external view and right valve, internal view..... | 37 |
| 25 | Photograph of <i>Megaloniaias boykiniana</i> , right valve, external view..... | 39 |
| 26 | Photograph of <i>Megaloniaias boykiniana</i> , right valve, internal view..... | 39 |
| 27 | Photograph of <i>Uniomereus tetralasmus</i> , left valve, external view..... | 42 |
| 28 | Photograph of <i>Uniomereus tetralasmus</i> , left valve, external view and right valve, internal view..... | 42 |
| 29 | Frequency of size classes (<i>Anodonta imbecilis</i>) Mt. Oak Creek (n=58)..... | 45 |
| 30 | Frequency of size classes (<i>Anodonta peggyae</i>) Mt. Oak Creek (n=25)..... | 46 |
| 31 | Frequency of size classes (<i>Elliptio complanata</i>) Upatoi Creek (n=189)..... | 51 |
| 32 | Frequency of size classes (<i>Villosa lienosa</i>) Upatoi Creek (n=99)..... | 52 |

LIST OF TABLES

| Table | Page |
|---|------|
| 1 Individual species records for the 18 productive sites included in this survey..... | 10 |

LIST OF MAPS

| Map | Page |
|---|------|
| 1 Area surveyed in this study with all collecting sites indicated..... | 61 |
| 2 Distribution of <i>Anodonta imbecilis</i> Say, 1829 within the study area..... | 62 |
| 3 Distribution of <i>Anodonta peggyae</i> Johnson, 1965 within the study area..... | 63 |
| 4 Distribution of <i>Anodonta grandis</i> Say, 1829 within the study area..... | 64 |
| 5 Distribution of <i>Villosa lienosa</i> Conrad, 1834 within the study area..... | 65 |
| 6 Distribution of <i>Villosa vibex</i> Conrad, 1834 within the study area..... | 66 |
| 7 Distribution of <i>Elliptio complanata</i> Lightfoot, 1786 within the study area..... | 67 |
| 8 Distribution of <i>Elliptio icterina</i> Conrad, 1834 within the study area..... | 68 |
| 9 Distribution of <i>Elliptio arctata</i> Conrad, 1834 within the study area..... | 69 |
| 10 Distribution of <i>Megalonaias boykiniana</i> Lea, 1840 within the study area..... | 70 |
| 11 Distribution of <i>Unio merus tetralasmus</i> Say, 1831 within the study area..... | 71 |
| 12 Distribution of <i>Corbicula fluminea</i> Muller, 1774 within the study area..... | 72 |

LIST OF MAPS

| Map | Page |
|---|------|
| 1 Area surveyed in this study with all collecting sites indicated..... | 61 |
| 2 Distribution of <i>Anodonta imbecilis</i> Say, 1829 within the study area..... | 62 |
| 3 Distribution of <i>Anodonta peggyae</i> Johnson, 1965 within the study area..... | 63 |
| 4 Distribution of <i>Anodonta grandis</i> Say, 1829 within the study area..... | 64 |
| 5 Distribution of <i>Villosa lienosa</i> Conrad, 1834 within the study area..... | 65 |
| 6 Distribution of <i>Villosa vibex</i> Conrad, 1834 within the study area..... | 66 |
| 7 Distribution of <i>Elliptio complanata</i> Lightfoot, 1786 within the study area..... | 67 |
| 8 Distribution of <i>Elliptio icterina</i> Conrad, 1834 within the study area..... | 68 |
| 9 Distribution of <i>Elliptio arctata</i> Conrad, 1834 within the study area..... | 69 |
| 10 Distribution of <i>Megaloniais boykiniana</i> Lea, 1840 within the study area..... | 70 |
| 11 Distribution of <i>Unio merus tetralasmus</i> Say, 1831 within the study area..... | 71 |
| 12 Distribution of <i>Corbicula fluminea</i> Muller, 1774 within the study area..... | 72 |

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INTRODUCTION AND NATURE OF STUDY

North America has the richest freshwater bivalve fauna in the world with approximately 297 species and subspecies (Neves, 1992); the vast majority (nearly 290 species) occurring in rivers of the southeastern United States. These species, with a few exceptions in the Family Margaritiferidae, belong to Family Unionidae. Of the 297 species and subspecies recognized, 21 species (7%) are presumed extinct, 42 (14%) are federally listed as endangered or threatened, and 69 (23%) are candidates for federal protection (Neves, 1992).

Freshwater bivalves continuously siphon water from their habitat, filtering microscopic organisms for food. Because of their nonselective feeding method, the bivalves can accumulate chemicals in their bodies and shells, including any pollutants present in their environment. As a result of this behavior, bivalves serve as excellent bioindicators of the environmental well-being of streams they inhabit. "People don't realize the value of a bivalve anchored on the bottom of a river or stream. Like canaries in a coal mine, these humble bivalve shellfish herald trouble" (Stolzenburg, 1992).

The Apalachicola, Chattahoochee, and Flint (ACF) river system forms one of the largest drainages in the eastern Gulf Coastal Plain. It comprises a large portion of the Apalachicolan Region, defined as the drainages flowing into the Gulf of Mexico, from the Escambia to the Suwannee River. Also included are the St. Marys and Satilla Rivers, although they flow into the Atlantic Ocean (Johnson, 1970). These river systems include parts of southeast Alabama, southwest Georgia, and northwestern Florida. Historically, the ACF River System was noted for its rich Unionidae populations composed of approximately 40 species, several of which are endemic to the system (Butler, 1993). In 1991 a comprehensive three-year study of freshwater bivalve populations in the ACF was initiated by the U.S. Fish and Wildlife Service (FWS); prior to this time, no study of this type having been conducted in the region (Butler, 1993). The survey was initiated by the FWS to determine the status of seven species of bivalves, including four species which are

endemic to the ACF River system. The seven species of greatest concern are the Fat Threeridge (*Amblema neislerii*), Shinyrayed Pocketbook (*Lampsilis subangulata*), Gulf Moccasinshell (*Medionidus penicillatus*), Ochlockonee Moccasinshell (*Medionidus simpsonianus*), Oval Pigtoe (*Pleurobema puriforme*), Chipola Slabshell (*Elliptio chipolaensis*), and the Purple Bankclimber (*Elliptioideus sloatinanus*). These species were of particular concern to the FWS as candidates for federal protection under the Endangered Species Act of 1973.

In this survey, I attempted to determine the distribution and abundance of Unionidae mollusks in five creek systems in west-central Georgia. The creeks included in the survey were Mountain Oak, Mulberry, Standing Boy, Bull, and Upatoi (Fig. 1). These creeks were chosen because they are the five largest tributaries of the Chattahoochee River drainage basin in the Columbus, Georgia, region. The most northern creek, Mountain Oak, originates in the western part of Pine Mountain, flows 26 km (16 miles) in a southwesterly direction, and empties into Harding Reservoir, a Georgia Power Company impoundment of the Chattahoochee River. The entire length of Mountain Oak Creek is located in the Piedmont geologic province, northern Harris County, Georgia. No reference of unionid specimens being collected from Mountain Oak Creek has been found in the literature. To the south Mulberry Creek, originates in western Talbot County, Georgia, in the Oak Mountain area and flows 48 km (30 miles) in a southwestern direction across the width of Harris County, also located in the Piedmont geologic province, and empties into Goat Rock Reservoir, another Georgia Power Company reservoir of the Chattahoochee River. Standing Boy Creek is also located in the Piedmont geologic province and originates in south central Harris County, Georgia. Standing Boy Creek flows 27.5 km (17 miles) in a southwesterly direction, entering the northwestern corner of Muscogee County, Georgia, and emptying into Oliver Reservoir, another Georgia Power Company reservoir of the Chattahoochee. Bull Creek originates in northern Muscogee County, flows southwesterly approximately 26 km (16 miles), and emptying into the Chattahoochee south of metropolitan Columbus. The southern most creek in the study is

Upatoi Creek. Upatoi Creek originates in east-central Talbot County, Georgia, flows south-southwest through the Piedmont, and enters the Coastal Plain geologic province at approximately the location at which Pine Knot Creek enters Upatoi. After entering the Coastal Plain Province, Upatoi flows through the Fort Benning Military Reservation and enters the Chattahoochee River south of Columbus, Georgia, for a total of 68 km (42 miles) length.

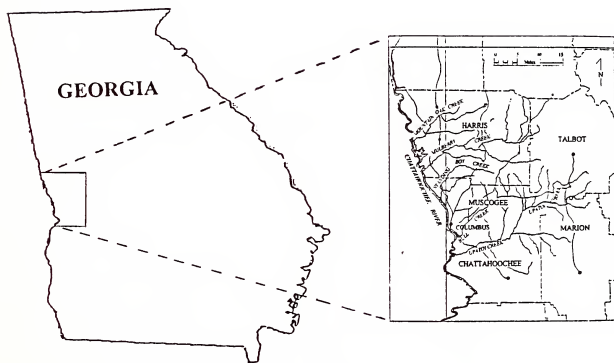


Figure 1. Location map of study area, West Central Georgia.

Considerable controversy and confusion surround historic collections made in this region. Lea (1840, 1856, 1857, 1869), described most species of Unionidae found in the Columbus, Georgia area. A number of collectors contributed to Lea's large collection (Clench and Turner, 1956). Conrad (1834) published a booklet with illustrations of some American freshwater shells. It is thought that Conrad collected a few species of freshwater bivalves in the Flint River, very probably at Albany, Georgia (Clench and Turner, 1956). Conrad traveled throughout much of Alabama and into limited areas of Georgia, where it is said that he made many notable discoveries. Lea and Conrad became antagonists regarding publication dates; the antagonism caused Lea to deposit his extensive collections in the United States National Museum, and not in the Academy of Natural Science at Philadelphia, under whose auspices many of his studies had been published (Clench and Turner, 1956). Discrepancies occurred in the original works when referring to Macon, Georgia; Macon County, Georgia; and Macon County, Alabama and exact localities could not be determined from the original data. These original errors were later published and republished with occasional new errors adding to the confusion. Many of the works and collections were lost or scattered among different museums. Simpson (1900) published a *Synopsis of the Naiades or Pearly Fresh Water Mussels of the World* (cited in Webb, 1942). This volume was a check list with brief shell descriptions. During the decade of the 1940's, considerable and intensive studies were made of the freshwater class of shells, new nomenclature was established, and the whole fauna of pearly mussels of the world was elevated to a systematic basis (Webb, 1942). Some confusion in the early years of freshwater mussel species identification was caused by the differences in shell characteristics found in the male and female of most species. Frequently, male and female specimens of the same species were classified as different species.

In the early 1950's W.J. Clench and R.D. Turner completed a survey entitled, *Freshwater Mollusks of Alabama, Georgia, and Florida, from the Escambia to the Suwannee River*. Some survey sites of this study included portions of Mulberry and Upatoi Creeks. Athearn (1955) located a limited number of species upstream and

downstream of Columbus in the Chattahoochee River. Some tributaries of the Chattahoochee River have been identified as sites of extant bivalve populations. On the east (Georgia) side of the Chattahoochee, Mulberry Creek is mentioned most often in the Unionidae (Mollusca: Bivalvia) historical literature, and there are occasional mentions of Upatoi and Bull Creeks; however, definitive locations are not provided. Jenkinson (1973) completed a study in which the distribution of the Unionacean bivalves in four creek systems in east-central Alabama were described. Two of the streams are Chattahoochee drainage streams: Halawakee and Uchee Creeks. The, 1991, Fish and Wildlife Service survey mentioned sampled sites of Upatoi but did not mention Mountain Oak, Standing Boy, Bull, or Mulberry Creeks. The most recent freshwater bivalve survey work in the Columbus, Georgia, area was conducted by Keferl (1994), including the section of Bull Creek from Schatulga Road bridge to the Georgia highway route 22 bridge.

METHODS AND MATERIALS

Specimens were collected at 45 sites in five tributaries of the Chattahoochee River drainage system. The field work was initiated in October 1995 and continued through the Fall of 1996. Sites selected for sampling in this study were located either at a road bridge or at some other recognizable landmark that would be easily identifiable for future location purposes. Location data for each site included: date, collection reference number, drainage, creek name, county and state, air kilometer and (mile) distance from two cities or towns, and names of the collector(s).

Collecting techniques varied at different sites, the methods included: using a small rake in sandy or silty substrates, visual spotting of siphons or trails in soft bottoms of streams, using manual probing in rocky substrates, and collecting dead bivalve shells on sand bars and overwash areas. Manually probing with hands has been the most productive method in the rocky Piedmont streams. At each collecting site, approximately 200 meters of stream were surveyed in two hours, one hour per each 100 meters reach of stream; if the site was at a bridge, 100 meters upstream and 100 meters downstream of the bridge were searched. If bivalves were found at a collection site, representative voucher specimens were selected for the site and the remaining living bivalves were returned to their habitat.

In the laboratory, living bivalve specimens were preserved by first relaxing the individuals by adding chloroform slowly to the medium until the valves gaped. After the valves were relaxed and gaped, a peg was inserted between the valves to prevent closing when the specimens were placed in a solution of 70% ethyl alcohol and 1% glycerin to preserve and fix the soft tissue (per McMahan, 1991). The specimens were allowed to remain in the fixing solution for approximately two weeks to insure proper fixation, the soft parts were removed from the shells, and both the shells and soft tissue were assigned catalog numbers. The soft tissue was labeled with catalog number, placed in individual preservative (70% ethyl alcohol and 1% glycerin) containers and the catalog number was written on the inside of each valve with India ink. After the shells had been numbered, the

thin shells (*Anodonta sp.*) were coated several times with Krylon clear polyurethane coating (Shelton, 1996) to prevent cracking, and all other shells were coated with Krylon matte finish clear polyurethane coating (Shelton, 1996) to protect the periostracum. The shells were placed in storage for later use. The specimens included in this study are deposited in the zoology museum, in LeNoir Hall at Columbus State University, Columbus, Georgia.

DESCRIPTION OF STUDY AREA

The area covered in this study is located in west central Georgia and includes all of Harris, Muscogee, and parts of Talbot and Chattahoochee Counties. The study area lies between $32^{\circ} 15'$ and $32^{\circ} 45'$ north latitude and between $84^{\circ} 30'$ and $85^{\circ} 15'$ west longitude.

Most of the study area lies in the Piedmont Geologic Province of Georgia, only the lower portion of the southern-most stream, Upatoi Creek, lies in the Coastal Plain Province. The Fall Line is the boundary between the Piedmont and Coastal Plain Provinces. This boundary approximately follows the contact between crystalline rocks of the Piedmont Province and the unconsolidated Cretaceous and Tertiary sediments of the Coastal Plain. Alluvial streams in the Piedmont have three general appearances: shoals, sometimes with white water and falls, gently meandering slower runs, and strongly meandering slow water (Wharton, 1978). The streams of the Piedmont have characteristically narrow floodplains, usually less than 0.8 km (0.5 mile) in width, and the floodplains may border one or both sides of the stream. Usually the shoals in Piedmont streams are degrading. These tend to alternate with floodplains or bottomlands that are generally maintained by aggradation (Wharton, 1978). The shoal areas supported a different biota from the slower stretches of Piedmont streams, which was evident because shoals were most productive for unionids included in this survey. Streams in the Coastal Plain typically lack the riffles and shoals common to Piedmont streams and usually have greater floodplains development.

RESULTS

The specimens collected during this survey totaled 494 individuals, representing six genera and 12 species. These totals for each species encountered at the 18 productive sites are presented in Table 1.

Table 1. Individual species records for the 18 productive sites included in this survey.
Totals by species for the entire area covered by this survey.

| CHATTAHOOCHEE RIVER SYSTEM | Mt. Oak Creek | Mulberry Creek | Standing Boy Creek | Bull Creek | Upatoi Creek | Number of Specimens |
|----------------------------------|---------------|----------------|--------------------|------------|--------------|---------------------|
| 1. <i>Anodonta imbecilis</i> | 58 | | | 2 * | | 60 |
| 2. <i>Anodonta grandis</i> | 2 | | | | | 2 |
| 3. <i>Anodonta peggyae</i> | 25 | | | | | 25 |
| 4. <i>Elliptio complanata</i> | 1 | 11 | 20 | | 189 | 221 |
| 5. <i>Elliptio arcata</i> | | 10 | 16 | | | 26 |
| 6. <i>Elliptio icterina</i> | | 2 | 16 | | 7 | 25 |
| 7. <i>Uniomereus tetralasmus</i> | | | | 5 * | | 5 |
| 8. <i>Villosa lienosa</i> | | | 14 | | 99 | 113 |
| 9. <i>Villosa vibex</i> | 1 | 5 | 2 | | 5 | 13 |
| 10. <i>Villosa sp.?</i> | | | 3 | | | 3 |
| 11. <i>Megalonias boykiniana</i> | | | | 1 | | 1 |
| 12. <i>Corbicula fluminea</i> | X | X | X | X | X | |
| Total Unionacean specimens | 87 | 28 | 71 | 8 | 300 | 494 |

X = Too numerous to count.

* Keferl - collected specimens 1994.

SPECIES ENCOUNTERED

The following descriptions includes all of the Unionidae bivalves collected as part of this survey. The overall range distribution was compiled from the literature and the distribution of species within the study area are based on location of specimens collected in this survey. Habitat information included with taxonomic description is based on the literature, data collected, and observations made during the survey. Maps with distribution of species in the survey streams are included as Appendix A.

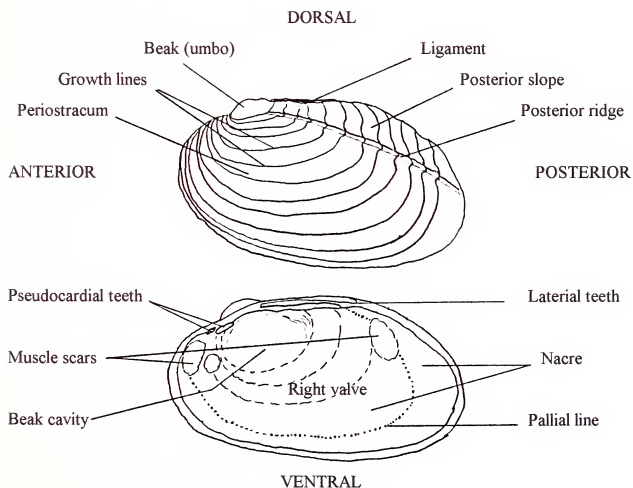


Figure 1. Morphology of freshwater mussel shell illustrating shell terminology.

Anodonta (Utterbackia) imbecilis Say, 1829

(Figs. 3 and 4)

Paper Pondshell

Synonyms: *Anodonta imbecilis* Say, 1829

Utterbackia imbecilis Baker, 1927

Description:

Shell medium to large in size, often reaching over 100 mm, subelliptical in outline, thin, smooth, and not inflated (Brim-Box 1996). Shell tapers to a blunt point posteriorly. Posterior slope slightly concave; posterior ridge poorly defined (Clench and Turner 1956). Umbos anterior to the center, very low and seldom extending above the dorsal margin. Color vivid green or blue-green to a dark greenish-brown; generally finely rayed with pale straw yellow. Periostracum smooth and shiny over the entire surface. Nacre bluish white and iridescent over the entire inner surface of the shell. Ligament short and small. All muscle scars are inconspicuous and poorly defined. Hinge plate and teeth absent.

Distribution:

This species is widely distributed throughout much of eastern North America, from Canada to Florida, and west to Texas.

West Georgia Habitat:

Specimens were found in quiet water with a mud or a muddy-sand substrate. Approximately 50% of specimens were located near the mouth of Mountain Oak Creek at its confluence with Harding Reservoir, Harris County, Georgia. Specimens were also collected along a 5 km (3.1 mile) reach of slow water extending from the reservoir

eastward to Lick Skillet Road. *Anodonta sp.* are adapted to still water and soft substrate habitat; their shells are very thin and light-weight, increasing their buoyancy (Simpson, 1895). Heavier shelled species are not adapted to survive in soft substrates, because of their body weight they would sink in the soft mud and suffocate.

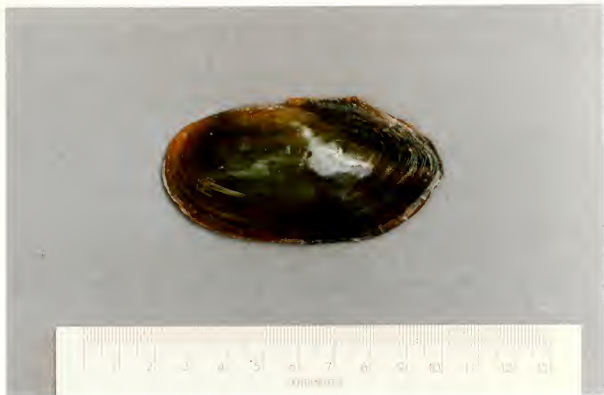


Figure 3. Photograph of *Anodonta imbecilis*, left valve, external view



Figure 4. Photograph of *Anodonta imbecilis*, left valve, external view and right valve, internal view

Anodonta peggyae Johnson, 1965

(Figs. 5 and 6)

Florida floater

Description:

The shell is usually small to medium in length, some specimens have been measured to be 80 mm plus; the length to height ratio is approximately 2:1 (Johnson 1965). The general shell shape is subrhomboidal with some inflation of the valves which are thin, delicate and smooth. Anteriorly the shell rounded, posteriorly more broadly rounded than the anterior end and slightly biangulate near the base. Ventral margin broadly curved and descends obliquely. Dorsal margin can be straight or slightly curved, forming a distinct wing-like angle at the point it intersects the obliquely descending posterior margin. Posterior ridge broadly rounded, posterior slope sometimes slightly concave and located toward the anterior third of the shell. The umbos are low and broad, with no extension above the dorsal line, their surface sculpture has seven or eight, low, delicate, slightly double-looped undulations (Johnson 1965). Color is straw yellow to yellowish-green, occasionally very dark green with numerous fine green rays covering the entire shell surface (Brim-Box 1996). Rays on the posterior slope of the specimen are much darker than those on the remainder of the shell. Periostracum smooth and shiny, except the posterior slope which may be somewhat roughened. Nacre is bluish-white and iridescent. Hinge plate, lateral, and pseudocardinal teeth are absent; muscle scars are poorly defined or inconspicuous.

Distribution:

Prior to this study the distribution of this species was the Gulf drainage of Florida, from the Choctawhatchee River system in Alabama to the Hillsborough River system in Florida. The specimens collected in this survey extend the known distribution into the Chattahoochee River system in Georgia (Brim-Box 1996).

West Georgia Habitat:

Anodonta peggyae inhabits sandy or silty mud bottoms of backwaters, ponds, and sluggish streams. Specimens collected in the survey were found in soft mud substrate bottoms of quiet water sloughs near the confluence of Mt. Oak Creek and Harding Reservoir. This species is readily adaptable to an impoundment type of habitat because of the shell morphology, thin, lightweight, and somewhat inflated.



Figure 5. Photograph of *Anodonta peggyae*, left valve, external view



Figure 6. Photograph of *Anodonta peggyae*, left valve, external view and right valve, internal view

Anodonta grandis Say, 1829

(Figs. 7 and 8)

Giant Floater

Description:

Anodonta grandis is medium to large, shell outline is subovate or subelliptical. The shell is usually thin, fragile, and inflated. Adult specimens commonly range from 100 to 175 mm (4 to 7 inches) in length (Clark and Berg 1959). Posterior slope compressed dorsally and somewhat winged in young specimens. Umbos extend above the dorsal hinge line with sculpture that is distinctive, variable, heavy, and sometimes tuberculate. Periostracum greenish, yellowish-brown to blackish-brown, sometimes shiny, often delicately rayed, and usually with concentric lighter and darker bands. Nacre white to bluish-white or partly pinkish and iridescent. Muscle scars inconspicuous or absent.

Distribution:

This species is found throughout the entire Mississippi system; St. Lawrence system; Lake Winnepeg, Manitoba; and Southwest Texas (Clark and Berg, 1959).

West Georgia Habitat:

Anodonta grandis can be found in many types of substrates in rivers, creeks, lakes, ponds, and canals. Specimens collected in this survey were found in sluggish water in a sandy-mud substrate located approximately 200 meters upstream of the mouth of Mountain Oak Creek

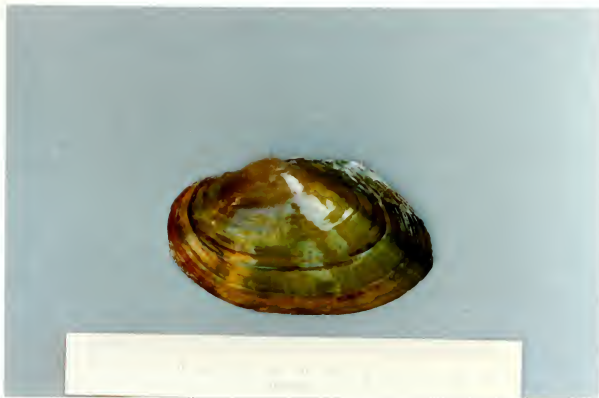


Figure 7. Photograph of *Anodonta grandis*, left valve, external view



Figure 8. Photograph of *Anodonta grandis*, left valve, external view and right valve, internal view

Villosa lienosa Conrad, 1834

(Figs. 9, 10, 11, and 12)

Little Spectaclecase

Synonyms: *Unio lienosus* Conrad, 1834

Description:

Shell medium in size, seldom larger than 100 mm in length, fairly thin but strong, smooth, subelliptical or subovate in outline, and usually inflated. The posterior slope is flattened with the posterior ridge poorly defined. Sexual dimorphism occurs in this species with male specimens being bluntly pointed posteriorly and female specimens moderately truncate or angulated posteriorly and more inflated (Clench and Turner 1956). Umbos well anterior to the center, broad and full, but not high with the beak sculpture double-looped. Shell color is generally dark brownish-black, but specimens may be chestnut brown and young specimens may be faintly rayed with green (Brim-Box 1996). Periostracum smooth on the upper disc, somewhat roughened or satiny on the ventral margin and over the posterior slope. Nacre color is variable ranging from whitish through various shades of pink or salmon to a deep purple and is highly iridescent posteriorly. Ligament rather long and narrow. Anterior muscle scars are well defined. Posterior scars poorly defined. Hinge plate is long and narrow. The right valve has two pseudocardinal teeth, one large and one small, both are coarsely crenulate. The left valve also has two pseudocardinal teeth, one large and one small, and less crenulate than the teeth in the right valve (Brim-Box 1996).

Distribution:

The species was originally described by Conrad (1834), from small streams in south Alabama. This species is widely distributed in the Apalachicola River System, particularly in the smaller rivers and creeks. Very often it is the only native species found at the site.

The range is from the Suwannee River system in Florida, west to Texas, and north to the Ohio River (Clench and Turner, 1956).

West Georgia Habitat:

The Little Spectaclecase (*Villosa lienosa*) specimens collected in this study were found in many different habitat types; gravel in moderate current, shifting sand, and sand mixed with mud. In shallow streams *V. lienosa* was easily found in pools anchored adjacent to some fixed object such as rocks or logs.



Figure 9. Photograph of *Villosa lienosa*, left valve, external view (female)



Figure 10. Photograph of *Villosa lienosa*, left valve, external view and right valve, internal view (female)

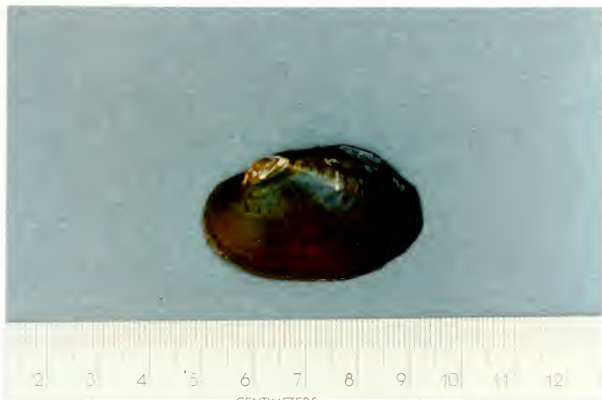


Figure 11. Photograph of *Villosa lienosa*, left valve, external view (male)



Figure 12. Photograph of *Villosa lienosa*, left valve, external view and right valve, internal view (male)

Villosa vibex Conrad, 1834

(Figs. 13, 14, 15, and 16)

Southern rainbow

Synonyms: *Unio vibex* (Conrad, 1834)

Description:

Shell usually small, not exceeding 60 mm in length, though occasionally reaching 100 mm. Outline subelliptical, valves subinflated, generally thin and translucent. Anterior end regularly rounded; posterior end of females more broadly rounded, somewhat pointed in males, often slightly arcuate in females. Dorsal margin straight with a very slight, if noticeable, angle where it meets the obliquely descending posterior margin. Hinge ligament small. Posterior ridge broadly rounded with the posterior slope slightly concave, occasionally with faint wrinkles and ridges. Umbos moderately swollen, slightly elevated above the hinge line, located in the anterior quarter of the shell, their sculpture consisting of several fine, low, slightly double-looped ridges. Surface of the shell is generally rather smooth, but roughened by periostracum posteriorly. Periostracum usually subshiny, greenish-yellow, yellowish-brown to almost black, the entire surface with numerous broad greenish rays, which in darker specimens can be seen in transmitted light. Nacre bluish-white, sometimes pinkish or purple, iridescent posteriorly. Left valve with two small pseudocardinal teeth, one in front of the other, the anterior pseudocardinal tooth somewhat triangular, the rear one tends to be vestigial. Hinge line is fairly long and narrow before two short, straight, lateral teeth. The right valve has two triangular, narrow, parallel pseudocardinal teeth which are separated by a narrow pit, the anterior tooth is vestigial or sometimes absent, and on the lateral tooth. The beak cavities tend to be shallow, some dorsal muscle scars are impressed, posterior scars are faint if visible. Pallial line very distinct anteriorly (data from Johnson, 1972).

Distribution:

This species are found from the West Gulf Coastal Region, Alabama-Coosa River System, and Apalachicola Region: Pearl River System, Mississippi, east to the Suwannee River System, Florida. Peninsular Florida. Southern Atlantic Slope: Altamaha River System, Georgia, north to the coastal ponds of the Cape Fear River System, North Carolina (Jenkinson, 1973).

West Georgia Habitat:

Villosa vibex was collected in mud or soft sand, particularly where the substrate is rich in plant detritus, of small rivers and creeks. The specimens collected in this survey were usually found near the shore in soft sandy sediments and most often anchored beside a log or other structure. Some were found at the shoreline in soft plant detritus and silt.



Figure 13. Photograph of *Villosa vibex*, left valve, external view (female)



Figure 14. Photograph of *Villosa vibex*, left valve, external view and right valve, internal view (female)



Figure 15. Photograph of *Villosa vibex*, left valve, external view (male)

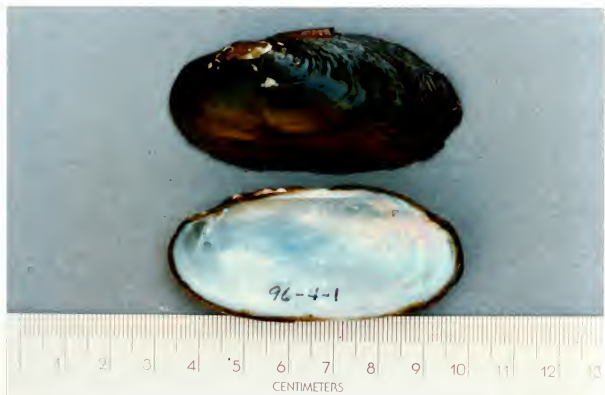


Figure 16. Photograph of *Villosa vibex*, left valve, external view and right valve, internal view (male)

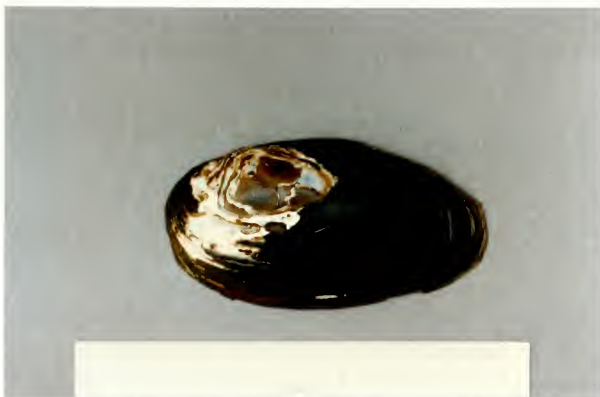


Figure 17. Photograph of *Villosa* sp., left valve, external view



Figure 18. Photograph of *Villosa* sp., left valve, external view and right valve, internal view

Elliptio complanata Lightfoot, 1786
(Figs. 19 and 20)
Eastern *Elliptio*

Synonyms: *Elliptio complanatus* (Solander) Clarke and Berg, 1959
Elliptio strigosus (Lea) *partim*. Clench and Turner, 1956

Description:

The shell is generally long, uniformly trapezoidal, sometimes rhomboid, sometimes subelliptical. Valves generally flat or subinflated, occasionally inflated. Posterior slope flat to faintly concave (Clench and Turner, 1956). Posterior ridge usually broad, double and rounded, sometimes rather angular, ending in a biangulation near the base (Johnson, 1970). Shell tapers to a blunt point posteriorly. Umbo well anterior to the center, broad, but not high or full. Hinge ligament moderately long, narrow, and prominent (Johnson, 1970). Color is dull to shiny black, sometimes dark blackish-brown or brown, or sometimes greenish. Rayed specimens are occasionally encountered (Simpson, 1892). Periostracum usually smooth and shiny on the disc, but somewhat scaly and dull on the ventral margin and over the posterior slope (Clench and Turner, 1956). The nacre is generally purplish, though often white, or slightly orange, iridescent, especially toward the margins (Johnson, 1970). Typically, the *Elliptio complanata* shell is larger, heavier, more nearly rectangular, and has much darker and rougher periostracum than *Elliptio icterina* (Fuller, 1971). Left valve with two stumpy pseudocardinal teeth, one in front of the other, the anterior one triangular, the hindmost one generally not much elevated above the hinge line. Left valve hinge line short and narrow; two long, straight, granular lateral teeth. Right valve with one chunky, serrated pseudocardinal, with a vestigial tooth in front of its single lateral tooth.

Distribution:

This species is found in the Apalachicola River System, Altamaha River System, Georgia, north to the Saint Lawrence River System, Canada. Westward to Lake Superior and in parts of the Hudson Bay drainage.

West Georgia Habitat:

The Eastern elliptio (*Elliptio complanata*) specimens collected in this study were found in a variety of habitats, ranging from between rocks in fast water to sandy mud in quiet waters. *Elliptio complanata* appear to be the most widely distributed Unionidae in the region covered by this survey, specimens were collected from four of the five streams in this study.



Figure 19. Photograph of *Elliptio complanata*, left valve, external view



Figure 20. Photograph of *Elliptio complanata*, left valve, external view and right valve, internal view

Elliptio icterina Conrad, 1834
(Figs. 21 and 22)
Variable Spike

Synonyms: *Unio icterinus* Conrad, 1834

Elliptio strigosus (Lea) *partim*. Clench and Turner, 1956.

Description:

Shell small to medium, rarely reaching over 100 mm in length (Johnson, 1972). Shell outline is variable, ranging from subquadrate to subelliptical, occasionally pointed. The valves are usually subinflated, subsolid to notably solid, and inequilateral. The anterior end of the shell is rounded, posterior end is generally biangulate near the base, sometimes pointed. Ventral margin straight or slightly arcuate, sometimes obliquely descending (Johnson, 1970); dorsal margin slightly curved or almost straight, meeting the obliquely descending posterior margin in a more or less distinct angle. Hinge ligament is long and low, posterior ridge is broadly rounded, and usually weakly double. Posterior slope flat to slightly concave, often with very faint radial sculpture. Disk surface is generally flat or slightly concave. Hinge line is short and narrow. Periostracum usually fine and shiny, although sometimes heavy and rough, black, brownish-black, or yellowish-brown or bright yellow, chestnut, occasionally with very fine green rays (Brim-Box 1996). Nacre usually purplish, although sometimes salmon, bluish-white, or pinkish in color, and the posterior is iridescent. Left valve with two short chunky pseudocardinal teeth, one in front of the other, usually the two are of equal height and have two long straight lateral teeth. Left valve has two long straight lateral teeth and the right valve has a single lateral tooth (Keferl, 1996). Right valve also has two approximately parallel pseudocardinal teeth, posterior tooth is usually serrated and chunky, and anterior tooth is generally short and vestigial.

Distribution:

Elliptio icterina (Conrad, 1834), ranges from the Escambia River System in the Apalachicolan Region, east through northern Florida, and north to the White Oak River of North Carolina.

West Georgia Habitat:

Specimens were found in lakes, ponds, small streams, and large rivers in nearly every type of substrate. In the Apalachicolan drainage *Elliptio icterina* is most easily confused with *Elliptio complanata*, individuals of both species can be collected at the same site (Johnson 1970).



Figure 21. Photograph of *Elliptio icterina*, left valve, external view



Figure 22. Photograph of *Elliptio icterina*, left valve, external view and right valve, internal view

Elliptio arctata Conrad, 1834
(Figs. 23 and 24)
Delicate Spike

Synonyms: *Unio arctatus* (Conrad, 1834), *Unio strigosus* Lea, 1840
Elliptio strigosus (Lea) *partim*. Clench and Turner, 1956.

Description:

Shell small, seldom exceeding 60 mm in length. Outline elongate, ventral margin arcuate. Valves compressed, umbos not inflated, not above hinge line, hinge located in the anterior sixth of the shell (Brim-Box 1996). The beak cavities are shallow with some dorsal muscle scars under the hinge plate. Shell color varies, sometimes greenish, or dull to shiny black, or dark blackish-brown to brown, older shells tend to be darker. Periostracum usually greenish or yellowish with green rays over the entire surface becoming wider and more prominent toward the posterior end, sometimes dark burnt brown on older individuals. Nacre is usually dirty white or purplish with yellowish splotches in color, iridescent on the posterior end. Left valve with two short, somewhat vestigial, triangular pseudocardinal teeth, hinge line short and narrow; two low, short, straight lateral teeth (Johnson 1970). Right valve with one large chunky pseudocardinal tooth and one lateral tooth.

Distribution:

Elliptio arctata have been identified in the Mobile River System, Escambia and Apalachicola Rivers, the Cooper-Santee, Cape Fear and Savannah Rivers of the Atlantic Slope (Hurd 1974).

West Georgia Habitat:

Elliptio arctata are found in streams near shore under and among rocks. The specimens in this survey were most often found in rock outcrops, in swift current, anchored in small patches of sand, and most often with the siphons directed into the current.



Figure 23. Photograph of *Elliptio arctata*, left valve, external view



Figure 24. Photograph of *Elliptio arctata*, left valve, external view and right valve, internal view

Megaloniaias boykiniana Lea, 1840

(Figs. 25 and 26)

Round Washboard

Synonym: *Crenodonta boykiniana* (Lea, 1840)

Description:

Shell winged, subquadrate or trapezoidal in outline, triangular, solid in structure, and somewhat inflated. Young specimens are olive green in color and dark brown to blackish-brown in adults. Specimens have been found that have been measured up to 168 mm. Posterior slope is slightly concave with the posterior ridge absent or only poorly defined (Clench and Turner 1956). Young individuals are usually winged on the dorsal margin of the posterior slope and as the shell matures the shell wing becomes less prominent. Shell is rounded anteriorly and is tapered to a blunt point posteriorly, umbos are located anterior to the center of the shell, are moderately broad and are not full. Shell ligament long and wide (Clench and Turner 1956); ligament short and thin (Lea 1857). Periostracum is shiny in young shells and satiny in older shells. Heavy pseudocardinal teeth and long, straight lateral teeth, and white to pink nacre (Burch, 1975).

Distribution:

This species is found throughout the Chattahoochee, Ochlockonee, Apalachicola, Chipola, Fline, and Escambia River Systems (Clench and Turner, 1956; Heard, 1977).

West Georgia Habitat:

Megaloniaias boykiniana is found in a variety of substrates ranging from sand and sandy mud to gravel, lime-rock rubble, in moderate currents. The single specimen reported in this survey was found at the confluence of Bull Creek and the Chattahoochee River.



Figure 25. Photograph of *Megaloniaias boykimiana*, right valve, external view



Figure 26. Photograph of *Megaloniaias boykimiana*, right valve, internal view

Unio merus tetralasmus Say, 1831
(Figs. 27 and 28)
Pondhorn

Synonyms: *Unio tetralasmus* Say, 1831
Unio columbensis Lea, 1857

Description:

Shell medium to large in size, reaching 114 mm in length, solid in structure, smooth, subelliptical to subquadrate in outline, and inflated (Clench and Turner, 1956). Periostracum is dark brownish-black, uniform over the entire surface, yellowish-brown in young specimens (Lea, 1857), posterior slope slightly roughened. Umbos located anterior to center, broad and full but not high (Clench and Turner, 1956). The umbonal sculpture consist of five or six heavy ridges that form a rounded angle on the posterior ridge, in front of which they tend to be corrugated (Johnson, 1970). Pallial line distinct, nacre white, bluish-white or pinkish to intense purple. Beak cavities compressed, but with several muscle scars; anterior adductor muscle scars deep, posterior ones faint. Left valve has two ragged, subequal pseudocardinal teeth and two straight lateral teeth. Right valve has one triangular pseudocardinal often with a vestigial tooth above it and one lateral tooth (Johnson, 1970).

Distribution:

This species is found in the Apalachicolan region, Peninsular Florida, and in the Southern Atlantic Slope rivers of Georgia (Kefert, 1996). Also, in the Everglades of southern Florida north to North Carolina and West to the Escambia River (Clench and Turner, 1956).

West Georgia Habitat:

Unio merus tetralasmus generally inhabits smaller streams and ponds with soft muddy substrates (Johnson, 1970). Keferl (1994), found one living specimen and four shells among rock outcropping at Chattsworth Road bridge, Muscogee County, Georgia.



Figure 27. Photograph of *Uniomerus tetralasmus*, left valve, external view



Figure 28. Photograph of *Uniomerus tetralasmus*, left valve, external view and right valve, internal view

DISCUSSION

In contrast with the Chattahoochee River main channel, many of its tributaries remain free flowing (Couch and others, 1996), a habitat requirement for many of the native species of (freshwater mussels) Unionidae bivalves found in the drainage system. However, the Piedmont Plateau is reported to have a very sparse mussel fauna (Heard, 1970) and the five streams included in this survey contain sparse isolated populations of Unionidae bivalves. A detrimental characteristic, specific to Unionidae, of regional streams is that Piedmont streams have higher sustained flows during winter months and show rapid responses to storm events throughout the year (Couch et al., 1996). As a result of this action, freshwater mussels can not establish a viable reproducing population in most Piedmont streams. Regional environmental variables may affect freshwater mussel distribution patterns in drainage systems. Among the variables are surface geology and soil porosity. Porous soils retain water, buffering runoff so streams draining them have relatively constant flow and are rarely dry. Therefore, they support greater numbers of mussel species than streams draining soils of poor water infiltration capacity and drainages prone to flooding and drying cycles (McMahon, 1991).

The majority of the survey streams' habitats are lotic with only mouths and scattered pools being slow moving. The most productive mussel sites were lotic environments associated with some type of stable substrate. Bedrock outcrops and shoal areas were usually the ideal habitat to search for Unionidae bivalves: eighty three percent of 494 specimens included in this study were located in lotic habitats and the remaining 17% were located in lentic habitats. As a result of this survey, ten Unionidae bivalves species were collected from 18 (37%) of 45 sites surveyed. Jenkinson, 1973, collected nine unionacean species from Halawakee and Uchee Creeks, north of the Fall Line, in east Alabama; these creeks are also part of the Chattahoochee River drainage basin.

When considering productive and non-productive stream sites, it seems advisable to consider each stream individually, beginning with the most northern and proceeding southward.

Mountain Oak Creek

Six sites were sampled and unionid species were encountered at three. The three productive sites were in the lower reaches and revealed viable, reproducing populations of two lentic dwelling species of *Anodontas*. Figures 29 and 30 show the distribution of shell lengths of specimens collected. Five Unionidae species were collected from Mountain Oak Creek; *Anodonta imbecilis*, *Anodonta peggyae*, two specimens of *Anodonta grandis*, one specimen each of *Elliptio complanata* and *Villosa vibex*, and populations of the Asiatic clam (*Corbicula fluminea*) were encountered. Figures 29 and 30 exhibit a bimodal or trimodal distribution of shell length classes of the most abundant *Anodonta* unionids encountered in Mountain Oak Creek, suggesting that the rapid drawdown of Harding Reservoir every three years for shoreline maintenance is directly responsible for this phenomenon. The three collection sites in the upper reaches were void of Unionidae but contain abundant populations of the Asiatic clam *Corbicula fluminea*.

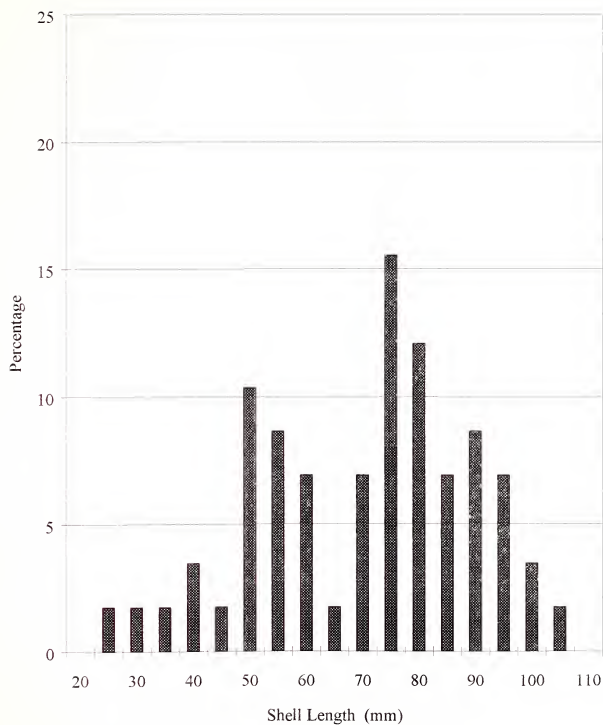


Figure 29. Frequency of size classes (*Anodonta imbecilis*) Mt. Oak Creek (n=58)

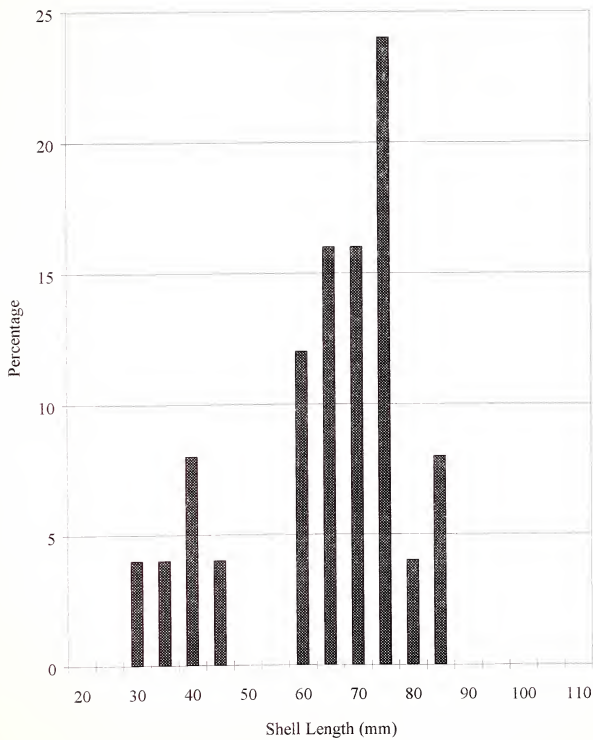


Figure 30. Frequency of size classes (*Anodonta peggyae*) Mt. Oak Creek (n=25)

Mulberry Creek

Mulberry Creek is an unstable drainage system; a minimal amount of precipitation in the headwaters basin will cause the stream to be silt laden for its entire length. The headwater portion of Mulberry is a typical Piedmont stream with moderately swift water, occasional isolated pools, shoal areas, and shifting substrate; its headwaters are surrounded by 15 to 20 large tracts of silviculture properties. Eleven sites were surveyed for unionid bivalves with only three sites producing unionid specimens. Representative specimens of *Elliptio complanata*, *Elliptio arctata*, *Elliptio icterina*, and *Villosa vibex* were taken at the productive sites. The most eastward specimen producing site was approximately two miles east of US highway 27, a single specimen of *Villosa vibex* was found in a muskrat midden. The upper third of Mulberry Creek appears to be unsuitable habitat for unionid bivalves, because of its clay bottom, moderately swift water, shifting coarse sand substrate, and very often heavy silt loads. The lower two thirds of the main channel has many shoal areas with sluggish water upstream, but the silt deposition is very soft and several inches deep, making the habitat inhospitable for stream dwelling unionacean bivalves. *Corbicula fluminea* was encountered at every site and appears to be well adapted to all habitat types.

Standing Boy Creek

The headwaters of Standing Boy Creek flow through cattle pasture land. The substrate being composed of clay and shifting sand and there were no Unionidae or Asian clams encountered at the headwater site. A total of nine sites downstream were visited, with four sites producing unionacean species. Twenty specimens of *Elliptio complanata*, 16 *Elliptio arctata*, 16 *Elliptio icterina*, 14 *Villosa lienosa*, two *Villosa vibex*, and three specimens of an unidentified *Villosa* species were collected at the productive sites. *Corbicula fluminea* was present at every site visited except the most eastern site as shown on map # 12 of appendix A. The lower portion of Standing Boy Creek has been only moderately disturbed, but it appears that in the near future suburban neighborhoods will be expanding northward from Columbus, Georgia, into this drainage. This rapid expansion could cause irreparable habitat destruction to the already impacted stream. In the very recent past there was a lake impoundment of the creek at Camp Callaway; the lake was drained a few years ago, and it is not known what impact this occurrence had on the benthic dwelling mussels downstream. Approximately 0.8 km below the lake site is an old gristmill dam constructed of concrete; above the dam, sediment deposition has occurred to within a meter of the top. Below the dam in the overwash areas more than 50 empty shells were collected and it appears that this large collection of shells could have been caused by the release of large amounts of water from the impoundment thus, displacing the Unionidae from their benthic habitat and stranding them several meters above the normal stream level.

Bull Creek

Seven sites were visited on Bull Creek which is the most impacted stream encountered in the survey. The headwaters have two impoundments and are surrounded by a golf course. The uppermost impoundment is the property of an individual citizen, and the golf course and lower impoundment are municipal government property. In a 1994 survey of the section of creek from Schatulga Road to State Road 22, only two live specimens of *Anodonta imbecilis* and five, one live and four recent dead empty shells of *Unio merus tetralasmus* were found (Keferl, 1994). Six sites yielded only specimens of *Corbicula fluminea* and one site at the confluence with the Chattahoochee River yielded only a recent dead right valve of *Megaloniaias boykiniana*. The results of this survey and the survey conducted by Keferl, 1994, indicate that Bull Creek is essentially devoid of unionacean bivalves.

Upatoi Creek

Upatoi Creek is the largest stream included in this survey and is the only one that is located in two geologic provinces. From about 1950 to 1970 the headwater drainage was surrounded by orchards of peach trees, whereas from 1970 to 1985 the area was used for row crops such as soybeans, corn, peanuts, and rye. Today this same area is in silviculture and pasture lands for cattle.

Sixteen sample sites were visited during the spring and summer 1996, with five sites producing Unionidae specimens. The productive sites were located in a section of creek 12 km in length, between Teal Road (County Rd. 96) and the confluence of Juniper Creek. The most abundant populations were encountered at the Teal Road site, specimens representing two genera and five species. The most common Unionidae species found in Upatoi Creek were *Elliptio complanata*, 189 and *Villosa lianosa*, 99 and also collected were seven *Elliptio icterina* and five *Villosa vibex*. Shell length distribution patterns for specimens of *E. Complanata* and *V. lianosa* included in the Upatoi Creek survey are shown in figures 31 and 32. There were no unionid specimens located upstream of the Teal Road site, nor were any found in Upatoi Creek downstream of the confluence with Juniper Creek.

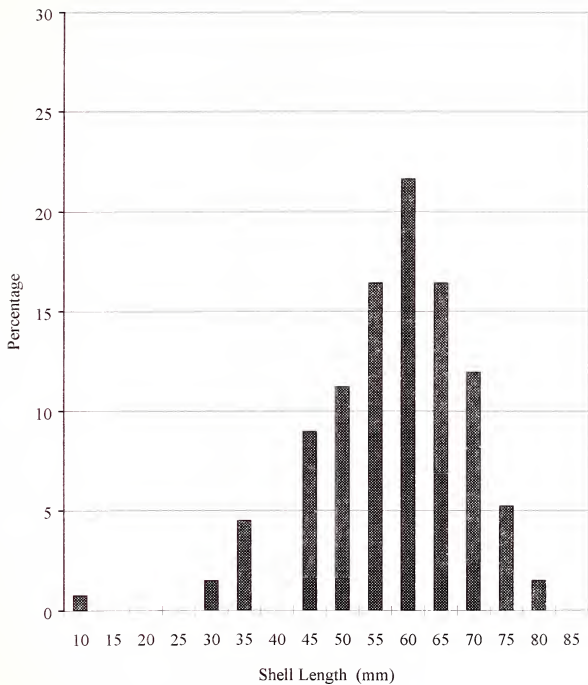


Figure 31. Frequency of size classes (*Elliptio complanata*) Upatoi Creek (n=189)

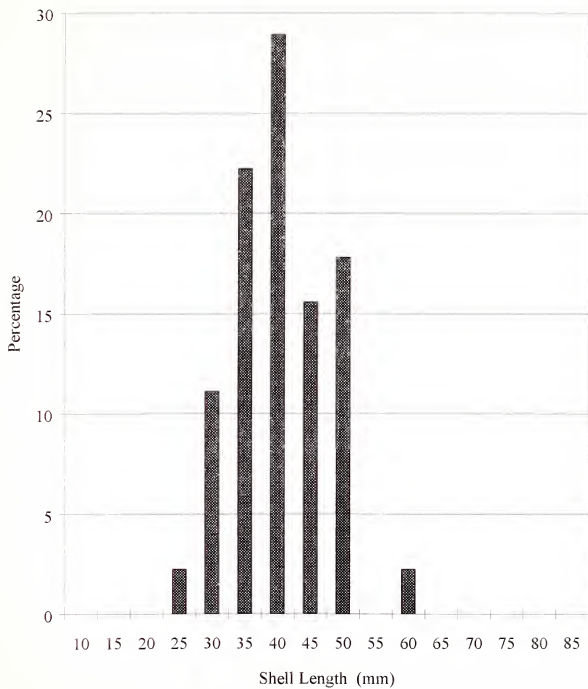


Figure 32. Frequency of size classes (*Villosa lienosa*) Upatoi Creek (n=99)

DISCUSSION OF THE ASIATIC CLAM

The introduced Asiatic clam *Corbicula fluminea* (Muller, 1774) is the most abundant mussel in the five creek systems included in this survey. The density of *C. fluminea* varied at the collection sites from a few per square meter to hundreds per square meter. *Corbicula fluminea* was found thriving in all substrate types, mud, gravel, silt, and sand. The only habitat exception is the lower portion of Upatoi Creek, which has an average pH 6.7 and alkalinity five, making it an inhospitable environment, even for *C. fluminea*. The majority of species prefer alkaline waters with the pH above 7.0; species diversity declines in more acidic habitats (McMahon, 1991). Habitats of low pH generally also have low calcium concentrations. Low pH leads to shell dissolution and eventually mortality in older individuals if shell penetration occurs (McMahon, 1991). The minimum ambient calcium concentration tolerated by freshwater bivalves appears to be the concentration at which the rates of calcium uptake and deposition to the shell exceed the calcium loss rate from the shell dissolution and diffusion, allowing maintenance of shell integrity and growth (McMahon, 1991).

I did not find any instance of *C. fluminea* being in direct competition with native Unionidae. Of greatest concern are substratum space and food use by Asian clams and juvenile mussels, particularly in streams where either of these requisite resources may be limited (Neves, 1992). Instances were documented of *C. fluminea* as a readily available food resource for wildlife and in some cases it was noted that *C. fluminea* were being taken by predators instead of native bivalves because of availability and accessibility. This bivalve seems to be able to survive and flourish in disturbed habitats unsuitable for Unionidae bivalves.

In the future, *C. fluminea* may provide an important protein and calcium supplement in animal feeds and may serve as a food resource for man in North America as it does in Asia (Sickel and Heyn, 1980).

CONCLUSIONS

The absence of mussels can logically be an indication of environmental disruption only when and where their former presence can be demonstrated (Fuller, 1974). Historically, many species of Unionidae were described originally from the Chattahoochee River, at Columbus, Georgia (Clench and Turner, 1956); However Peter Okkelberg and W.J. Clench failed to find a single freshwater mollusk at this locality during a collecting trip in 1929 (Clench and Turner, 1956). W.J. Clench and Ruth Turner did not find any unionacean bivalves in the Chattahoochee River at Columbus, Georgia during their collecting trips in 1953 and 1954, and considered the river to be depauperate of freshwater mussels (Clench and Turner, 1956). Athearn (1955) located a limited number of species both above and below Columbus, Georgia, in the Chattahoochee River (Clench and Turner, 1956). It is not clear whether the historical collectors are referring only to the main channel of the river or the river and its tributaries. The three-year survey initiated by the US Fish and Wildlife Service, in 1991, to determine the status of six species of mussels the Fat Three-ridge, *Amblema neislerii*; the Winged Spike, *Elliptio nigella*; the Purple Bankclimber, *Elliptoides sloatianus*; the Lined Pocketbook, *Lampsilis binominata*; the Shiny-rayed Pocketbook, *Lampsilis subangulata*; and the Oval Pigtoe, *Plurobema pyriforme*, did not include the historic site, Chattahoochee River, Columbus, Georgia because collectors in more recent historic times had not reported any of the proposed listed species. Therefore, collecting efforts were focused elsewhere, mainly in drainages south of the Fall Line. In my opinion, in some instances, collectors acted in haste when concluding: "Although riverine mussels were probably once abundant in the main channel of the Chattahoochee River, they appear to now be extirpated from the entire length of the river" (FWS Survey, 1994).

Standing Boy and Upatoi Creeks contained the largest and most diverse populations of Unionidae bivalves of the creeks visited during this survey. Populations of Unionidae

found in Upatoi Creek, as mentioned earlier, are located in a continuous 12 km stretch from Teal Road to the confluence with Juniper Creek. The majority of the properties adjoining this stretch of Upatoi Creek is held by large paper producing companies (ex. Mead Coated Board Corporation) and is still relatively undisturbed. Also, this stretch of Upatoi Creek is in close proximity to the Fall Line, and the floodplains and surface geology are more similar to that of the Coastal Plain Geologic Province than to the Piedmont Province. The surrounding soils are more porous, allowing water to infiltrate and preventing severe channel damage from seasonal storm events (which is a common in the Piedmont). The productive sites visited on Standing Boy Creek are located in the 16 km stretch between US Highway 27 and Georgia Highway 103, which has been until recently a low impact area. At the time this survey was conducted Unionidae bivalves continue to inhabit isolated niches which are associated with numerous rock outcrops and shoal areas in this stretch of Standing Boy Creek. As mentioned earlier, increased pressure from expanding suburban communities is beginning to adversely affect the remaining population and their natural habitat in the western section of the 16 km stretch. Exposed rock outcrops, shoals, and free flowing water are properties common to the productive sites in the study area.

There is as much confusion concerning the taxonomic relationships of the area's freshwater Unionidae today as was the case historically, especially concerning the genus *Elliptio*. Many of the *Elliptio* specimens collected during this survey have been identified as different species by different authorities and this is understandable because of the complexity of this widespread group of Unionidae. In an attempt to alleviate some of the taxonomic questions related to *Elliptio* and other genera, genetic studies are being carried out by research groups to establish phylogenetic relationships within the groups. Tissue samples from some specimens collected in this study have been sent to Dr. Peg Mulvey at The Savannah River Ecology Lab for genetic analysis. At this writing, analysis is incomplete and the results cannot be reported here.

It is hoped that this survey will aid malacologists in providing geographical data that has not been provided in the past for this region.

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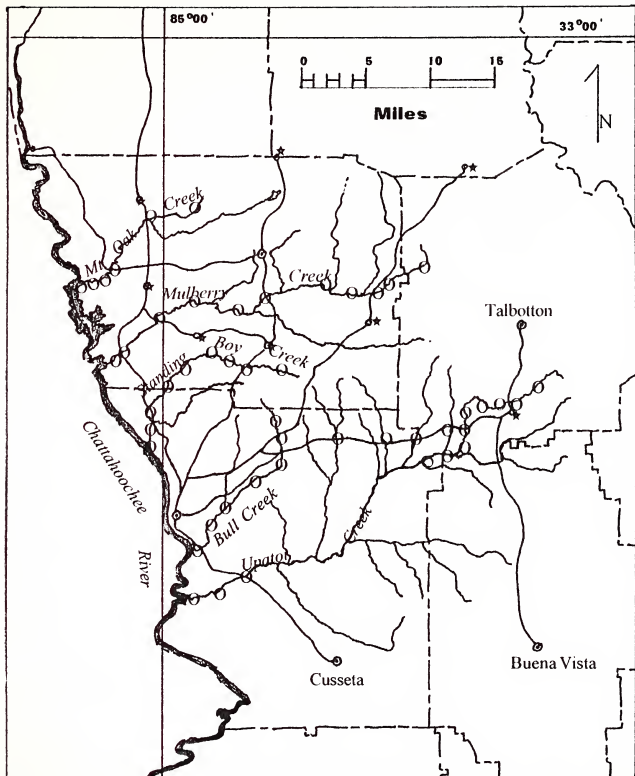
APPENDIX - A

Study Area and Unionidae Species Distribution Maps

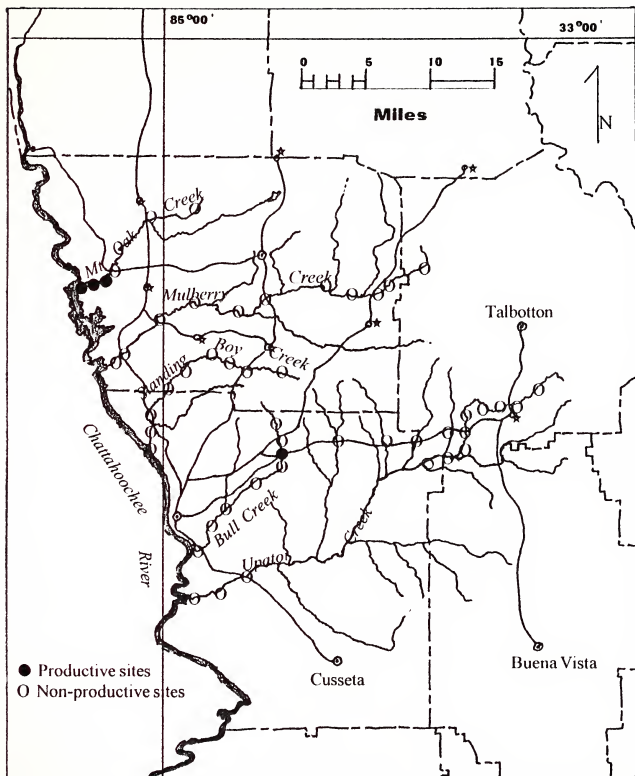
The following 12 maps indicate the locations of sample site and landmarks referred to in the locations of sample sites in Appendix - B and the distributions of each of the freshwater bivalve species encountered in this study. Map #12 in Appendix - A indicates the sites at which the Asiatic clam *Corbicula fluminea* was encountered.

These maps are derived from a tracing of the US Geologic Survey 1:500,000 topographic map, State of Georgia, 1970 edition. The tracing was electronically scanned and reduced to a computer graphics program for further manipulation. The placement of the sample sites is as accurate as the size and scale of the map will allow.

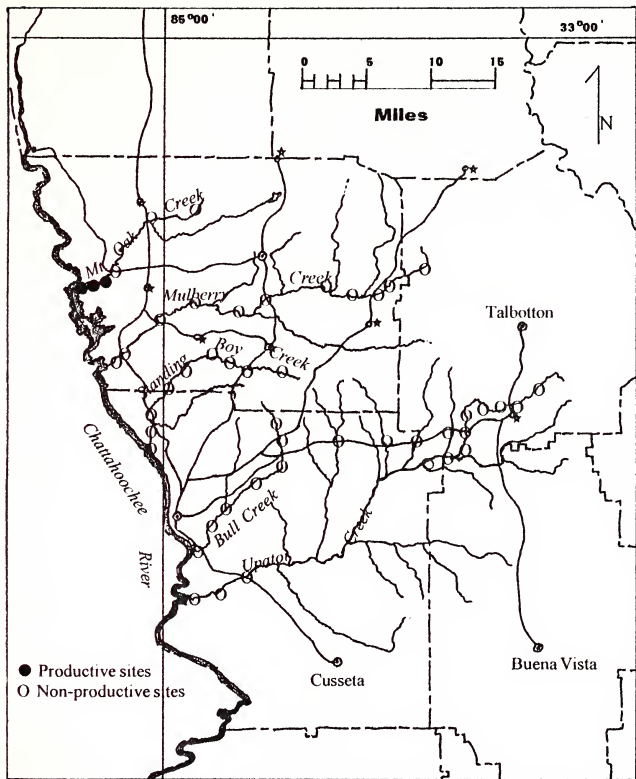
A circle [○] represents a non-productive sample site and a darkened circle [●] represents a productive site for the species.



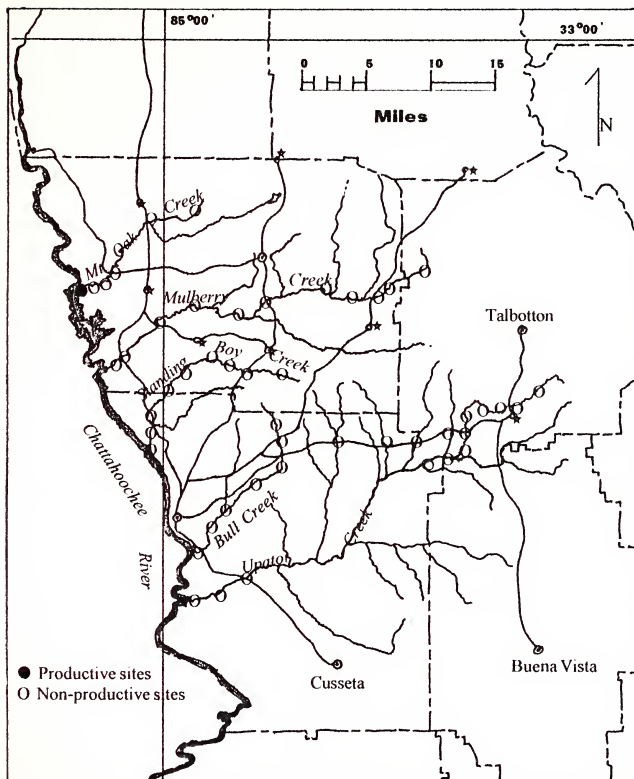
Map 1. Streams included in this study with sample sites indicated.



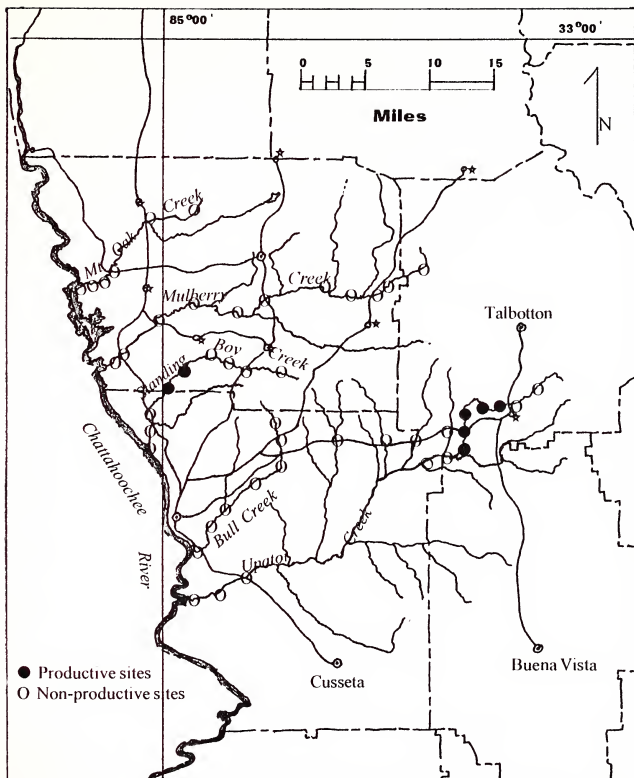
Map 2. The distribution of *Anodonta imbecilis* (Say, 1829) within the study area.



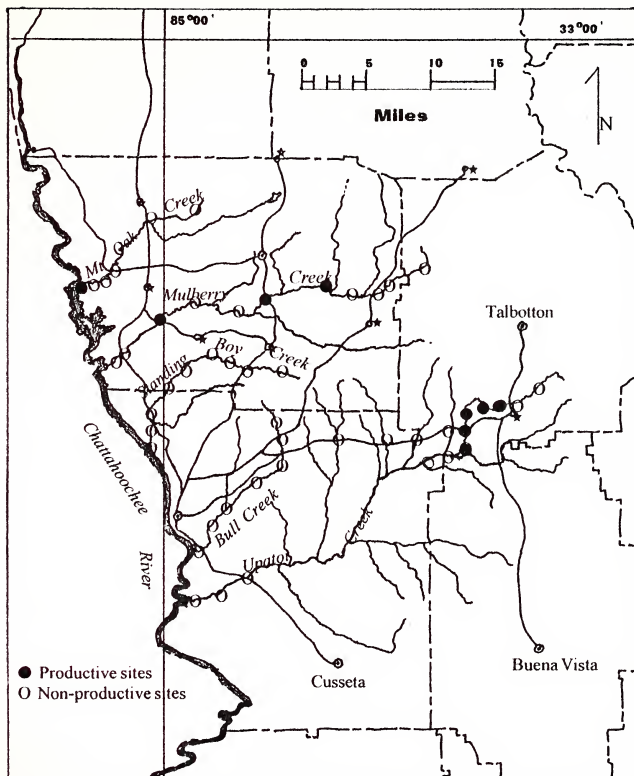
Map 3. The distribution of *Anodonta peggyae* (Johnson, 1965) within the study area.



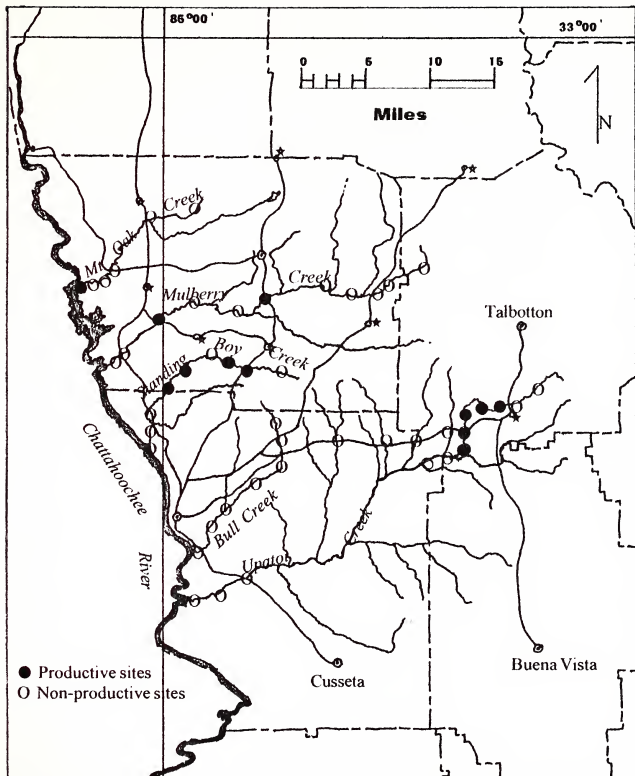
Map 4. The distribution of *Anodonta grandis* (Say, 1829) within the study area.



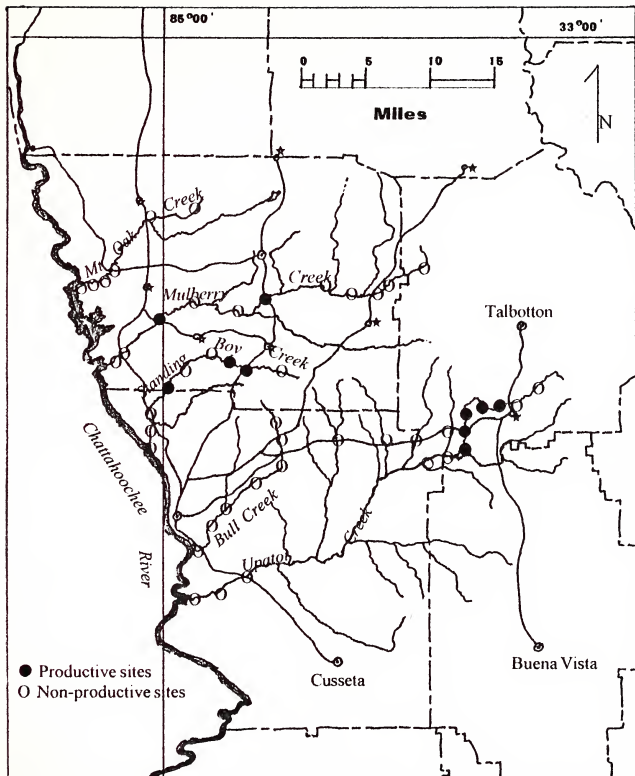
Map 5. The distribution of *Villosa lienosa* (Conrad, 1834) within the study area.



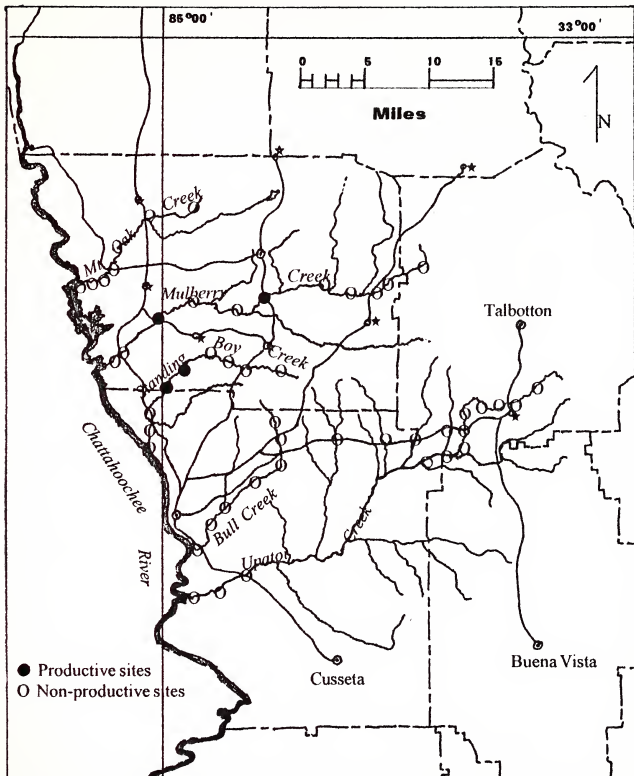
Map 6. The distribution of *Villosa vibex* (Conrad, 1834) within the study area.



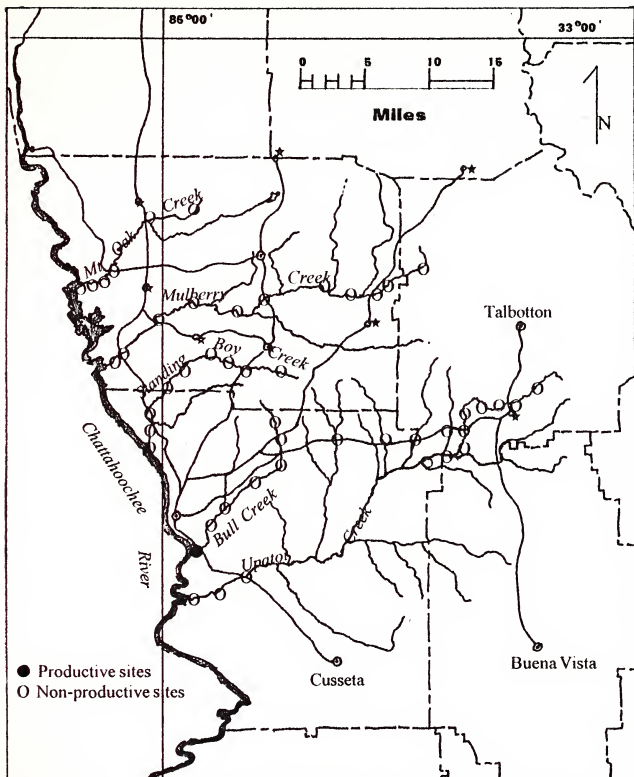
Map 7. The distribution of *Elliptio complanata* (Lightfoot, 1786) within the study area.



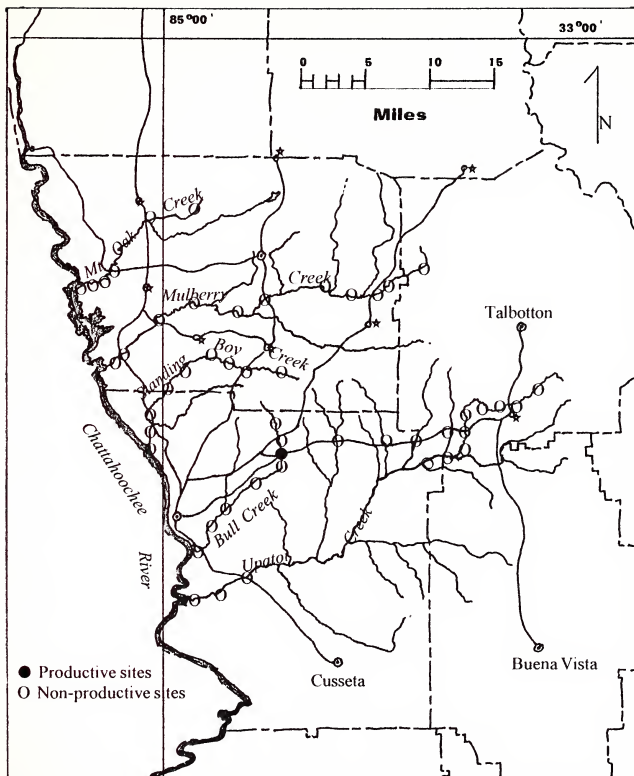
Map 8. The distribution of *Elliptio icterina* (Conrad, 1834) within the study area.



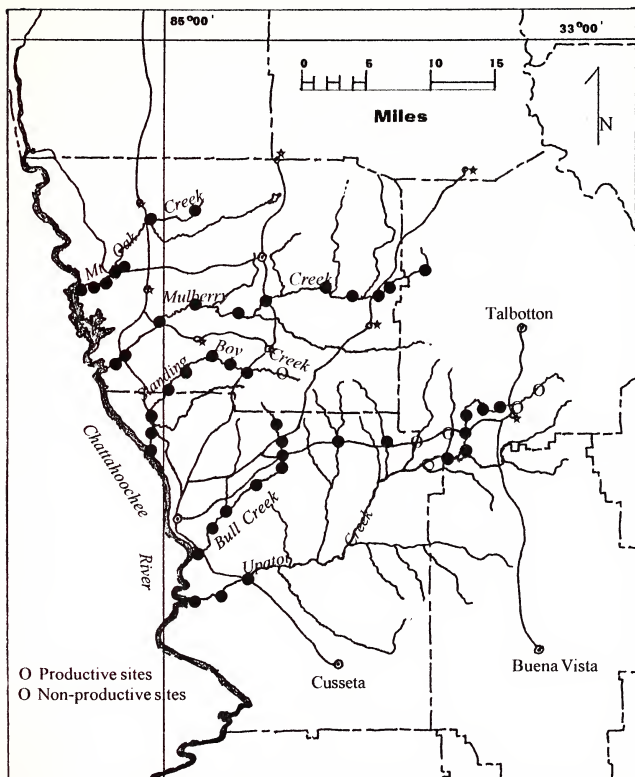
Map 9. The distribution of *Elliptio arctata* (Conrad, 1834) within the study area.



Map 10. The distribution of *Megaloniias boykiniana* (Lea, 1840) within the study area.



Map 11. The distribution of *Uniomerus tetralasmus* (Say, 1831) within the study area.



Map 12. The distribution of *Corbicula fluminea* (Muller, 1774) within the study area.

APPENDIX - B

Location of Survey Collection Sites

Appendix B consists of a list of stream sites which were used as collection points for this survey. The sites are arranged by creek system and are listed in order from the headwaters to the mouth. The creeks are arranged in the order they occur from north to south.

The locations of sample sites were taken from a US Geologic Survey 1:500,000 topographic map, State of Georgia, 1970 edition. The distances from towns were measured between the collecting site and the major highway intersection in the towns. Two measurements were made to improve the accuracy of the described location of the sample sites.

Mountain Oak Creek

Mountain Oak Creek at County Road 71 bridge, 12.0 air km (7.5 air mi.) WSW of Pine Mountain, 10.0 air km (6.2 air mi.) NNW of Hamilton, Harris County, Georgia.

Mountain Oak Creek at State Road 219 bridge, 2.5 air km (1.6 air mi.) south of Whitesville, 15.0 air km (9.3 air mi.) WNW of Hamilton, Harris County, Georgia.

Mountain Oak Creek at State Road 103 bridge, 18.0 air km (11.2 air mi.) west of Hamilton, 5.0 air km (3.1 air mi.) WNW of Mountain Hill, Harris County, Georgia.

Mountain Oak Creek at Lick Skillet Road bridge (County road 389), 6.5 air km (4.0 air mi.) west of Mountain Hill, 12.0 air km (7.5 air mi.) SSW of Whitesville, Harris County, Georgia.

Mountain Oak Creek 1.0 air km (0.6 air mi.) west of Lick Skillet Road bridge, 12.5 air km (7.8 air mi.) SSW of Whitesville, Harris County, Georgia.

Mountain Oak Creek 2.0 air km (1.3 air mi.) west of Lick Skillet Road bridge, 14.0 air km (8.7 air mi.) SSW of Whitesville, Harris County, Georgia.

Mulberry Creek

Mulberry Creek at Alabama Road bridge, 4.5 air km (2.8 air mi.) NNE of Waverly Hall, 12.0 air km (6.2 air mi.) south of Shiloh, Harris County, Georgia.

Mulberry Creek at Georgia Highway 85 bridge, 3.0 air km (1.9 air mi.) north of Waverly Hall, 12.0 air km (7.5 air mi.) south of Shiloh, Harris County, Georgia.

Mulberry Creek at County Dirt Road #205, 4.0 air km (2.5 air mi.) NNW of Waverly Hall, 12.0 air km (7.5 air mi.) SSE of Hamilton, Harris County, Georgia.

Mulberry Creek at Winfree Road, 7.0 air km (4.3 air mi.) SSE of Hamilton, 8.0 air km (5.0 air mi.) NNW of Waverly Hall, Harris County, Georgia.

Mulberry Creek at U.S. highway 27 bridge, 5.5 air km (3.4 air mi.) south of Hamilton, 13.0 air km (8.1 air mi.) west of Waverly Hall, Harris County, Georgia.

Mulberry Creek at Hudson Mill Road bridge, 8.0 air km (5.0 air mi.) SSW of Hamilton, 10.0 air km (6.2 air mi.) SSE of Mountain Hill, Harris County, Georgia.

Mulberry Creek at Mulberry Grove Road bridge, 6.5 air km (4.0 air mi.) East of Mountain Hill, 10.0 air km (6.2 air mi.) SSW of Hamilton, Harris County, Georgia.

Mulberry Creek at Mountain Hill Road, 4.8 air km (3.0 air mi.) SSE of Mountain Hill, 5.0 air km (3.1 air mi.) NNW of Mulberry Grove, Harris County, Georgia.

Mulberry Creek at Georgia Highway 103 bridge, 8.5 air km (5.3 air mi.) south of Mountain Hill, 9.0 air km (5.6 air mi.) west of Mulberry Grove, Harris County, Georgia.

Mulberry Creek 1.5 air km (0.9 air mi.) SSW of Georgia Highway 103 bridge, Harris County, Georgia.

Mulberry Creek at the confluence of the Chattahoochee River, Harris County, Georgia.

Standing Boy Creek

Standing Boy Creek 2.0 air km (1.4 air mi.) east of U.S. Highway 27, and 4.0 air km (4.5 air mi.) west of Ellerslie, Harris County, Georgia.

Standing Boy Creek at U.S. Highway 27 bridge 6.5 air km (4.0 air mi.) SSE of Mulberry Grove, Harris County, GA and 9.0 air km (5.5 air mi.) NNW of Midland, Muscogee County, Georgia.

Standing Boy Creek at Fortson Road bridge 11.0 air km (6.8 air mi.) SSE of Mountain Hill and 8.0 air km (5.0 air mi.) west of Cataula, Harris County, Georgia.

Standing Boy Creek at Interstate 185 bridge 11.0 air km (6.8 air mi.) west of Cataula and 11.2 air km (7.0 air mi.) SSE of Mountain Hill, Harris County, Georgia.

Standing Boy Creek north of Whitesville Road at Camp Callaway and below Lake Mobley Dam 11.3 air km (7.1 air mi.) SSE of Mountain Hill and 4.8 air km (3.0 air mi.) NNW of Fortson, Harris County, Georgia.

Standing Boy Creek 0.1 air km west of Whitesville Road bridge and 5.5 air km (3.3 air mi.) west of Fortson, Harris County, Georgia.

Standing Boy Creek at Georgia Highway 103 bridge 8.3 air km (5.1 air mi.) SSW of Fortson, Harris County, Georgia.

Standing Boy Creek at the confluence of Hefierhorn Creek, Muscogee County, Georgia.

Standing Boy Creek at the confluence of the Chattahoochee River, Muscogee County, Georgia.

Bull Creek

Bull Creek at Old Warm Springs Road bridge 3.0 air km (1.8 air mi.) SSW of Midland, Muscogee County, GA and 9.0 air km (5.8 air mi.) SSE of Fortson, Harris County, Georgia.

Bull Creek at U.S. Highway 27A bridge 3.0 air km (1.8 air mi.) SSW of Midland, Muscogee County, GA and 10.0 air km (6.2 air mi.) SSE of Fortson, Harris County, Georgia.

Bull Creek at U.S. Highway 80 culvert 4.5 air km (2.8 air mi.) SSW of Midland, Muscogee County, GA and 11.2 air km (7.0 air mi.) SSE of Fortson, Harris County, Georgia.

Bull Creek at Georgia Highway 22 4.8 air km (3.0 air mi.) SSW of Midland, Muscogee County, GA and 13.0 air km (8.1 air mi.) south of Cataula, Harris County, Georgia.

Bull Creek at Woodruff Farm Road 10.5 air km (6.5 air mi.) SSW of Midland, Muscogee County, GA and 17.3 air km (10.7 air mi.) south of Cataula, Harris County, Georgia.

Bull Creek at Old Cusseta Road 19.0 air km (11.8 air mi.) south of Fortson, Harris County, GA and 19.0 air km (11.8 air mi.) SSW of Midland, Muscogee County, Georgia.

Bull Creek at the confluence of the Chattahoochee River, Muscogee County, Georgia.

Upatoi Creek

Upatoi Creek at Carisle Road bridge 8.5 air km (5.3 air mi.) south of Talbotton and 4.0 air km (2.5 air mi.) NNE of Geneva, Talbot County, Georgia.

Upatoi Creek at U.S. Highway 80 bridge 1.2 air km (0.8 air mi.) north of Geneva and 9.7 air km (6.0 air mi.) south of Talbotton, Talbot County, Georgia.

Upatoi Creek at Teal Road bridge 2.9 air km (1.7 air mi.) west of Geneva and 10.5 air km (6.7 air mi.) SSW of Talbotton, Talbot County, Georgia.

Upatoi Creek 1.8 air km (1.1 air mi.) NNW of Teal Road bridge and 10.0 air km (6.3 air mi.) SSW of Talbotton, Talbot County, Georgia.

Upatoi Creek 3.0 air km (1.8 air mi.) west of Teal Road bridge and 12.5 air km (7.7 air mi.) SSW of Talbotton, Talbot County, Georgia.

Upatoi Creek at U.S. Highway 80 bridge 5.7 air km (3.5 air mi.) SSW of Geneva and 3.5 air km (2.3 air mi north of Juniper, Talbot County, Georgia.

Upatoi Creek at the confluence of Juniper Creek 1.5 air km (1.0 air mi.) west of Juniper and 3.5 air km (2.2 air mi.) east of Box Springs, Talbot County, Georgia.

Upatoi Creek at the confluence of Scoggins Creek (Thomas' Bottoms) 2.0 air km (1.2 air mi.) east of Box Springs and 3.4 air km (2.1 air mi.) west of Juniper, Talbot County, Georgia.

Upatoi Creek at Box Springs (King's Bottoms) 5.0 air km (3.1 air mi.) west of Juniper and 11.5 air km (7.3 air mi. SSW of Geneva, Talbot County, Georgia.

Upatoi Creek at U.S. Highway 27 bridge 16 air km (9.9 air mi.) NNW of Cusseta,, Chattahoochee County, GA and 20.5 air km (12.7 air mi.) SSW of Midland, Muscogee County, Georgia.

Upatoi Creek 4.5 air km (2.8 air mi.) east of Chattahoochee River and 20.0 air km (12.4 air mi.) NNW of Cusseta, Chattahoochee County, Georgia.

Upatoi Creek at the confluence of the Chattahoochee River 20.0 air km (12.4 air mi.) WNW of Cusseta, Chattahoochee County, Georgia.

