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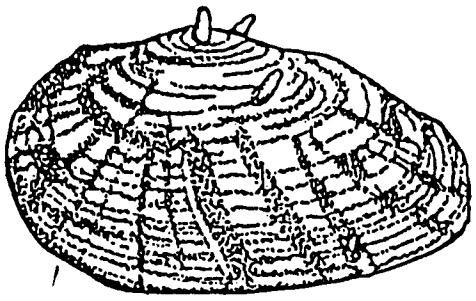
A REPORT ON THE CONSERVATION STATUS OF NORTH CAROLINA'S FRESHWATER AND TERRESTRIAL MOLLUSCAN FAUNA



Elliptio steinstansana

Goniobasis interrupta

Triodopsis soelneri

Prepared by

The Scientific Council on Freshwater and Terrestrial Mollusks

MAY 1990

JUN 13 1990

A REPORT ON THE CONSERVATION STATUS OF NORTH CAROLINA'S FRESHWATER AND TERRESTRIAL MOLLUSCAN FAUNA

MAY 1990

Prepared by

The Scientific Council on Freshwater and Terrestrial Mollusks

in accordance with

Article 25 of Chapter 113

of the

General Statutes of North Carolina

A REPORT ON THE CONSERVATION STATUS OF NORTH CAROLINA'S

FRESHWATER AND TERRESTRIAL MOLLUSCAN FAUNA

MAY 1990

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PREFACE

This report documents the negative trends and uncertain future which surrounds North Carolina's freshwater and terrestrial molluscan fauna. Indeed, if this document tells the truth well, its reader should be troubled that the situation has become so critical; that, in almost a century of documented decline, so little has been done to reverse the decline of so many species towards extinction. It is the hope of the scientific council this this report clearly illustrates that we cannot afford to wait any longer to act on behalf of these species.

W.F.A

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A REPORT ON THE CONSERVATION STATUS OF NORTH CAROLINA'S FRESHWATER AND TERRESTRIAL MOLLUSCAN FAUNA

Introduction

This report presents the findings of the scientific council established to evaluate the status of North Carolina's freshwater and terrestrial mollusks. At the outset of the evaluation process, the committee determined that a listing of all species of freshwater and terrestrial mollusks which occur in North Carolina was needed as a basis for review. A checklist was therefore developed using literature records and the personal records of committee members and is included as Appendix A to this report. Using this list, the scientific council deliberated the population conditions of each taxon of freshwater and terrestrial mollusk known to occur in North Carolina and assigned statuses under several different ranking systems. These statuses, including their definitions, are included in the checklist.

The species accounts provided as a part of this report will be published in the near future by the North Carolina State Museum of Natural Sciences as a component of their ongoing series which reevaluates the state's endangered, threatened and rare fauna. The statuses used in the species accounts provided in this report are, therefore, those developed by the state museum and are consistent with its other published reevaluations. Statuses used in the recommendations section of this report are those used and defined in Article 25 of Chapter 113 of the General Statutes of North Carolina.

Background

The Scientific Council on Freshwater and Terrestrial Mollusks was established in December, 1988. Collectively, it offers a broad background of expertise in the systematics, distribution, and ecology of North Carolina's molluscan fauna. The scientific council met on 6 and 7 May, 1989, at the North Carolina Wildlife Resources Commission's wildlife depot at Butner, North Carolina, to assess the population condition of each taxon known to be a component of the state's freshwater or terrestrial molluscan fauna and to assign statuses under the various ranking systems.

Prior to this effort, the 1975 mollusk committee convened by the North Carolina State Museum of Natural Sciences determined that 28 species of freshwater or terrestrial mollusks were either endangered, threatened, of special concern, or status undetermined. At the time that number seemed high, equaling 10% of the state's known fauna (Fuller, 1977). Today, we know that that number was, in actuality, too low. The number of species being recommended for listing in this report, <u>excluding</u> status undetermined species, stands at 71, equaling roughly one-fourth of the state's known fauna. If the status undetermined species were included in this tally, the species of concern would swell to over one-half of the

state's fauna. The number of taxa of freshwater and terrestrial mollusks being recommended for listing, within each listing category, are shown, by family, in Table 1.

Table 1. Summary of the statuses of North Carolina's families of native freshwater and terrestrial mollusks.

Family	Number of Taxa	Number of Taxa							
		Ext.	Extirp.	End.	Th.	S.C.	Und.	% E/T/SC	% U
FRESHWATER MOLLUSKS									
Valvatidae	1	-	-	-	-	-	1	-	100%
Viviparidae	5	-	-	-	-	-	3	-	60%
Hydrobiidae	5	-	-	-	-	2	1	40%	20%
Pleuroceridae	11	-	-	1	1	-	5	18%	45%
Lymnaeidae	3	-	-	-	-	-	2	-	67%
Physidae	3	-	-	-	-	-	-	-	-
Planorbidae	9	-	1	1	-	-	4	11%	44%
Ancylidae	5	-	-	-	-	1	-	-	20%
Sphaeriidae	13	-	-	-	-	-	6	-	46%
Unionidae	64	1	1	11	12	10	20	53%	31%
Subtotal	119	1	2	13	13	13	42	34%	35%
TERRESTRIAL MOLLUSKS									
Helicinidae	1	-	-	-	-	-	1	-	100%
Pomatiasidae	1	-	-	-	-	-	-	-	-
Carychiidae	4	-	-	-	-	-	1	-	25%
Cochlicopidae	1	-	-	-	-	-	-	-	-
Valloniidae	1	-	-	-	-	-	1	-	100%
Pupillidae	14	-	-	-	-	-	9	-	64%
Strobilopsidae	3	-	-	-	-	-	-	-	-
Succineidae	13	-	-	-	1	-	8	8%	62%
Philomycidae	10	-	-	-	-	1	3	10%	30%
Discidae	9	-	-	-	-	1	3	11%	33%
Helicodiscidae	4	-	-	-	-	2	-	50%	-
Punctidae	3	-	-	-	-	-	3	-	100%
Zonitidae	54	-	-	1	2	11	15	26%	28%
Helicarionidae	5	-	-	-	-	-	4	-	80%
Haplotrematidae	2	-	-	-	-	1	-	50%	-
Spiraxidae	1	-	-	-	-	-	1	-	100%
Polygyridae	56	-	-	-	6	5	19	20%	36%
Subtotal	182	-	-	1	9	21	68	17%	38%
COMBINED TOTALS	301	1	2	14	22	34	110	23%	37%

Several factors account for the higher number of taxa currently being recommended for listing. First, the 1975 mollusk committee underestimated the number of species which actually occur in the state. Many systematic revisions have occurred in the 15 years following the 1975 symposium and many taxa which were formerly lumped together have now been split, and vice versa. The net result of this systematic activity has been an increase in the number of recognized species occurring, or potentially occurring, in the state.

Second, heightened interest in freshwater and terrestrial mollusks in the past decade has resulted in a larger database from which status assessments can be made. With this enlarged database, trends from historic population distributions could clearly be seen, and species no longer occurring in formerly occupied habitats could be clearly identified.

Third, and most important, is that the habitat for many species of mollusks is still deteriorating. Many aquatic sites, such as the Deep River in Chatham County, once harbored many species of bivalve mollusks but today support comparatively few. In still other areas, many adult bivalve mollusks can be found but few or no young, suggesting impairment of reproduction. High elevation mountain habitats are deteriorating as well and our terrestrial mollusks are, without doubt, suffering accordingly.

The combined effects of these three driving forces are illustrated in Table 2, which shows the current systematic treatment and status recommendations for those taxa of concern identified by the 1975 mollusk committee (Fuller 1977) and compares them with their previously used names and assigned statuses. It will be noted that some scientific names have changed, some species have been found to be more common, other species have become rarer, while still other species have been removed from the state list. Such changes have occurred for many other taxa not on the 1975 committee's list and illustrate the need for continual monitoring of the state's molluscan population on four fronts: systematics, distribution, habitat quality, and population vigor. Without all four, some taxa in need of protection will be overlooked while others may be needlessly regulated. Recommendations for future monitoring are included elsewhere in this report.

Table 2. Currently recommended statuses and names of those North Carolina freshwater and terrestrial mollusks which were listed in 1975 (Fuller 1977).

Taxa - 1975 Name	Taxa - 1989 Name	Status-1975	Status-1989
GASTROPODA			
Freshwater			
Lioplax subcarinata	Lioplax subcarinata	Endangered	Common
Amnicola sp.	Amnicola sp.	Endangered	Sp. Concern
Spirodon dilatatum	Leptoxis dilatata	Undetermined	Threatened
Helisoma magnificum	Planorbella magnifica	Threatened	Endangered
Taphius eucosmium	Helisoma eucosmium	Extinct?	Extirpated
Terrestrial			
Anguispira paucicostata	Anguispira mordax	Undetermined	Undetermined
Mesodon archeri	Mesodon archeri	Undetermined	Possible
Meson clarki nantahala	Meson clarki nantahala	Threatened	Threatened
Mesodon jonesianus	Mesodon jonesianus	Endangered	Threatened
Mesodon orestes	Mesodon orestes	Undetermined	Threatened
Triodopsis soelneri	Triodopsis soelneri	Threatened	Threatened
BIVALVIA			
Alasmidonta triangulata	Alasmidonta undulata	Undetermined	Threatened
Alasmidonta varicosa	Alasmidonta varicosa	Sp. Concern	Threatened
Anodonta couperiana	Anodonta couperiana	Sp. Concern	Extirpated
Anodonta implicata	Anodonta implicata	Undetermined	Sp. Concern
"Canthyria" sp.	Elliptio steinstansana	Endangered	Endangered
Carunculina pulla	Toxolasma pulla	Endangered	Threatened
Elliptio lanceolata *	Elliptio lanceolata	Sp. Concern	Threatened
Elliptio marsupiobesa	Elliptio marsupiobesa	Endangered	Threatened
Elliptio sp.	Elliptio folliculata	Threatened	Sp. Concern
Elliptio sp.	Elliptio cistelliformis	Undetermined	Undetermined
Elliptio waccamawensis	Elliptio waccamawensis	Endangered	Threatened
Fusconaia masoni	Fusconaia masoni	Threatened	Threatened
Lampsilis ochracea	Lampsilis ochracea	Sp. Concern	Sp. Concern
Lampsilis radiata "complex"	Lampsilis fullerkati	Endangered	Threatened
Lampsilis radiata "complex"	Lampsilis radiata	Endangered	Sp. Concern
Ligumia nasuta	Ligumia nasuta	Undetermined	Sp. Concern

* The lanceolata complex discussed by Fuller (1977) has been broken out into several taxa. The "lanceolata" on the 1989 list is sensu stricto.

Discussion

Although invertebrates are essential components of properly functioning ecosystems, the study of invertebrates has generally progressed more slowly than studies of other groups of animals because invertebrates frequently occupy cryptic habitats and can be difficult to observe, collect and identify. These impediments, plus an aversion to such creatures by many people, have resulted in minimal interest in the welfare of invertebrates on the part of the public. Consequently, in comparison with the higher order vertebrates, little effort has been expended by scientists in the areas of taxonomy, distribution and natural history of many invertebrate groups.

This poor public image and scientific neglect have resulted in a general lack of consideration of invertebrates in the process of identifying and protecting essential habitats. For example, many endemic species of mollusks are known from only a single locality or river drainage in North Carolina and yet, of these, only three have been federally listed as threatened or endangered. With highly visible species which profit from enhanced public interest, it is doubtful that such a situation would occur. As scientists and resource managers working together to provide sound stewardship of our resources, we must see beyond the crises facing our higher order taxa and extend the same measures of protection to threatened invertebrates as well. To do otherwise raises ethical questions which we are ill-equipped to answer.

Animals which spend their lives within very small territories are often habitat specialists and, as such, are extremely sensitive to changes in their environment. For such animals, substantial energy savings are realized through avoiding extensive movements; however, this energy efficiency carries a price - if all of the requirements necessary for the maintenance of the individual are not regularly located in a very small area, it will ultimately perish. All of our freshwater and terrestrial mollusks fall into this group of range restricted, energy efficient animals.

Like other groups of animals, some freshwater and terrestrial mollusks have very broad ecological tolerances while others are more restricted. Most mollusks are tied to their environments in intricate ways which researchers are just beginning to understand. While we still have much to learn about these species, some generalities are permissible and are provided in the following discussion to help understand why populations of so many species of North Carolina's mollusks are facing serious declines.

Today, no group of North Carolina mollusks is more critically imperiled than the freshwater bivalves of the family Unionidae. The seriousness of their situation can hardly be overstated. Over half of the species known to occur in North Carolina have suffered drastic population declines and are being recommended for protection (Table 1). Other species are showing signs of decline as well and may be listed in the near

future. Moreover, of the species being listed as species of special concern or threatened, their continuing declines may require status changes to threatened or endangered in the next few years. Some of the species classified by the council as undetermined (e.g. Ptychobranchus fasciolaris and Medionidus conradicus) have quite probably been extirpated, only surveys to confirm the fact are needed.

Problems with this group are neither new or restricted to North Carolina. Documented declines in freshwater bivalves have been reported throughout the nation since the turn of the century. Causes recognized early were sewage and industrial waste discharges, unregulated forestry, dredging, and dam construction (Coker et al. 1922). In 1918, freshwater bivalve populations of the French Broad River at Asheville and the Pigeon River below Canton were already reported to be severely impacted (Ortmann 1918). In spite of this knowledge, insufficient pollution abatement efforts have allowed the decline in freshwater bivalve populations to continue and spread.

The life cycles of the Unionidae make them especially susceptible to pollutants or disturbances in their habitat, and will be discussed here to illustrate the complexities which are often involved in the conservation or restoration of freshwater molluscan populations. The Unionidae filter ambient waters to obtain the oxygen and food necessary for maintenance of the individual, and to carrying out successful reproduction. During filtering, the female takes in sperm discharged into the water column by the male and is fertilized. She broods the developing embryos in a modified gill called a marsupium. Prior to completion of embryonic development, she discharges young into the water column. In this larval stage, the young are called glochidia and are entering into the parasitic stage of their life cycle. The glochidia must affix themselves to the gills or fins of a host fish to complete their embryonic development. Some species of unionids are thought to be host specific while others can use a variety of host species. Once attached to a fish, they are encysted until their physiological development is completed, then they drop off and begin their lives as the sessile bivalves we all know so well. The percentage of discharged glochidia which actually find a host, complete their development and survive to adulthood is unknown but, even under the best of conditions, is presumed to be quite low.

In degraded waters, this life cycle proves to have many weak spots. First, certain pollutants can affect the viability and motility of sperm. Second, in periods of low dissolved oxygen, females sometimes abort the developing embryos in order to increase the capacity of brood gills to capture oxygen necessary for their own survival. Third, glochidia which are discharged into the water column in the presence of certain types of pollutants have a weakened sensitivity of their abductor muscles (these are the muscles used by the adult mussel to close its valves). This reduced sensitivity impairs the ability of glochidia to attach to host fish. Fourth, adult populations must be dense enough to allow successful transfer of sperm from male to female. Should populations continually decline, the likelihood of successful sperm transfer becomes progressively worse. Fifth, if the host fish for a host specific bivalve is extirpated or significantly reduced in numbers, the reproduction of its associated

bivalve will fail or drop below the recruitment rate necessary for survival of the population. Sixth, due to the limited mobility of adult bivalves, once they are extirpated from a stream or river system they are totally dependent on the movements of glochidia-laden host fish for eventual reoccupation of an impacted area. Clearly, the greater the length of the impacted stream, the longer recolonization will require.

Because of reduced numbers, most of our native freshwater bivalves have lost their important roles in the proper functioning of our aquatic ecosystems. Recovering their former numbers and diversity will not be easy. Water quality has improved in some streams in recent years but, generally, the Unionidae have not reoccupied these areas. No studies are available which document or discuss natural stream recovery periods, quite possibly because it has not yet happened. For the present at least, we must manage our unionid populations with the guarded philosophy that once we have lost a population from a given stream, it is probably gone for decades.

The ecosystem instability produced by man's actions selects against organisms which have low fecundity or have complex life-cycle requirements and selects for those which are prolific and have simple life-cycle requirements. Today, so much instability is introduced to rivers and streams through constant or periodic introduction of pollutants, that the ancient lineage of the Unionidae is rapidly disappearing. The introduced Asian clam (Corbicula fluminea), which has a very different and quite simple life-cycle, has replaced the Unionidae in so many areas that it is now our most common bivalve. Indeed, because it is such an efficient competitor, it has been implicated by some researchers as contributing to the demise of the Unionidae. Additionally, Corbicula may not be the last species to be introduced to our waters. Other foreign mollusks may ultimately make their way to North Carolina and their impacts may be as severe or worse.

In many cases, freshwater mollusks have their best, or only, remaining populations in headwater areas of river basins where water quality remains good. This circumstance will present difficult choices in the years ahead, as these are the very areas which, because of their good water quality, will be targeted for water supply reservoirs as society's demand for water increases.

It should be clearly understood that remnant populations of many freshwater and terrestrial mollusks may be threatened by their demographic and genetic insularity even if additional impacts to them can be averted. How long such populations can perpetuate themselves is academic; insularity threatens the gene pools of these taxa and every population lost affects the total gene pool remaining. For this reason, pilot programs to restore species to locations once occupied need to be given serious consideration. This will require experimentally controlled studies where streams are first restocked with native fish populations and then restocked with native unionids. This technology will probably be essential if we are to reestablish endangered species of bivalves in cleaned-up streams which they formerly occupied. However, as a precursor

of such action, a report documenting their historical ranges within the state would have to be prepared.

While this discussion has focused on the freshwater bivalves, it should be remembered that many species of freshwater and terrestrial gastropods are also facing uncertain futures. Land snails, in particular, face competition from introduced species of snails, habitat disruption and fragmentation, genetic swamping, acid precipitation, and a host of other ills conferred directly or indirectly by man's actions. Because the niches of most of these species are totally unknown to us, we cannot adequately assess the impacts of any proposed action on a given population, much less design any type of manipulative habitat management plan for the benefit of the species.

Long-term conservation of freshwater mollusks in North Carolina can only lie in the restoration and maintenance of habitat quality and stability in the waters of the state. This task, requiring strict enforcement of existing laws, additional monitoring and, most likely, even further restrictions on air and water discharges, will not be easy. One of the most serious threats to freshwater and terrestrial mollusks, because of its all pervasiveness and North Carolina's lack of information and ability to control it, is acid precipitation. This is not just a problem of the high elevation forests of our mountains. With increasing justification, it has been implicated in the gradual demise of much of our freshwater and terrestrial molluscan fauna. The "smoking gun" has not yet been found, and perhaps never will be, but our molluscan populations indicate that something spanning the breadth of the state is inhibiting their reproduction and atmospheric pollutants are certainly a prime suspect.

In managing our molluscan fauna and other aquatic species, influencing the actions of our fellow citizens will be the ultimate conservation challenge. Evidence indicates that society is a fickle partner for some conservation efforts, supporting those efforts with obvious and quick benefits while hedging when the fruits of such labors are hidden, silent, or too long in the making. For conservation of invertebrates to ever capture the will of society, it will require a higher level of public education and a greater dose of fervor on the part of those who understand its importance. The potential fruits of success become fewer as time slips by; with each passing year we are working for less and less. Already a number of species have been lost forever and the costs of these losses will never be known.

Recommendations

The following species of freshwater and terrestrial mollusks are recommended for protection in accordance with Article 25 of Chapter 113 of the General Statutes of North Carolina.

FRESHWATER MOLLUSKS

Endangered

Snails

Knotty elimia	Goniobasis interrupta (Haldeman, 1840)
Magnificent rams-horn	Planorbella magnifica (Pilsbry, 1903)

Mussels

Tennesse pigtoe	Fusconaia barnesiana (I. Lea, 1838)
Pistolgrip	Tritigonia verrucosa (Rafinesque, 1820)
Neuse spike	Elliptio judithae Clarke, 1986
Tar River spiny mussel	Elliptio steinstansana Johnson and Clarke, 1983
Carolina heelsplitter	Lasmigona decorata (I. Lea, 1852)
Tennessee heelsplitter	Lasmigona holstonia (I. Lea, 1838)
Green floater	Lasmigona subviridus (Conrad, 1835)
Dwarf wedge mussel	Alasmidonta heterodon (I. Lea, 1829)
Appalachian elktoe	Alasmidonta raveneliana (I. Lea, 1834)
Slippershell mussel	Alasmidonta viridis (Rafinesque, 1820)
Barrel Floater	Anodonta couperiana I. Lea, 1842

Threatened

Snails

Seep mudalia	Leptoxis dilatata (Conrad, 1835)

Mussels

Atlantic pigtoe	Fusconaia masoni (Conrad, 1834)
Yellow lance	Elliptio lanceolata (I. Lea, 1828)
Cape Fear spike	Elliptio marsupiobesa Fuller, 1972
Roanoke slabshell	Elliptio roanokensis (I. Lea, 1838)
Waccamaw spike	Elliptio waccamawensis (I. Lea, 1863)
Triangle floater	Alasmidonta undulata (Say, 1817)
Brook floater	Alasmidonta varicosa (Lamarck, 1819)
Squawfoot	Strophitus undulatus (Say, 1817)
Savannah lilliput	Toxolasma pullus (Conrad, 1838)
Mountain creekshell	Villosa vanuxemensis (I. Lea, 1838)
Yellow lampmussel	Lampsilis cariosa (Say, 1817)
Waccamaw fatmucket	Lampsilis fullerkati R. I. Johnson, 1984

Special Concern

Snails

Waccamaw siltsnail	Cincinnatia sp.
Waccamaw amnicola	Amnicola sp.
Blackwater ancylid	Ferrissia hendersoni (Walker, 1908)

Mussels

Spike	Elliptio dilatata (Rafinesque, 1820)
Pod lance	Elliptio folliculata (I. Lea, 1838)
Alewife floater	Anodonta implicata Say, 1829
Alabama rainbow	Villosa nebulosa (Conrad, 1834)
Carolina creekshell	Villosa vaughanianus (I. Lea, 1838)
Eastern pondmussel	Ligumia nasuta (Say, 1817)
Waccamaw lampmussel	Lampsilis crocata (I. Lea, 1841)
Wavy-rayed lampmussel	Lampsilis fasciola Rafinesque, 1820
Tidewater mucket	Lampsilis ochracea (Say, 1817)
Eastern lampmussel	Lampsilis radiata (Gmelin, 1791)

TERRESTRIAL MOLLUSKS
(Land Snails)

Endangered

Fragile glyph	Glyphyalinia clingmani (Dall, 1890)

Threatened

Waccamaw ambersnail	Catinella waccamawensis Franzen, 1981
Sculpted supercoil	Paravitrea ternaria Hubricht, 1978
Roan supercoil	Paravitrea varidens Hubricht, 1978
Noonday globe	Mesodon clarki nantahala (Clench and Banks, 1932)
Smoky Mountain covert	Mesodon ferrissi (Pilsbry, 1897)
Big-tooth covert	Mesodon jonesianus (Archer, 1938)
Engraved covert	Mesodon orestes Hubricht, 1975
Clingman covert	Mesodon clingmanicus (Pilsbry, 1904)
Cape Fear threetooth	Triodopsis soelneri (J. B. Henderson, 1907)

Special Concern

Black mantleslug	Pallifera hemphilli (W. G. Binney, 1885)
Saw-tooth disc	Discus bryanti (Harper, 1881)
Spiral coil	Helicodiscus bonamicus Hubricht, 1978
Fringed coil	Helicodiscus fimbriatus Wetherby, 1881

Special Concern (cont.)

Dark glyph	Glyphyalinia junaluskana (Clench & Banks, 1932)
Pink glyph	Glyphyalinia pentadelphia (Pilsbry, 1900)
Honey glyph	Glyphyalinia vanattai (Pilsbry & Walker, 1902)
High mountain supercoil	Paravitrea andrewsae (W. G. Binney, 1879)
Mirey Ridge supercoil	Paravitrea clappi (Pilsbry, 1898)
Ramp Cove supercoil	Paravitrea lacteodens (Pilsbry, 1903)
Lamellate supercoil	Paravitrea lamellidens (Pilsbry, 1898)
Glossy supercoil	Paravitrea placentula (Shuttleworth, 1852)
Open supercoil	Paravitrea umbilicaris (Ancey, 1887)
Bidentate dome	Ventridens coelaxis (Pilsbry, 1899)
Appalachian gloss	Zonitoides patuloides (Pilsbry, 1895)
Blue-foot lancetooth	Haplotrema kendeighi Webb, 1951
Great Smoky slitmouth	Stenotrema depilatum (Pilsbry, 1895)
Queen crater	Mesodon chilhoweensis (J. Lewis, 1870)
Dwarf proud globe	Mesodon clarki (I. Lea, 1858)
Velvet covert	Mesodon subpalliatus (Pilsbry, 1893)
Dwarf threetooth	Triodopsis fulciden Hubricht, 1952

Three species of freshwater mollusks are currently believed to be either extinct or extirpated from North Carolina. These species should also be protected under the act in the event surviving North Carolina populations are one day found. These species are:

Greenfield rams-horm	Helisoma eucosmium (Bartsch, 1908)
Little-wing pearlymussel	Pegias fabula (I. Lea, 1838)
Carolina elktoe	Alasmidonta robusta Clarke, 1981

In spite of improvements in the mollusk database which have taken place over the past 15 years, the scientific council still encountered difficulty in assessing the status of many of the taxa occurring in the state. Its difficulties are reflected in the great number of species classified as status undetermined. Every council member was, at times, plagued with concerns over the accuracy of certain status assessments. One of the most difficult classifications to assign is that of "common", because its meaning is interpreted in so many different ways. Without being unduly cautious, the council wanted to assure that only declining or restricted range species would be protected.

During the course of the council's deliberations, discussions understandably migrated with great frequency to the theme of what needed to be done to make the job easier and to protect the state's molluscan fauna in the future. The following recommendations are the result of these deliberations and are offered in the hope that they will be taken to heart and followed to the extent legislative and budgetary constraints will permit.

1. Known refugia for listed species (see species accounts) should receive the strictest possible protection. Protecting good habitat for these species is far less expensive than trying to reestablish populations in the future.

2. Existing laws which were promulgated to protect the water quality in our streams and rivers should be strictly enforced and steps should be taken to upgrade water quality wherever possible. Quite literally, a single accidental spill or discharge violation could obliterate much of a river's molluscan fauna for decades. Due to their limited motility and complicated life-cycles, natural recovery of our remaining native species will be an extended process. Indeed, should all sources of pollution disappear today, recovery would probably not occur within our life-times. Clearly, with recovery periods requiring these time frames, we cannot afford to lose further ground.

3. Dechlorination units should be added to sewage treatment plants whenever possible. Chlorine and its compounds have been used as bacteriocides for sewage effluents for many years; however, its affects on aquatic systems has come under serious study only in recent years. In wastewaters, chlorine and hypochrlorites react with other substances to produce chloramines and a variety of other chlorinated compounds which, though less toxic, are more stable. These products are inimical to bivalve mollusks and a variety of other aquatic organisms, as has been demonstrated in case after case.

4. Agencies responsible for the regulation of major land-use activities such as farming and forestry need to intensify their ongoing efforts to educate their clients in the use of land management practices which control erosion and reduce runoff of toxic substances. In spite of the progress that has been made, agriculture and forestry operations are still causing problems in many of our streams.

5. Local governments need to recognize their responsibility and potential for protecting rare species through zoning. Without their support, the chances for species recoveries are significantly diminished. In most cases, local governments do not realize that rare species occur within their jurisdiction; therefore, the transfer of information about these species needs to be improved.

6. Statewide mollusk surveys should be performed and the habitat niches of our rarer species defined. For streams and rivers, this effort should be similar in scope to fish surveys performed by the Wildlife Resources Commission in the early 1960's. Such surveys should be performed in a systematic manner, and should be closely allied to, and aligned with, the Division of Environmental Management's benthic assessment program. For terrestrial species, surveys should be systematically directed to habitat types, which should be defined on the basis of soils, hydrology, vegetation, location and elevation, etc.

7. All surveys should be performed by qualified personnel, should address clearly defined goals and objectives, and should be designed so that

results can be published. Voucher specimens should be placed in an institution where they will be properly catalogued and curated. Arrangements for curation of material should be made prior to collections.

8. A reference collection of all species of mollusks known from the state should be established and maintained within the state for the benefit of current and future researchers. This collection should include both specimens of shells and properly narcotized and preserved specimens. Many of our species are taxonomically difficult and a reference collection is greatly needed for verification of identifications. Topotypic specimens of taxa believed or known to occur in North Carolina should be sought and used in the standardization of species concepts.

9. Future surveys of taxa with uncertain taxonomic position should require the use of molecular data as an additional character for interpretation. This information is extremely valuable as a diagnostic tool and, for some taxa, the opportunity to obtain it may only last a few more decades. Standardized techniques should be followed. Information gained should be published and raw data catalogued and curated with the specimens.

10. When defensible data are available to show that a species has been seriously depleted, this information should be transferred to the U.S. Fish and Wildlife Service to facilitate the species' listing on the federal endangered and threatened species list. Federal listing would provide additional protection and, potentially, additional funding for research and conservation efforts.

11. The status of all species on the checklist (Appendix A) should be periodically reevaluated. A suggested interval is once every 3 years.

12. When conducting molluscan surveys for target species, collection of other non-listed species and field notation of other listed species should be required whenever possible. This is the only way existing data gaps on undetermined species can be addressed in a cost-effective manner. In addition, deposition of voucher specimens in an institution where they will be properly curated should be required.

13. The reasons for the rapid decline of North Carolina's freshwater bivalves should be vigorously studied. Entire genera of bivalves are on the verge of disappearing from the state and causes are still a matter of speculation. Once the causes have been identified, swift action to ameliorate their effects should be undertaken.

14. The effects of acid precipitation on mountain land snails should be thoroughly studied and monitored. Gradual changes in soil chemistry and microflora which are now occurring will undoubtedly have profound direct and indirect consequences for many of our most beautiful and restricted species.

15. Education of the public about the state's molluscan fauna should receive a high priority. Additional articles in regional magazines, news features, museum and aquarium displays, etc., should all be used to heighten public awareness of this resource. Such measures should stress the importance of these species as indicator organisms, their complex natural histories, their rates of disappearance, their beauty, etc.

16. Habitat and population monitoring which specifically targets mollusks should be undertaken. Without it, their cryptic nature almost assures that deterioration of habitats will go largely undetected. As stated earlier, this monitoring should occur on four fronts: systematics, distribution, habitat quality, and population vigor.

Species Accounts

It will be noted in the species accounts that the taxonomy of many species has been, and continues to be, very unsettled. This is a result of early malacologists describing species with Linnaean brevity on the exclusive basis of shell topography and color. Today we know that shell morphology in some species of freshwater mollusks is very plastic, varying with stream flow, substrate, water chemistry and other factors. Terrestrial mollusks are also prone to ecophenotypic variation, usually based on altitudinal and soil chemistry characteristics. As a result of these early conchological descriptions, many "forms" of the same species were described as distinct species. As an extreme example, a highly variable species of freshwater bivalve, Elliptio complanata, was described over 100 times, over 70 times by the same person. The harried systematist must methodically unravel this Gordian knot of taxonomic chaos to determine which species names actually represent distinct taxa and which should be relegated to synonymy. Today, soft-tissue anatomy, glochidia and allozyme data are among the tools being used in this effort. Unfortunately, many of these earlier "species" can no longer be found at their type locality, making absolute comparisons impossible. In spite of these obstacles, progress is being made, and higher level taxonomic groupings are fairly well established. Most changes to be expected in coming years will probably occur at the level of genus and species.

In the pages that follow, a species account is provided for each species being recommended by the scientific council for classification as endangered, threatened, or special concern. In addition, accounts for species which are believed to be extinct or extirpated from the state are provided in the hope that surviving populations will be found. Abbreviated accounts for species of undetermined status have also been provided for information purposes.

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William F. Adams

EXTINCT OR EXTIRPATED SPECIES

Helisoma eucosmium (Bartsch, 1908)
GREENFIELD RAMS-HORN

Description. The Greenfield rams-horn has a discoidal (i.e., coiling in one plane) shell. It is extremely small, with a maximum diameter of about 6 mm and a height of about 3 mm. It is easily distinguished from other small planiform species by the presence of "two rather broad, bright chestnut bands" against a "yellowish horn color" background (Bartsch 1908). For a complete description and illustration of shell characters, the reader should consult the work of Bartsch (1908) or Baker (1945).

Range. The Greenfield rams-horn is assumed to be a North Carolina endemic, as it has been reported only from its type locality. Bartsch (1908) also described a subspecies of the Greenfield rams-horn, Helisoma e. vaughani from specimens which were collected at Burkes Place, Louisiana, and provided to him by Dr. T. Wayland Vaughan.

Habitat. Nothing is known of the habitat of the Greenfield rams-horn. It is likely to be similar to that of Planorbella magnifica (see its species account) since Bartsch collected it during searches for that species.

Life History and Ecology. Nothing is known about the life history and ecology of this species.

Special Significance. If the Greenfield rams-horn is eventually determined to be a member of the genus Taphius (see Systematics, below), it would be the most northern species known for that tropical genus.

Type Locality. Greenfield Lake in Wilmington, North Carolina.

Systematics. Burch (1982) raises the possibility that Helisoma eucosmium may simply be a form or a juvenile of Helisoma anceps (Menke 1830). It was originally placed in the genus Planorbis (Muller 1774) by Bartsch (1908). Baker (1945) reassigned the species to the genus Helisoma Swainson 1840. Fuller (1977), reassigned the species from Helisoma to the Central American genus Taphius (H. &. A. Adams 1855) based on J. P. E. Morrison's observations of the soft-tissue anatomy of its subspecies Helisoma eucosmium vaughani from Louisiana. However, Taphius cannot be given priority over Biomphalaria (Preston 1910) when the two genera are considered synonyms (Opinion 735 (1965) of the International Commission on Zoological Nomenclature). Therefore, if J. P. E. Morrison's observations and Fuller's reassignment ultimately prove correct, the proper name for this taxon will be Biomphalaria eucosmium. Resolution of the systematic placement of this animal can only be achieved by the acquisition of additional specimens for soft-tissue examination. In light of all this confusion, I have elected to follow Burch's (1982) treatment of this species as a member of Helisoma, not on the basis of any convictions about its proper placement, but solely for the sake of continuity within the literature until an authoritative review of its systematics can be made.

Status. Extirpated.

Rationale for Evaluation. This species has been extirpated from its only known locale (Fuller 1977, Adams, in press).

Current Protection. None.

Recommendations. In light of the rediscovery of *Planorbella magnifica* in Orton Pond and the recognition of the unusually high molluscan diversity in that system, it seems possible that the Greenfield rams-horn may occur there as well. Searches of that location should be made to determine if the species may survive there. Should the species be found, studies of its autecology should be undertaken so that potential conservation measures can be developed and implemented should they prove necessary.

Remarks. The only known specimens of the Greenfield rams-horn are curated in the collections of the U.S. National Museum. They are provided in the accompanying table with the hope that future research on this species will be facilitated.

Table 1. Catalogue numbers of *Helisoma eucosmium* specimens currently housed in the U.S. National Museum.

Collector(s)	Catalogue Numbers	Comments
Bartsch	USNM 193890a	(Type)
	USNM 193890	(46 shells)

LITERATURE CITED

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Prepared by WILLIAM F. ADAMS

Pegias fabula (Lea 1838)
LITTLE-WING PEARLY MUSSEL

Description. The little-wing pearly mussel (the only species in the genus Pegias) is small, not exceeding 38 mm in length, 22 mm in width, and 13 mm in width. The shell's outer surface (periostracum) is usually eroded, giving the shell a chalky or ashy white appearance. When the periostracum is present, the shell is light green or dark yellowish brown with dark rays of variable width along the shell's anterior surface. The hinge teeth are well developed but incomplete. The lateral teeth are short and are either vestigial or entirely lacking. Detailed descriptions with illustrations are available in Clarke (1981), Bogan and Parmalee (1983), and Ahlstedt (1986).

Range. The little-wing pearly mussel was historically widespread but uncommon (see Table 1) in the smaller tributaries of the upper Cumberland and Tennessee River basins in Alabama, North Carolina, Kentucky, Tennessee, and Virginia (Stansbery 1976, Clarke 1981, Bogan and Parmalee 1983, Ahlstedt 1986). Based on a 1986 survey involving extensive field sampling of 55 potential and historic habitats in Cumberland and Tennessee River tributaries (Ahlstedt 1986) and other data (Steve Bakaletz, U.S. Park Service, Big South Fork National Recreation Area, pers. comm., 1986; Richard Neves, Virginia Cooperative Fish and Wildlife Research Unit, pers. comm., 1987), the species is now known to inhabit only seven stream reaches (four in Kentucky, one in Tennessee, and two in Virginia). No North Carolina populations are known to survive.

Table 1. Historic (H) and present (P) occurrences of the little-wing pearly mussel.*

	Cumberland River System	
(H)	Rockcastle River	Laurel and Rockcastle Counties, KY
(P)	Horse Lick Creek	Jackson and Rockcastle Counties, KY
(H)	Buck Creek	Pulaski County, KY
(H)	Pitman Creek	Pulaski County, KY
(P)	Big South Fork Cumberland River	McCreary and Wayne Counties, KY
(P)	Little South Fork Cumberland River	McCreary and Wayne Counties, KY
(P)	Cane Creek	Van Buren County, TN
(H)	Collins River	Warren County, TN
(H)	Stones River	Rutherford County, TN
(H)	West Fork Red River	Todd County, KY
(P)	Whipperwill Creek	Todd County, KY
	Tennessee River System	
(H)	South Fork Holston River	Washington County, VA, and Sullivan County, TN
(H)	Middle Fork Holston River	Smyth County, VA

(P)	North Fork Holston River	Smyth and Washington Counties, VA
(H)	Big Moccasin Creek	Scott County, VA
(P)	Clinch River	Tazewell County, VA
(H)	Copper Creek	Scott County, VA
(H)	Flag Pond	Lee County, VA
(H)	Wallen's Creek	Lee County, VA
(H)	Powell River	Lee County, VA
(H)	French Broad River	State and County Unknown
(H)	Valley Creek	Cherokee County, NC
(H)	Elk River at Estell Spring	Franklin County, TN
(H)	Blue Water Creek	Lauderdale County, AL
(H)	Duck River	County Unknown, TN

* Data taken from Stansbery (1976), Clarke (1981), Bogan and Parmalee (1983), Ahlstedt (1986), and Bakaletz (pers. comm., 1987).

Habitat. The little-wing pearly mussel inhabits small to medium size streams with low turbidity, cool water, and high to moderate gradient (Bogan and Parmalee 1983, Ahlstedt 1986). Blankenship (1971) reported the species in riffles lying on top of the substratum in the Rockcastle River. In the Little South Fork Cumberland River, Starnes and Starnes (1980) reported the mussel partly buried in or on top of the substratum in the transition zone between a long pool and riffle. Di Stefano (1984) reported the species buried in gravel or beneath boulders and slabrock in Horselick Creek. Ahlstedt (1986) suggests that late spring (May and June) or late fall (October and November) may be the best times to find the species since they tend to be on top of or only partially buried in the substratum during spawning.

Life History and Ecology. This species is rare, and little is known of its life history. However, ecological observations by biologists collecting the species for taxonomic study and status surveys have provided some insight into the species' biology (reviewed in Gordon and Layzer 1988). Specific food habits of the little-wing pearly mussel are unknown, but it likely feeds on food items similar to those consumed by other freshwater mussels. Freshwater mussels are known to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The species' reproductive biology remains unknown, but it likely reproduces like other freshwater mussels. Males release sperm into the water column, which are then taken in by the females through their siphons during feeding and respiration. The fertilized eggs are retained in the gills until the larvae (glochidia) fully develop. Gravid female little-wing pearly mussels have been reported in both September and October, and nongravid or spent females have been observed in March (Ortmann 1913 and 1914, Ahlstedt 1986). Ahlstedt (1986) suggests that the species is a winter or long-term brooder, holding glochidia from mid-summer until the following spring. When the glochidia are released into the water, they attach and encyst on the gills or fins of a fish host. When metamorphosis is complete, they drop to the streambed as a juvenile mussel. The species of fish utilized by the little-wing pearly mussel are unknown. Ahlstedt (1986) reports that the banded sculpin (*Cottus carolinae*) and redline darter (*Etheostoma rufilineatum*) are found in the same habitat as this mussel in parts of its range and may be prime candidates as host species.

Special Significance. The last reported North Carolina collection of the species was a pre-1918 collection from Valley Creek, Cherokee County, North Carolina. Although the species has been apparently extirpated from the State, this species exists in much smaller streams than most mussel species, and thus it is possible that a population may still exist in North Carolina.

Status. Extirpated. Listed as endangered by the U.S. Fish and Wildlife Service.

Rationale for Evaluation. This mussel has not been seen in North Carolina in recent years and has declined significantly throughout the rest of its range. The reasons for the demise of the species in most streams are unknown, but siltation from coal mining and impoundments were important decimating factors in some watersheds.

Current Protection. The species was listed by the U.S. Fish and Wildlife Service as an endangered species under the Federal Endangered Species Act of 1973 (Act) on November 14, 1988. The Act provides protection for the species through restrictions on take and by requiring Federal agencies to ensure that their actions no not jeopardize the continued existence of the species.

Recommendations. The smaller streams within North Carolina's portion of the Tennessee River valley should be surveyed to determine if an isolated population may still exist and to search for potential suitable habitat for reintroductions.

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Prepared by RICHARD G. BIGGINS

Addendum: On 8/27/90, John Alderman told me that Richard Biggins located a specimen of Pegias fabula in the Little Tennessee River, near River Mile 95, Swain County, North Carolina.

M. C. Odom

Alasmidonta robusta Clarke, 1981
CAROLINA ELKTOE

Description. The Carolina elktoe is known from five specimens. The length ranges from 42 to 66 mm; the height ranges from 26 to 42 mm; the width ranges from 18 to 33 mm. The holotype is 66 mm long, 43 mm high and 33.2 mm wide. The following abbreviated description is taken from Keferl and Shelly (1988). A more complete description can be obtained from Clarke (1981). The shell of the Carolina elktoe is thin and sturdy, the anterior margin is well rounded; the ventral margin broadly curved; the posterior end forms a round point below the center. The periostracum is glossy, pale greenish-yellow with broad greenish rays which diminish at the posterior ridge. The posterior slope is covered with corrugations which are perpendicular to the posterior margin of the posterior slope. The Carolina elktoe has a large interdental projection in the left valve. See Keferl and Shelly (1988) for a comparison with Alasmidonta varicosa (Lamarck, 1819).

Range. The type lot and the only lot collected was taken from Long Creek, a tributary of the Catawba River, Mecklenburg County, North Carolina.

Habitat. Nothing is known of the about the specific habitat of the Carolina elktoe. Long Creek, its only collection site, is a small creek with a fairly steep gradient and substrates which vary from mud to bedrock. The stream has numerous deep isolated pools separated by rapids over small rocks, boulders and bedrock.

Life History and Ecology. Nothing is known.

Special Significance. Apparently this species had a very restricted range in one river system in North Carolina.

Type Locality. See Range, above.

Status. Extinct.

Rationale for Evaluation. According to Keferl and Shelly (1988), Alasmidonta robusta was not found in any part of the Catawba or Pee Dee river systems. A thorough search of its only known locality yielded no specimens. Based upon current data this species is probably extinct. Clarke (1981) came to the same conclusion.

Current Protection. None needed, it is too late.

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Prepared by EUGENE P. KEFERL

Goniobasis interrupta (Haldeman 1840)
KNOTTY ELIMIA

Description. This species appears similar to many other species in the genus Goniobasis but is distinguished principally by its indistinct sutures and costate surface. Haldeman (1840) briefly described it as follows: "Shell conical, with 4 flat whirls (sic) which are crossed by elevated ribs and spiral lines: apex truncated; suture indistinct; aperature elliptic, two-thirds the length of the shell. Color olivaceous, sometimes banded with black. Length, 1/2 in." Tryon (1873) figured both juveniles and adults and therefore provided our best illustrations of this species. Burch (1982) figured adults.

Range. Records for this species exist only from the Hiwassee River and its tributaries in North Carolina and Tennessee (however, see discussion of systematics below).

Habitat. The habitat of this species has not been described but it is presumed to be similar to that of other peurocerid snails. This group of snails prefers medium to fast moving water over rocky substrates.

Life History and Ecology. Nothing specific is known about the life history or ecology of this species. It probably has a life span of two to four years and follows the typical reproductive strategy of the genus.

Special Significance. None known.

Type Locality. The precise type locality is unknown as the location given by Haldeman (1840) was "Tennessee".

Systematics. Due to their polymorphic nature, the systematics of most of the Pleuroceridae, including this species, are in an indeterminate state. Haldeman (1840) described this species and placed it in the genus Melania Say 1821. George Tryon (1864) considered this to be a valid species with one synonym, Goniobasis ornatella Lea, 1862 (type locality also "Tennessee"). Later (1873), in his landmark monograph on the Pleuroceridae, Tryon removed G. ornatella from synonymy with G. interrupta considering it instead a synonym for G. formosa Conrad, 1834. In the 1873 monograph, he considered Goniobasis christyi (Lea, 1862) and Goniobasis instabilis (Lea, 1862) as synonyms for G. interrupta. Goodrich (1940) retained Tryon's 1873 synonymy.

The type locality for G. christyi is the Valley River in Cherokee County, North Carolina, and the type locality for G. instabilis is 21 miles north of Murphey, also in Cherokee County. From this synonymy, it follows that G. interrupta also occurs in the tributaries of the Hiwassee River in North Carolina, as indicated by Goodrich (1940) and Burch (1982). However, I consider this synonymy questionable. Two of G. interrupta's distinguishing characters, surface costations and indistinct sutures, are not displayed in either of Tryon's illustrations of these synonymized forms. A reexamination of the type material appears to be in order.

Status. Vulnerable, Category 1.

Rationale for Evaluation. Goniobasis interrupta is known definitively only from the Hiwassee River basin in North Carolina and Tennessee. It is, at best, a very rare species in North Carolina. In recent years, it is known only from a single juvenile specimen taken in 1982 by the NC Division of Environmental Management (NCDEM) from the Hiwassee River in Cherokee County (now in the collection of R. T. Dillon, College of Charleston). In NCDEM's 1982 field notes on the Hiwassee River collection site, pleurocerids were noted to be "very rare." Subsequent NCDEM collecting trips to the Hiwassee have not produced any other specimens (D. Lenat, NCDEM, pers. comm.), indicating that the species is extirpated from at least a portion of the river. Further, pleurocerids collected by NCDEM from tributaries to the Hiwassee were all Goniobasis proxima. Given its reduced population in the state and the decline in other aquatic mollusks being experienced in other portions of the Appalachians, this species should be considered Endangered in North Carolina until stable and protected populations can be identified.

Current Protection. None.

Recommendations. Surveys to reconfirm and assess populations of this species in North Carolina are greatly needed as it could be one of our rarest freshwater species.

Acknowledgments: Ms. Betty Sue Westbrook, Librarian, demonstrated great skill and perseverance in obtaining a copy of Haldeman's original description. Mr. Dave Lenat, NCDEM, provided access to his agency's benthic collections, thereby greatly expanding our knowledge of pleurocerid distribution in North Carolina. Dr. R. T. Dillon, College of Charleston, examined recent material from the Hiwassee River basin and gave the author a primer on pleurocerid systematics. It is with great thanks that I acknowledge the invaluable help of each.

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Prepared by WILLIAM F. ADAMS

Planorbella magnifica (Pilsbry 1903)
MAGNIFICENT RAMSHORN

Description. Like other rams-horn snails, the magnificent rams-horn has a discoidal (i.e., coiling in one plane) shell. Its spire is deeply sunken, with whorls having steep sides and acute angles on their summits; the umbilicus is deep. This species is remarkable for its great size, with the maximum diameter of adults commonly exceeding 35 mm and heights exceeding 20 mm. The great width of this species, in relation to its diameter, makes it easily identifiable at all ages. Pilsbry (1903) gives a complete description of the shell characters of the species and Baker (1945) figured its soft-tissue anatomy. Adams and Gerberich (1988) illustrated adult and juvenile specimens (see Systematics, below).

Range. The magnificent rams-horn is a North Carolina endemic, having been recorded only from Greenfield Lake in Wilmington (Bartsch 1908) and Orton Pond in Brunswick County (Adams and Gerberich 1988). Greenfield Lake's water quality has undergone dramatic declines in recent decades and its molluscan diversity has declined as a result (Adams, in press). In spite of arduous searchs, the magnificent rams-horn has not been found in Greenfield lake in recent years (Fuller 1977; Adams and Gerberich 1988) and is assumed to be extirpated from that system. With that loss, Orton Pond is now the only known locale for this species.

Habitat. This species appears to be restricted to sheltered portions of water bodies which possess a diverse assemblage of aquatic plants. Searching a variety of habitats, Bartsch (1908) found this species in Potamogeton sp. and Nymphaea odorata beds in cove portions of Greenfield Lake. Adams and Gerberich (1988) report this species from similar habitats in Orton Pond. Maximum water depths at the Orton Pond collecting site were 1 m and the bottom substrate was organic. The rich aquatic flora of Orton Pond, in conjunction with its circumneutral pH, make it exceedingly rich in molluscan fauna.

Life History and Ecology. Little is known about the life history of the magnificent rams-horn. The few records available indicate that young are probably born during early summer. Dall (1907) reported that they grow very rapidly, reaching one-third of their adult size in their first six months. He further reported that the species probably lives about two years and that its preferred food is "lily-pads". Both he and Bartsch (1908) report that the species gradually loses its eyes as it matures and that the adults are totally blind. The reasons for this are, at present, an intriguing mystery. Attempts to collect this species on bottom debris and remnant Nymphaea stems in Orton Pond during January, 1987, met with no success (Adams and Gerberich 1988).

Special Significance. The magnificent rams-horn is a treasure for malacolgists worldwide. It is the largest native planorbid snail in North America and, because of this great size, is one of the more striking and beautiful of our freshwater mollusks. The potential value of this species as an experimental animal was mentioned by Fuller (1977). Due to their large size, the species could be used in school labs and possibly in the

aquarium trade if it could be reared in captivity in commercially viable numbers.

Type Locality. "Lower Cape Fear River in the vicinity of Wilmington, North Carolina" (Pilsbry 1903). Bartsch (1908) correctly surmised that the magnificent rams-horn was not a fluvial species based on its large but fragile shell. Pilsbry's description of the magnificent rams-horn was done on the basis of specimens furnished to him by Mr. William P. Seal of Wilmington. Based on the careful notation of collection locales which Pilsbry displayed throughout his career, it seems probable that he never knew the precise location of their collection. Either Greenfield Lake or Orton Pond could actually have been the source of the type material.

Systematics. *Planorbella magnifica* was originally placed in the genus *Planorbis* (Muller 1774) by Pilsbry (1903). This was a common practice of the day in the systematic treatment of rams-horn snails. Today, *Planorbis* is applied only to species of the Palaearctic and Ethiopian regions (Burch 1982). In his landmark review of the Planorbidae, Baker (1945) reassigned the species to the genus *Helisoma* Swainson 1840. He further recognized two subgenuses under *Helisoma* which proved pertinent to this species, *Pierosoma* Dall 1905 and *Planorbella* Haldeman 1842. He placed the magnificent rams-horn in the subgenus *Pierosoma*. Taylor (1966) subsequently elevated *Planorbella* to full genus rank and placed the subgenus *Pierosoma* within it.

I have found the magnificent rams-horn occurring sympatrically with *Planorbella trivolvis* (Jeffreys 1830) in Orton Pond. That, in conjunction with the distinctive radula and soft-tissue characters figured by Baker (1945), dispels the possibility that the species may be an ecophenotypic form of *P. trivolvis*.

Status. Vulnerable, Category 1.

Rationale for Evaluation. As stated previously, the species is known today only from Orton Pond. Currently, the land immediately surrounding the pond is managed solely for timber and wildlife; unfortunately, not all of the pond's watershed is managed in this way. As a result, events or developments elsewhere in the pond's watershed could have deleterious effects on its water quality. For example, in the recent past a diked dredged material disposal area on the Military Ocean Terminal at Sunny Point leaked salty water into Tom's Branch, a tributary of Orton pond. Through tremendous effort and great expense to the Army, this situation has been largely alleviated. Also, the residential population of southern Brunswick County is growing rapidly as its popularity as a vacationing and retirement area increases. Extensive developments in the upper reaches of Orton Pond's watershed have not yet occurred; but, new roads have been cut in some areas. Finally, the greatest threat may be that changes in the ownership of Orton Pond and its surrounding lands are, ultimately, inevitable. What land use changes this may bring are unknown.

Current Protection. None.

Recommendations. Until such a time when the future of the magnificent rams-horn is more secure, developments which could effect the water

quality of Orton Pond should be severely scrutinized. Studies of the autecology of the species are urgently needed so that potential conservation measures can be developed and implemented should they prove necessary. In addition, the potential of this species for use as a lab animal should be investigated.

Remarks. Bartsch also collected the magnificent rams-horn from "Sprunt's Pond" (now Orton Pond) in 1908. These collections, known only from museum specimens, were not reported in the literature, perhaps because of the contemporaneous report of his Greenfield Lake collections.

So few specimens of this species are available to researchers today that a recounting of the institutions holding them and the catalogue numbers of the specimens in those institutions seems in order. They are provided in the accompanying Table in the hope that future research on this species will be facilitated.

Table 1. Collectors and catalogue numbers of *Planorbella magnifica* specimens currently housed in museum collections.

Collector(s)	Catalogue Numbers*	Comments
Pilsbry	ANSP 85941A	(Lectotype, shell)
	ANSP 85941	(5 paralectotypes, shells)
	ANSP 87342	(3 paralectotypes, shells)
	ANSP 88945	(aquarium specimens, shells)
	ANSP A1726A	(8 with soft-tissue)
Bartsch	USNM 536817	(19 shells)
	USNM 529486	(4 shells, Orton Pond)
	USNM 205958	(1 aquarium specimen, shell)
	USNM 193321	(34 shells)
Adams & Gerberich	NCSM P468-P471	(5 shells)
	USNM 857935	(3 with soft-tissue)

* ANSP = Academy of Natural Sciences of Philadelphia; USNM = United States National Museum (Smithsonian Institution); NCSM = North Carolina State Museum of Natural Science.

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Prepared by WILLIAM F. ADAMS

Fusconaia barnesiana (Lea, 1838)
TENNESSEE PIGTOE

Description. This description is based upon two shells recently collected from muskrat middens located along the Little Tennessee River, North Carolina.

Shell No.	Length (mm)	Height (mm)	Width (mm)	H/L ratio	W/L ratio
ONE	59.95	41.2	23.05	.69	.38
TWO	41.5	28.8	15.35	.69	.37

The periostracum is a yellowish-brown, tending to become darker with age. On the larger of the two specimens, narrow green rays are present in the area of the umbos, and the posterior ridge is darkened by these rays along most of its length. Both the anterior and posterior ends are rounded, and the ventral margin is regularly rounded. The posterior ridge tends to be angular. The posterior slope has two radial groves running from the umbonal area toward the posterior end of the shell. Growth rests are distinct and the periostracum is roughened over most of its surface. The right valve has two pseudocardinal teeth, the more anterior tooth tending to be vestigial. An interdental projection may be present or tends to be vestigial. There is one lateral tooth in the right valve. Two stumpy pseudocardinal teeth are present in the left valve. The two lateral teeth are distinct and clearly separated by a deep channel running between them. The nacre is white with some signs of iridescence toward the posterior end. The shell is thicker toward the anterior end. Both the anterior and posterior adductor mussel scars are well impressed. Also, the pallial line is distinct and well impressed.

Range. The Tennessee pigtoe is a Tennessee Drainage Basin endemic species. Extant populations exist in the Clinch, Little, Nolichucky, Powell, Little Tennessee, Elk, Duck, and Buffalo rivers (Starnes and Bogan 1988). In North Carolina, this species is only found in a short stretch of the Little Tennessee River above Fontana Reservoir.

Habitat. Fusconaia barnesiana is a riffle and shoal species. Throughout most of its range it is found in clean-swept substrates of sand, gravel, and mixed habitats of sand, gravel, and cobble. It is rare in pools and slack waters (S. Ahlstedt 1984).

Life History and Ecology. The Tennessee pigtoe is a short-term (tachytictic) breeder (Ortmann 1919). Additional information is not available for this species.

Special Significance. As discussed for the slippershell mussel, the Tennessee pigtoe is part of a mussel community which is North Carolina's best extant example of the Mississippi Drainage Basin's diverse mussel assemblage.

Type Locality. Lea lists the type locality as the upper Cumberland River, Tennessee. This locality is in error since the Tennessee pigtoe is not found in the Cumberland River (Ortmann 1918).

Status. *Vulnerable, Category 1.*

Rationale for Evaluation. The Tennessee pigtoe is extremely rare in the Little Tennessee River above Fontana Reservoir in North Carolina. During a typical survey day, hundreds of mussel shells are often found in muskrat middens; however, at most one or two shells of the Tennessee pigtoe may be found in the middens.

Fontana Reservoir isolates the small population of the Tennessee pigtoe in North Carolina from other local populations of the species in Tennessee; therefore, if the population is lost in our state, natural reestablishment would be impossible. A viable population could only be established by physically reintroducing the species into North Carolina.

Current Protection. As with the other mussels in the Little Tennessee River in North Carolina, these species are found in the spotfin chub's critical habitat. Therefore, measures to protect this federally listed threatened species will also help protect the mussels found in the same area.

Recommendations. There are three subspecies of the Tennessee pigtoe - F. b. barnesiana, F. b. bigbyensis, and F. b. tumescens. Further research is required to determine which of these three subspecies exist in North Carolina's Little Tennessee River.

Of the several mussel species found in the Little Tennessee River above Fontana Reservoir, the Tennessee pigtoe is the most rare. More information is needed about the biology of this species to allow better management of its habitat.

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Prepared by JOHN M. ALDERMAN

Tritogonia verrucosa (Rafinesque, 1820)
PISTOLGRIP

Description. This freshwater mussel reaches 70 mm or more in length. Pseudocardinal and lateral teeth are well-developed. The shell is elongate, rhomboidal and covered with pustules. The nacre tends to be purple and at times tinted with pink. The posterior ridge is prominent.

Range. The pistolgrip is found in the Mississippi and Gulf of Mexico drainages (Burch 1975). In North Carolina, it is only known from the New River near the Virginia border (A. G. Gerberich, unpubl. data).

Habitat. This species is known from a wide range of habitats - creeks, small rivers, and large rivers. In smaller rivers and creeks it is found usually in riffle areas with nearby macrophytes such as Justicia americana. In larger rivers it may be found in deeper waters with sand or mud bottoms. Current velocities may range from 0 to 52 cm/s (Gordon and Layzer 1989).

Life History and Ecology. Ovulation occurs from March to May (Jirka 1986) and gravid females are found from April through June (Gordon and Layzer 1989). Individuals of this species may, at times, be hermaphroditic (Van der Schalie 1970). The glochidial fish host is unknown.

Special Significance. The pistolgrip is the only representative of its genus.

Status. Vulnerable, Category 1.

Rationale for Evaluation. The New River is threatened by sedimentation, excess nutrients, pesticides and other chemical contaminants. There are expanding pressures to develop the lands along this river for retirement homes and other residential communities.

Current Protection. None.

Recommendations. The entire New River Drainage Basin in North Carolina needs to be surveyed for all mollusk species. Critical habitats for the pistolgrip need to be identified and protected.

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Prepared by JOHN M. ALDERMAN

Elliptio judithae Clarke 1986
NEUSE SLABSHELL

Description. The Neuse slabshell is a freshwater mussel with an appressed, elliptical shell. Specimens up to about 85 mm in length have been collected. Height of the shell is about 48% of the length and the valves are thin. The shell is sculptured with plicate ridges, each about 1.5 mm to 3.0 mm wide, and the periostracum is glossy. The shell is generally yellowish to dark brown with faint, narrow green rays. The hinge teeth are complete, the pallial line distinct, and the nacre pale purple. Morphs of other Elliptios may share some of these characteristics, however, soft-part anatomy of Elliptio judithae will serve to distinguish it from such specimens. E. judithae has coronate incurrent papillae and irregularly-developed brachial septa, characters not known to be shared by any other Elliptio. A complete description and photographs of the species can be found in Clarke (1986).

Range. Known definitively only from the Neuse River at Milburne (Wake County), Smithfield (Johnston County), and Seven Springs (Wayne County). Conchologically similar shells collected from the Tar River below Rocky Mount probably belong to this species, however, soft-part anatomy should be examined to verify the occurrence of the species in that basin.

Habitat. Nothing is known of the habitat requirements of Elliptio judithae. The only habitat information available was provided by Clarke (1986) in his description of the species. The holotype was collected in water 0.15 m deep on a sand bar in the middle of the Neuse River, which was about 100 m wide at the site. Habitat data for the paratypes was unavailable to Clarke (1986).

Life History and Ecology. Nothing is known of the life history and ecology of the species. Its fish host is unknown; however, like some other coastal plain species of mussels, its fish host may be an anadromous species.

Special Significance. Elliptio judithae may be a relict and primitive species (Clarke, 1986). Its unique soft-part anatomy indicates an early divergence from other unionid stock and suggests a great antiquity for the species. The suspected age of this species makes it of particular interest and value to malacologists trying to unravel the evolutionary history of the Unionidae.

Type Locality. The holotype is from the Neuse River at Seven Springs, Wayne County, North Carolina. Paratypes are from the Neuse River above the U. S. Route 301 bridge near Smithfield, Johnston County, and at Milburne, 7 miles east of Raleigh, in Wake County.

Systematics. There have been no published systematic discussions of Elliptio judithae since the description of the type material by Clarke (1986).

Status. Vulnerable, Category 1.

Rationale for Evaluation. The last verified collection of this rare animal was in 1983. Recent surveys of the Neuse River near Smithfield indicate that the species no longer occurs at that locality (A. G. Gerberich, pers. comm.). In addition, Clarke (1986) states that the introduced Asian clam, *Corbicula fluminea*, has overwhelmed the lower Neuse River in recent years and poses a serious threat to the continued survival of *Elliptio judithae*. Given that *E. judithae* has a restricted range, is declining within it, and has an introduced competitor, the need for protection and management of its remaining habitat is obvious.

Current Protection. None.

Recommendations. Survey work to locate remaining populations of *E. judithae* are urgently needed. Its fish host(s) should also be identified and, once done, the fishery of the lower Neuse River should be managed to promote that species. All measures to improve water quality in the Neuse River should be vigorously pursued.

Remarks. Recently, J. M. Alderman collected a gradating series of specimens of *Elliptio roanokensis* from the Tar River near Tarboro, N. C., and found that the smaller specimens bore striking conchological and soft-tissue similarity to *E. judithae*. This elevates the possibility that our species concept of *E. judithae*, as defined by Clarke (1986), needs to be reassessed. Allozyme analysis and comparison of the soft-part anatomies of these taxa from their type localities is greatly needed.

This species has no recognized vernacular name. The name assigned in this account was derived from the type locality and the cognomen slabshell, which is frequently applied to non-lanceolate *Elliptios*.

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Prepared by WILLIAM F. ADAMS

Elliptio steinstansana Johnson and Clarke, 1983
TAR RIVER SPINY MUSSEL

Description. This small, subrhomboidal mussel grows to approximately 60 mm long. Short spines (up to 5 mm long) are found on most specimens. As many as 12 spines have been found on juveniles; however, adults tend to lose some of their spines as they mature. In general, spines arranged in a radial row slightly anterior of the posterior ridge on one valve are symmetrically positioned with the spines on the opposite valve. Some individuals may have two rows of spines on each valve. The smooth, orange-brown to dark brown periostracum may be rayed in younger individuals. The shell is significantly thicker toward the anterior end, and the nacre is usually pink in this area. The posterior end of the shell is thinner with an iridescent bluish white color. Two or more linear ridges, originating within the beak cavity and extending to the ventral margin, can be found on the interior surface of the shell. The distance between these ridges widens toward the ventral margin. Johnson and Clarke (1983) provide additional descriptive material.

Range. The Tar River spiny mussel probably ranged throughout most of the Tar River Drainage Basin before the area was settled during the 1700s. By the mid-1960s, its known range had been reduced to the main channel of the Tar River from Spring Hope in Nash County to Falkland in Pitt County (Shelley 1972, Clarke 1983). By the early 1980s, its range in the Tar River was restricted to only 12 miles of the river in Edgecombe County (Clarke 1983), and by 1989 the species could only be found in a one mile section of the river in Edgecombe County (Alderman, unpubl. data). However, one additional population with successful reproduction has been discovered in Swift Creek - a tributary of the Tar River flowing from Vance County to the Tar River in Edgecombe County (Alderman 1988).

Habitat. It appears that the Tar River spiny mussel's preferred habitat includes the following:

1. relatively fast flowing, well oxygenated, circumneutral pH water,
2. relatively silt-free, uncompacted, gravel/coarse sand substrate,
3. sites prone to significant swings in water velocity.

Presently, this preferred habitat exists only in Swift Creek and in limited other areas of the Tar River Drainage Basin. This habitat is usually found in shallow water areas. However, muskrat middens along Swift Creek associated with deeper waters have produced Tar River spiny mussel shells. Their presence in these deep water habitats can be explained once the substrate is explored. In virtually every instance, there is gravel/coarse sand substrate toward the middle of the creek channel.

Habitat diversity is relatively low in the Tar River in Edgecombe County because of sedimentation problems; however, live spiny mussels found in the Tar River during 1987 were in habitat which most closely approximated the above preferred habitat.

Life History and Ecology. The Tar River spiny mussel is probably a tachytictic reproducer with gravid females present at some time from April

through August (Widlak 1987). The glochidia have not been described and the fish host is unknown. However, plans exist to determine the fish host(s) for the Tar River spiny mussel once the techniques are developed and the fish hosts are determined for the James River spiny mussel.

Johnson (1970) is probably correct in his belief that the spines on Elliptio spinosa help to stabilize the mussels in the substrate. Similarly, I believe the spines also serve the same function for the Tar River spiny mussel found in the coarse sands and gravels in relatively pristine areas of the Tar River Drainage Basin. The spines and anchoring by the foot probably help to maintain the mussels in their preferred position in the substrate and, most importantly, help to prevent the spiny mussels from being pulled from the substrate while they are feeding in the relatively fast flowing water. Support for this argument comes from the observation that E. spinosa, E. steinstansana, and some young P. collina shells have linear ridges below the spines on the inside of the shells. These ridges probably offer support for the shell when environmental stresses are applied to the spines.

When working in coarse sand/gravel substrates, species associates which are good indicators for the presence of the Tar River spiny mussel include (in decreasing order of association) Fusconaia masoni, Elliptio lanceolata, Lampsilis cariosa, Villosa constricta, Alasmidonta undulata, Strophitus undulatus, and Lampsilis ochracea.

Johnson (1970) stated that Fusconaia masoni appeared to be closely associated with Pleurobema collina in the James River Drainage Basin. This same close association is true for the Tar River spiny mussel and Fusconaia masoni. In habitats which have not been significantly degraded in the Tar River Drainage Basin, the presence of Fusconaia masoni is the best indicator of the potential presence of Elliptio steinstansana.

Special Significance. Only three spined mussels exist globally - Pleurobema collina in the James River, Elliptio steinstansana in the Tar River, and Elliptio spinosa in the Altamaha River. The James spinymussel and the Tar River spiny mussel are presently listed as endangered by the U.S. Fish and Wildlife Service. The Altamaha spinymussel is also a declining species. Questions relating to the evolution, ecology, biogeography, and basic biology of these species can be answered only if we maintain these species in nature.

Type Locality. Near Tarboro in Edgecombe County, North Carolina (MCZ 282677, holotype).

Systematics. Both Elliptio spinosa and Elliptio steinstansana are typical Elliptio species except for the presence of spines. The subgenus Canthyria is reserved for these two Elliptio species which posses spines. The phylogenetic relationships among the three spined species have yet to be resolved.

Note: During a recent visit to the Smithsonian Institution, J. M. Alderman and A. G. Gerberich (unpubl. information) found a specimen in the type collection which looks exactly like an unspined Tar River spiny mussel. This taxon, Unio castus, was described by I. Lea (1860) using this single specimen from South Carolina (location in the state unknown). T. A. Conrad (1838) stated that a spined Unio could be found abundantly near Columbia,

South Carolina in the 1800s. Further research may show that the appropriate name for the spined species from the Tar River should be Elliptio castus, and its range may extend into South Carolina.

Status. Endangered.

Rationale for Evaluation. The continued existence of the Tar River spiny mussel as a viable species in North Carolina is threatened by numerous point and nonpoint sources of pollution, reservoir construction, interbasin transfer of water, competition from exotic species, disease, rock quarries and many other threats.

Current Protection. As determined by the U.S. Fish & Wildlife Service, Elliptio steinstansana is an endangered species. Recent court rulings have expanded the Fish & Wildlife Service's ability to protect all red-cockaded woodpecker habitat - even habitat owned by individual land owners or developers. Hopefully, as a result of these rulings, additional ways to protect habitat for other endangered species will be developed.

Recommendations. Improved land use practices are essential in the Tar River Drainage Basin. Of the 17 drainages in North Carolina, erosion rates are greatest in the Tar River Drainage Basin. Forestry and agricultural best management practices need to be implemented by all landowners, and NPDES permit limits should be enforced. Local zoning is greatly needed to protect water resources, and individual citizens need to be educated about their responsibilities to protect the environment.

In addition to determining whether the species ranges into South Carolina, the fish host(s) and other life history data are essential to allow the proper management of the species.

Remarks. The Tar River spiny mussel has always been a rare species. Probably the major reason for its historic rarity is that its preferred habitat in the riffle areas with a gravel/coarse sand substrate is often lost when sedimentation problems develop. Sedimentation of aquatic habitats has been a major problem in the Tar River Drainage Basin since the early 1800s.

B.F. Baldwin (1816) surveyed the Tar River from Louisburg to Washington for impediments to navigation. He documented immense numbers of roots, logs and trees, sand shoals, and obstructions increased by the cutting of trees into the river by the proprietors of the banks. Baldwin stated that the "obstructions divert the usual course of the current, to the great injury of the banks, which are now so much washed and undermined . . ." Local residents who had observed the river for many years informed Baldwin that the sandy shoals had gradually increased. Hamilton Fulton (1819) corroborated Baldwin's findings. In a report to the Board for the Internal Improvements of the State of North Carolina, Fulton gave a clear description of navigation conditions in the Tar River. He also found numerous sand shoals, sunken logs, and floating logs. At times trees were so numerous in the river channel that he had to cut a passage through the trees for his canoe's passage.

In recognition of the seriousness of the obstructions found in the Tar River, the United States Senate passed S. Bill 83 (1820) consenting to the

N.C. general assembly's act passed in 1816 to remove "logs, shoals, and other impediments, in the Tar River, below the town of Washington, ..."

Clearly, sedimentation has been a contributing factor in the decline of the Tar River spiny mussel for almost 200 years. The Tar River spiny mussel populations in Swift Creek and the Tar River can only remain viable if erosion and other forms of environmental degradation are controlled.

Sadly, our generation can only glimpse fragments of what was once a beautiful, diverse, and thriving Tar River. Our ancestors wrote warmly of the remarkable charms offered by her waters. In fact, Indians knew her as the Tau - river of healthful waters. It is our responsibility to look to our past to know what we have lost and work in the present to prevent loss which will be forever. Our children will never forgive us if we knowingly fail to become careful stewards of their natural resources.

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Prepared by JOHN M. ALDERMAN

Lasmigona decorata (Lea, 1852)
CAROLINA HEELSPLITTER

Description. The Carolina heelsplitter can reach a length of 118 mm, with a height of 68 mm and a width of 39 mm. Based on some specimens collected by Keferl and Shelley (1988) from three different streams and rivers, the mean length is 78 mm, the mean height is 43 mm and the mean width is 27 mm. The shell is an ovate trapezoid. The dorsal margin is straight and may end with a slight wing. The umbo is flattened. The beaks are depressed and project a little above the hinge line. The beak sculpture is double looped. The unsculptured shell can have a yellowish, greenish or brownish periostracum. The Carolina heelsplitter can have greenish or blackish rays. The lateral teeth may or may not be well developed, in most cases they are thin. The pseudo-cardinal teeth are lamellar and parallel to the dorsal margin, and there is a slight interdentum. The nacre varies from an iridescent white to a mottled pale orange.

Range. Historically the Carolina heelsplitter was recorded from the Abbeville District in South Carolina, and around Mecklenburg County in North Carolina (Clarke 1985). Johnson (1970) assumed that the records from the Abbeville District, South Carolina were in the Savannah River system. However, it is more likely that the Carolina heelsplitter was in the Saluda River drainage instead (Clarke 1985, Keferl and Shelley 1988). The Saluda and Catawba Rivers are both part of the Congaree-Wateree-Santee River system. The Saluda River drains the southern part of the system and the Catawba River drains the northern part of the system. It has never been found in any river or stream between these two drainages.

Keferl and Shelley (1988) did not find any evidence of L. decorata in the Saluda River drainage. Keferl and Shelley (1988) did find the species living in Waxhaw Creek (Catawba River drainage) Union County, North Carolina; Goose Creek (Pee Dee River system), Union County, North Carolina; and Lynches River (Pee Dee River system), Lancaster and Chesterfield counties, South Carolina. At the present time living specimens of the Carolina heelsplitter have been found from just five localities in three different drainages of two different river systems.

Habitat. Historically the Carolina heelsplitter was collected in creeks, streams, a river and ponds. The ponds were probably mill ponds. Keferl and Shelley (1988) found L. decorata living in two small streams and one small river. All specimens found were in shaded areas, either in a ponded portion of a small stream, or in runs along steep banks with a moderate current. All specimens were found in less than three feet of water during low waters of summer and fall. The substrates included soft mud, sand, muddy-sand, and sandy gravel.

Life History and Ecology. Almost nothing is known about the life history and ecology of Lasmigona decorata. Living specimens of L. decorata have been collected in late June, August and late October and none had any glochidia. The fish host(s) has not been determined.

Special Significance. The Carolina heelsplitter is only found in a restricted area of North and South Carolina. It represents the southern most member of the genus Lasmigona on the eastern coast.

Systematics. The Carolina heelsplitter was originally described as Unio decoratus Lea, 1852. It was subsequently placed in the genus Symphynota by Simpson (1900). Simpson (1914) placed Unio insolidus Lea, 1872 in synonymy with S. decorata. Frierson (1914) determined that Symphynota was a synonym of Proptera and all species placed in Symphynota should be placed in the genus Lasmigona Rafinesque, 1831. Dawley (1965) listed Lasmigona decorata (Lea, 1852) and Lasmigona charlottensis (Lea, 1863) from North Carolina. Johnson (1970) believed that L. decorata was a robust form of Lasmigona subviridis (Conrad, 1835). Consequently, Johnson (1970) placed U. decorata, U. charlottensis and U. insolidus in synonymy with L. subviridis. Clarke (1985) and Keferl and Shelley (1988) disagree. Clarke (1985) recognized L. decorata as a distinct species from L. subviridis, but did place L. charlottensis in synonymy with L. decorata.

Status. Vulnerable, Category 1.

Rationale for Evaluation. The Carolina heelsplitter is a rare naiad. Its present distribution is limited to two small streams and a small river all originating out of Union County, North Carolina. Union County is just south of Mecklenburg County and the rapidly expanding metropolitan area of Charlotte. If and when development moves to the now rural Union County, all three drainages could be permanently altered enough to destroy all naiad populations. Historically, most L. decorata were collected from Mecklenburg County and the Charlotte area. Now there are very few naiades in any of the streams in that county (Keferl, unpublished records).

Current Protection. At the present time the Carolina heelsplitter does not have any state or federal protection.

Recommendations. Pending the results of some upcoming survey work sponsored by the U. S. Fish and Wildlife Service, Lasmigona decorata should be listed as endangered in the United States and be given special protection.

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Prepared by EUGENE P. KEFERL

Lasmigona holstonia (Lea 1838)
TENNESSEE HEELSPLITTER

Description. The Tennessee heelsplitter (the most primitive living species in the genus Lasmigona) has a long, ovate shell with a length of up to 61 mm, a height of 34 mm, and a width of 22 mm (Clarke 1985). The shell's outer surface (periostracum) is generally smooth except for shallow, concentric growth mark grooves in adults and low, concentric growth ridges in post-juveniles. The periostracum is yellow, yellowish brown, or brownish in color. Some shells, especially evident in juveniles, have greenish or brown rays. The inside of the shell (nacre) is whitish anteriorly and bluish posterialy. However, as the nacre is thin along the shell's margin, the outer shell color shows through. The species' hinge teeth are only partially developed, but the pseudocardinal teeth are relatively thick and strong. A detailed description of the shell, soft parts, and glochidia is contained in Clarke (1985).

Range. The Tennessee heelsplitter has been collected from numerous streams in the Tennessee and Alabama River systems in the States of Alabama, Georgia, North Carolina, Tennessee, and Virginia (Clarke 1985). Within North Carolina, the mussel has been reported only from a pre-1918 collection in Valley Creek, Cherokee County. A comprehensive list of collection records is contained in Clarke (1985).

Habitat. The mussel was categorized by Clarke (1985) and Bates and Dennis (1985) as a species that inhabits small streams. Ortmann (1918) reported the species from larger streams, but he stated that in these situations specimens, came from small sloughs within the stream and not the main stream channel.

Life History and Ecology. Little is known of the species' life history and ecology. Specific food habits of the Tennessee heelsplitter are unknown, but it likely feeds on food items similar to those consumed by other freshwater mussels. Freshwater mussels are known to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The species' reproductive biology remains unknown, but it likely reproduces like other freshwater mussels. Males release sperm into the water column, which are then taken in by the females through their siphons during feeding and respiration. The fertilized eggs are retained in the gills until the larvae (glochidia) fully develop. Based on historic collections of gravid specimens in August and October from the Clinch River system in Virginia, Clarke (1985) stated that the species' period of gravidity likely begins in the middle of August and runs until the spring of the following year. The host fish is unknown.

Special Significance. This species has apparently been extirpated from North Carolina. However, as this species exists in smaller streams than most mussel species, it is possible that a population may still exist in the State.

Status. Vulnerable, Category 1.

Rationale for Evaluation. This mussel has not been seen in North Carolina in recent years and has declined significantly throughout the rest of its range. The reasons for the demise of the species in most streams was unknown, but siltation from poor land use practices was likely an important factor in some watersheds.

Current Protection. None.

Recommendations. The smaller streams within North Carolina's portion of the Tennessee River valley should be surveyed to determine if an isolated population may still exist.

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Prepared by RICHARD G. BIGGINS

Lasmigona subviridus (Conrad, 1835)
GREEN FLOATER

Description. The thin shell of the green floater is an ovate trapezoid. It can be up to 62 mm long, 33mm high, and 20 mm wide. The shell is unsculptured. The beaks are depressed and project a little above the hinge line. The posterior ridge is usually rounded, but frequently ends to form a biangulate margin on the lower posterior end. The posterior slope is compressed and concave and may expand dorsally to form a small wing. The periostracum is yellowish or brownish, usually with many greenish rays. The hinge teeth are well developed but small and delicate. The pseudocardinal teeth are usually small, elevated, serrated angular, directed anterior-ventrally and parallel to the dorsal margin. The interdental projection is present, but poorly developed, in the left valve. The nacre is shiny, whitish anterio-ventrally, bluish and iridescent posteriorly. There may be yellowish or pale salmon colors in the beak cavity. A complete description with illustration can be found in Johnson (1970) and Clarke (1985).

Range. The green floater is found along the east coast of the United States from the Hudson River system in New York to the Cape Fear River system in North Carolina. Lasmigona subviridis has also been found in the Erie Barge Canal and the Champlain Canal in New York, consequently it has been introduced into some small streams in the St. Lawrence River system. Lasmigona subviridis has also been collected in the Watauga River, Greenbrier River and New River of the Kanawha River system in North Carolina, Virginia and West Virginia. Check Johnson (1970) and Clarke (1985) for a more complete review of the distribution of this species.

In North Carolina, the green floater has been recorded from the Tar River (Clarke 1985), Neuse River system (Walter 1954, 1956), and the Cape Fear River (Shelley, 1987). All records in Johnson (1970) for L. subviridis in the Savannah, Catawba, and Yadkin River drainages apply to L. decorata.

Habitat. According to Johnson (1970), Lasmigona subviridis is "usually found in gravel or sandy bottoms in medium or small streams, as well as canals and pond areas of streams, and seems to avoid large rivers." According to Ortmann (1919) L. subviridis "avoids large rivers and prefers smaller streams". Ortmann (1919) also mentioned that "it is averse to very strong current, and prefers more quiet parts or eddies with gravelly and sandy bottoms, and it also goes into canals, where it seems to flourish". Clark (1985) agrees with Ortmann's descriptions of L. subviridis habitat. Walter (1954) found L. subviridis in one to four feet of water, with a slow to moderate current, in sand and gravel substrates. Walter (1956) listed the green floater from large creeks and small and large rivers in the Neuse River system.

Life History and Ecology. Ortmann (1919) reported gravid specimens of L. subviridis collected in Pennsylvania from August, September and then again in April, May and June. Ortmann (1919) states that (in Pennsylvania) the season began about the middle of August with the first glochidia appearing in September. It appears as if the glochidia are carried over the winter and that the species is bradytictic (Ortmann,

1919). Ortmann (1919) mentions that after examining several hundred individuals, all had female characteristics and the species is hermaphroditic. The fish host(s) of this species are not known. Clark (1985) describes glochidia taken from a specimen collected in September.

Special Significance. No special significance of this species is known.

Type Locality. The type specimens of Unio subviridis Conrad, 1835 were taken from the Schuykill River, Juniata River (Blair County), and creeks (Lancaster County), all in Pennsylvania. The holotype originally cataloged under ANSP 2105 has been lost (Johnson, 1970).

Systematics. According to Frierson (1915), a figure of the green floater was originally published by Conrad in 1835 under the name Unio viridis, a Rafinesque name. Conrad was uncertain of the shell's identification since the Rafinesque shell was from the Ohio drainage and the shell Conrad was figuring was from the Atlantic drainage. Conrad then proposed a new name, Unio subviridis (Conrad, 1835). Simpson (1900, 1914) apparently did not know of Conrad's 1835 description of U. subviridis and listed Lasmigona subviridis under the name Symphynota viridis (Conrad, 1835). Frierson (1915) reviewed the previous synonymy for the species and changed the name to Lasmigona subviridis (Conrad, 1835).

Simpson (1914) synonymized Unio tappanianus Lea, 1838, Unio hyalinus Lea, 1845 and Unio pertenuis Lea, 1863, with Symphynota viridis (now Lasmigona subviridis). Later, Johnson (1970) synonymized Unio decoratus Lea, 1852, Unio pygmaeus Lea, 1852, Unio charlottensis Lea, 1863 and Unio insolidus Lea, 1872 with Lasmigona subviridus. Clark (1985) recognized Lasmigona decoratus as a distinct species and reduced the synonymy under L. subviridis to essentially those recognized by Simpson (1914).

Status. Vulnerable, Category 1.

Rationale for Evaluation. In North Carolina, the green floater has been collected from the New and Ohio River systems and from the Tar, Neuse and Cape Fear River systems of the Atlantic drainage. The naiad populations of the Neuse and Cape Fear River systems have suffered greatly over the last 40 years due to various kinds of development and reduction of water quality. The green floater, which was once common in the Neuse River (Walter, 1954) system is now hard to find. Shelley (1987) reported L. subviridis from only two localities in the Cape Fear system. The continued existence of this naiad in North Carolina is seriously threatened.

Current Protection. Currently, the green floater is not under any protection.

Recommendations. The best chances for maintaining viable populations of L. subviridis in North Carolina are to monitor carefully those populations which are known to exist in the New, Tar, Neuse and Cape Fear Rivers. In addition, search for other populations in some of the small drainages off the larger rivers, then protect some of those drainages from any type of development leading to water quality deterioration. It would

also be essential to study the ecology and reproduction of the species carefully so that sound management practices can be adopted.

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Prepared by EUGENE P. KEFERL

Alasmidonta heterodon (I. Lea 1830)
DWARF WEDGE MUSSEL

Description. This is generally a small mussel, with a shell length normally ranging between 25 mm and 38 mm. The largest specimen ever recorded was 56.5mm long, taken from the Ashuelot River in New Hampshire (Clarke 1981). The periostracum is generally olive green to dark brown; nacre bluish to silvery white, usually cream or salmon colored towards the umbonal cavities. Shell outline is subrhomboidal or subtrapezoidal; lateral teeth reversed, with one on the left valve and two on the right. All other laterally dentate species in North Carolina have two lateral teeth on the left valve and one on the right. This species is sexually dimorphic; valves of females are swollen in the region of the posterior slope, whereas those of males are generally flattened. Detailed descriptions and illustrations are provided by Johnson (1970) and Clarke (1981).

Range. This species formerly ranged from the Petitcodiac River in New Brunswick, Canada, south to the Neuse River, North Carolina. Outside North Carolina, populations are currently known only from portions of the Connecticut River system in New Hampshire and Massachusetts, and from portions of the Potomac and the Choptank river systems in Maryland (Master 1986). Recent surveys failed to locate Alasmidonta heterodon in 16 river systems where it was previously recorded (Masters 1986). In North Carolina, it is known from both the Neuse and the Tar river systems. Its historical range within those systems is unclear, but available records show that it was once more widely distributed than at present. Today, the only known populations in the Neuse River basin are in the Little River in Johnston County (W. F. Adams and A. G. Gerberich, unpubl. data), and in Middle Creek in Johnston County (W. Laney, pers. comm.). The statuses of these populations are already in doubt (see Recommendations below). In the Tar River basin, populations are known in the upper Tar River in Granville County and in Crooked Creek and Cedar Creek in Franklin County (W. F. Adams and J. M. Alderman, unpubl. data). Shelley (1987) argues convincingly that Dawley's (1965) unverified record of this species from a lake in Guilford County (Cape Fear River basin) is in error.

Habitat. In North Carolina, the dwarf wedge mussel seems to prefer areas of deep runs with coarse sands. Other habitats noted for this species are on bottoms of gravel or mud, among submersed aquatic plants, and near the stream bank underneath overhanging tree limbs.

Life History and Ecology. Little is known of the natural history of the dwarf wedge mussel. It is bradytictic, with glochidia having been reported from February, April, June, and August (Clarke, 1981). Glochidia are figured in Clarke (1981). It is not known whether the dwarf wedge mussel uses a single species of host fish or multiple species. No host fish has ever been recorded. The general distribution of this mussel along the coastal plain has lead to speculation that at least one of its hosts is anadromous or catadromous (Masters 1986). Other unionids frequently found with this species are Elliptio complanata and Strophitus undulatus. The dwarf wedge mussel appears to be a preferred food item for

muskrats during the winter months as I have frequently found it disproportionately represented in muskrat shell middens.

Special Significance. The dwarf wedge mussel is considered to have a naturally relict distribution (Fuller 1977). Its distribution, in concert with its anomolous shell characters, indicates an early divergence from other unionid stock and suggests a great antiquity for the species. The suspected age of this species makes it of particular interest and value to malacologists trying to unravel the evolutionary mysteries and ancient distributions of the Unionidae.

Type Locality. Schuylkill River and Derby [sic] Creek (mostly in Delaware County), Pennsylvania. Type material is lost. Syntypes are in the collection of the Academy of Natural Sciences of Philadelphia (ANSP 41004 and 41005).

Systematics. The dwarf wedge mussel was originally described as *Unio heterodon* (I. Lea, 1830). It was subsequently placed in the genus *Alasmidonta* by Simpson (1914). Due to its unique soft-tissue anatomy and conchology, Ortmann (1914) placed it in a monotypic subgenus *Prolasmidonta*. Fuller (1977) believed the antiquity and unique shell characters of *Prolasmidonta* were sufficient for elevation to full generic rank and named the species *Prolasmidonta heterodon*. Clarke (1981) retained the genus name *Alasmidonta* and considered *Prolasmidonta* to be a subjective synonym of the subgenus *Pressodonta* Simpson 1900.

Status. Endangered.

Rationale for Evaluation. The decline of dwarf wedge mussel populations in North Carolina as well as in the rest of North America testifies to its difficulty in coexisting with current land use practices. As with most species of mollusks, the precise causes are unclear, but the decline is generally attributed to stream modification (e.g. dams, channelization), sedimentation, and degraded water quality. The species is now so restricted in North Carolina that remaining populations could easily be lost.

Current Protection. The dwarf wedge mussel has been listing as endangered by the U.S. Fish and Wildlife Service (55 FR 9447; March 14, 1990).

Recommendations. Continued growth east of Raleigh in Wake and Johnston counties threatens the Little River and Middle Creek populations of the dwarf wedge mussel. In 1989, a qualitative survey of the Little River area by J. M. Alderman indicated a decline in the dwarf wedge mussel population has occurred. The most noticable change in the area appeared to be the invasion of the Asiatic clam, *Corbicula fluminea*. This situation should be carefully monitored. The Middle Creek population has not been checked in recent years and should be thoroughly assessed. Additional measures (e.g. outstanding resource water designation, zoning) to maintain or improve the water quality of both stream basins should be applied to protect surviving populations. Although development is not known to be an immediate threat in any of the Tar River basin sites,

measures to protect the water quality of these areas against future degradation would be easiest to apply now while development interest is low. The advance of Corbicula into this area should also be carefully monitored. Apart from protection efforts, study of the autecology of the species is needed so that management measures can be developed and the recovery of the species facilitated.

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Prepared by WILLIAM F. ADAMS

Alasmidonta raveneliana (Lea 1834)
APPALACHIAN ELKTOE

Description. Clarke (1981) describes the Appalachian elktoe mussel as having a subovate or kidney-shaped shell that reaches a maximum length of 80 cm, a height of 35 mm, and a width of 25 mm. The shell's outer surface (periostracum) is yellowish brown in juveniles but dark brown in adults. Although rays are prominent on some shells, most individuals only have obscure greenish rays. The inside surface of the shell (nacre) is shiny and generally bluish or bluish white. However, the nacre in the central and beak cavity portion of the shell is salmon, pinkish, or brownish. The species has incomplete hinge teeth, rather small and compressed pseudocardinal teeth, and it lacks lateral teeth. A detailed description of the shell with illustrations is contained in Clarke (1981). Soft parts are discussed by Ortmann (1921).

Range. This mussel is endemic to the upper Tennessee River system in the mountains of eastern Tennessee and western North Carolina (Clarke 1981). In Tennessee it has been collected from the Holston River. In North Carolina it has been taken from the Nolichucky River, county unknown; from the French Broad River system (Little River, Transylvania County; the Swannanoa River, Buncombe County; the Pigeon River, Haywood County; the French Broad River, Buncombe County; and the French Broad River, county unknown); and from the Little Tennessee River system (Tulula Creek, Graham County, and the Little Tennessee River, Swain and Macon Counties). Recent (1986-1988) searches of the Upper French Broad River and some of its tributaries in Buncombe, Henderson, and Transylvania Counties have failed to locate any specimens (John Fridell and James Widlak, U.S. Fish and Wildlife Service, pers. comm., 1989; personal observation, 1988). The Pigeon River downstream on Canton, North Carolina, is severely polluted and likely no longer supports the species. The species has been found in recent years (1987) only from the Little Tennessee River in Macon and Swain Counties, North Carolina (Widlak, pers. comm., 1989; personal observation, 1989; Tennessee Valley Authority 1987).

Habitat. Little is known of the species' habitat needs, but Widlak (pers. comm., 1989) reported that he found fresh dead shells in a riffle area with gravel and cobble substrate in the Little Tennessee River.

Life History and Ecology. Specific food habits of the Appalachian elktoe are unknown, but it likely feeds on food items similar to those consumed by other freshwater mussels. Freshwater mussels are known to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). This species' specific reproductive biology remains unknown, but it likely reproduces like other freshwater mussels. Males release sperm into the water column, which are then taken in by the females through their siphons during feeding and respiration. The fertilized eggs are retained in the gills until the larvae (glochidia) fully develop. Ortmann (1921) reported collecting four gravid females, two discharging glochidia, from the Pigeon River on May 14, 1914. He concluded that the species' breeding season ended in May. Other aspects of its life history are unknown.

Special Significance. North Carolina's Little Tennessee River population is the only population of the species presently known to exist. Thus the protection of this population is critical to the survival of the species.

Status. Vulnerable, Category 1.

Rational for Evaluation. Although some mussel surveys have been conducted, the species has not been seen in the French Broad River system or Holston River in recent years. Therefore, the only population that is still known to survive is in the Little Tennessee River. If this is the only surviving population, then the species is vulnerable to extinction from a catastrophic accident such as a toxic chemical spill or from the general declines in water and substrate quality.

Current Protection. Although the species has some limited protection by virtue of other environmental laws that protect aquatic ecosystems, this mussel presently has no specific protection. However, the species is considered by the U.S. Fish and Wildlife Service as a potential candidate for Federal protection under the Endangered Species Act of 1973.

Recommendations. Projects in the Little Tennessee River system that could impact water or substrate quality in the inhabited river reaches should be carefully reviewed and monitored to provide for the greatest environmental protection possible. A survey of the species' current and historic range is needed to assist in determining if this species should be proposed for Federal endangered or threatened species status.

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Prepared by RICHARD G. BIGGINS

Alasmidonta viridis (Rafinesque, 1820)
SLIPPERSHELL MUSSEL

Description. The slippershell mussel is a relatively small freshwater species. Total length rarely exceeds 50 mm. For specimens examined from North Carolina's Little Tennessee River, the height to length ratio ranged from 0.61 to 0.67 and the width to length ratio ranged from 0.41 to 0.49. Both the anterior and posterior ends of the shell are rounded. The posterior ridge is inflated and well rounded. In most North Carolina specimens, the posterior half of the ventral margin is straight. Most specimens are dark brown over the entire surface of the periostracum; however, young individuals are often found with green rays over the entire surface. Shells are slightly to significantly thicker toward the anterior end of the shell. The nacre is white anteriorly and an iridescent blue posteriorly in younger individuals. In older specimens the white extends farther toward the posterior end. The nacre is a creamy beige extending from the pallial line inward into the beak cavity. There is one pseudocardinal tooth in each valve; however, a vestigial additional tooth may be present in each valve. Lateral teeth are vestigial. See Clarke (1981) for additional descriptions and a description of the glochidia.

Range. This is a Mississippi Drainage Basin species which is also found in some of the tributaries to the Great Lakes. In North Carolina the slippershell mussel is only found in the lower Little Tennessee River above Fontana Reservoir.

Habitat. In North Carolina, live individuals have been collected from riffle areas with a gravel/cobble/boulder substrate. In other parts of its range, the slippershell mussel has been found in a variety of habitats ranging from slowly moving or standing water with a sand bottom (Baker 1928; Buchanan 1980) to faster flowing streams, creeks, and rivers with more coarse substrates (Mathiak 1979; Zale and Neves 1981; Oesch 1984).

Life History and Ecology. This is a long-term breeder (bradytictic) with glochidia being reported from fall through spring (Baker 1928; Zale and Neves 1981; Clarke 1981). Hermaphroditic slippershell individuals have been found (Ortmann 1911). Clarke (1981) lists the johnny darter and the mottled sculpin as fish hosts for the slippershell mussel. Additionally, Zale and Neves (1981) found the banded sculpin to be another fish host. Although the johnny darter and banded sculpin are not found in the lower Little Tennessee River, the mottled sculpin is one of the fish species found there.

Special Significance. Alasmidonta viridis, Alasmidonta raveneliana, Lampsilis fasciola, Elliptio dilatata, Fusconaia barnesiana, and an undescribed Villosa species are all found in the same area of the Little Tennessee River in North Carolina. This mussel community is North Carolina's best extant example of the Mississippi Drainage Basin's tremendously diverse mussel assemblage.

Type Locality. Ohio and Kentucky rivers including the small rivers adjacent to the Kentucky River. The original materials have been lost.

Systematics. A list of taxonomic synonyms is provided by Clarke (1981). Clarke considers both Alasmidonta calceola and Alasmidonta minor to be synonyms of Alasmidonta viridis.

Status. Vulnerable, Category 1.

Rationale for Evaluation. Although the slippershell mussel is rather wide ranging throughout much of the Mississippi Drainage Basin, it is considered rare throughout (Kitchel 1990). For example, Starnes and Bogan (1988) reviewed the mussels known from Tennessee and found very few records of the slippershell mussel post 1960 from many of the rivers in that state. In North Carolina, it is only found in about 11 miles of the lower Little Tennessee River. In this area, only Fusconaia barnesiana is more rare.

Current Protection. Although there is no federal protection for this species at the present time, its habitat is protected since the slippershell mussel is found in the spotfin chub's critical habitat in North Carolina. The spotfin chub is listed as threatened by the U.S. Fish & Wildlife Service.

Recommendations. North Carolina's lower Little Tennessee River provides important habitat for a great diversity of fish, mollusks, and other aquatic species. This river from Franklin to Fontana Reservoir should be considered for Outstanding Resource Water and/or High Quality Water designations to help protect one of our state's most valuable large rivers. Improved land use practices are needed to prevent additional sedimentation problems, and local citizens and governments must be further educated about the importance of this resource.

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Prepared by JOHN M. ALDERMAN

Anodonta couperiana Lea, 1842
BARREL FLOATER

Description. The barrel floater may reach over 100 mm in length. Like other Anodonta, this species also lacks pseudocardinal and lateral teeth. The shell of the barrel floater is similar to that of Anodonta imbecilis in that the umbos do not extend above the dorsal margin. However, the barrel floater's height to length ratio is around 2 compared with 1.5 for Anodonta imbecilis. The ventral margin of the barrel floater is broadly rounded and there are fine green rays on the periostracum. Additional descriptive information is found in Johnson (1970).

Range. The barrel floater is found from Florida's Apalachicola region to the Cape Fear drainage basin in North Carolina.

Habitat. According to Johnson (1970), the barrel floater is found in ponds and slow-flowing streams with mud or sand bottoms.

Special Significance. The barrel floater reaches the northern limit of its range in North Carolina. According to Johnson (1970), the specimens from the northern range limit tend to be quite large and beautiful.

Type Locality. McIntosh County, Georgia.

Status. Vulnerable, Category 1.

Rationale for Evaluation. This species has been extirpated from one of its two known locations in North Carolina. The barrel floater was once known from the Greenfield Lake basin near Wilmington; however, Bill Adams (1990) has documented an almost total elimination of the Unionidae, including the barrel floater, from this area. Vidrine (1980) documents this species from Bladen County.

Current Protection. None.

Recommendations. The lower Cape Fear Drainage Basin and other coastal rivers, creeks, and streams need to have complete mollusk surveys completed. Critical habitats for rare species need to be identified and protected.

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Prepared by JOHN M. ALDERMAN

Leptoxis dilatata (Conrad 1835)
SEEP MUDALIA

Description. Like other pleurocerid snails, species within the genus Leptoxis are subject to extreme environmental polymorphism, often with great morphological variability expressed in individuals of the same species within a given population. Adults of this species usually exceed 15 mm in length, are ovately conic with a high spire, and lack carinae and color bands; however, variations are to be expected. This species is very similar to Leptoxis carinata of the Atlantic slope and replaces it in the Ohio River drainage. Any Leptoxis taken in the New River drainage is almost certainly this species.

Range. This species has been reported from the Kanawha, Monongahela, and New River systems (Goodrich 1940, Fuller 1977). In North Carolina, it is known only from the New River drainage in Ashe County (Dillon 1977, Fuller 1977) (2 collection locations are from areas where the New River serves as a boundary between counties, therefore, records will also occasionally include Alleghaney and Watauga counties as locales).

Habitat. Known from large cobbles and slab boulders in areas of high flow velocity (Miller-Way and Way 1989). Food for this species and other members of the genus Leptoxis is presumed to be primarily algae and diatoms.

Life History and Ecology. Miller-Way and Way (1989) found that a population of Leptoxis dilatata in the Laurel Fork River, West Virginia, was semelparous and biennial. Individuals lived between 23 and 26 months, with growth rates ranging from 0.02 to 0.04 mm per day. Reproduction took place during the second year of life with eggs being laid between late April and early May. Sex ratios were not significantly different from 1:1.

Special Significance. None known.

Type Locality. Conrad (1835) described this species from specimens provided by Mr. William B. Rogers taken from "rivers in Munroe (sic) Co., Virginia." Monroe County was among the western counties of Virginia which became West Virginia in 1863. The boundaries of Monroe County at the time of Conrad's description are unknown to the author; however, the New and the Greenbriar rivers currently form portions of Monroe County's boundary, and it is probable that Conrad's specimens came from either or both of these rivers.

Systematics. Due to their polymorphic nature, the systematics of most of the Pleuroceridae, including this species, are in an indeterminate state. For the sake of brevity, a full systematic treatment will not be given here. Conrad (1835) described this species and placed it in the genus Anculosa Say 1821. Since that time, many authors (Tryon 1873, Hannibal 1912, Pilsbry 1917, Walker 1918, Goodrich 1940, Morrison 1954)

have reviewed or revised the pleurocerids and the species has been variously included in Ellipstoma Rafinesque 1818, Spirodon Tryon 1873, and Mudalia Haldeman 1840. Fuller (1977) included it in Spirodon during North Carolina's last evaluation of its threatened and endangered species. Spirodon is now considered a synonym of Mudalia and Mudalia a subgenus of Leptoxis (Burch 1982).

Status. Vulnerable, Category 1.

Rationale for Evaluation. Leptoxis dilatata is peripheral in North Carolina, known only from the New River basin. Given its restricted distribution in the state and the decline in other aquatic mollusks being experienced throughout the Appalachians, this species should be considered threatened in North Carolina until stable and protected populations can be identified.

Current Protection. None.

Recommendations. Surveys to reconfirm and assess populations of this species in North Carolina are needed.

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Prepared by WILLIAM F. ADAMS

Fusconaia masoni (Conrad, 1834)
ATLANTIC PIGTOE

Description. Atlantic pigtoes are sub-rhomboidal except in individuals from headwater areas. Such individuals tend to be more elongate. The posterior ridge is very distinct, and the umbos extend well above the dorsal margin. The periostracum is yellow to dark brown and parchmentlike. The nacre ranges from an iridescent blue, to salmon, to white, to orange. Pseudocardinal and lateral teeth are well developed except for the anterior pseudocardinal tooth in the right valve which is vestigial. All four demibranchs serve as marsupia in gravid females. As the glochidia mature, the demibranchs and adductor muscles develop a bright orange-red to red color. Additional species descriptions can be found in Johnson (1970) and Fuller (1973).

Range. The Atlantic pigtoe ranges from the Ogeechee Drainage Basin, Georgia north to the James Drainage Basin, Virginia. In North Carolina, this species was once found in every Atlantic drainage except the Cooper-Santee and Waccamaw drainage basins (Johnson 1970).

Fuller (1973) found the Atlantic pigtoe in the Cape Fear River near Fayetteville in the early 1970s, and Shelley (1987) found this species at one station in the Rocky River, a tributary of the Cape Fear River in Chatham County, in the 5970s. Preliminary surveys at both stations document no Atlantic pigtoes present in the late 1980s (Alderman, unpubl. data).

In North Carolina's Pee Dee Drainage Basin, Keferl (unpubl. data) found only two live individuals and two shells at three stations of 194 stations surveyed during the late 1980s.

In the Neuse Drainage Basin, Walter (1954) found the Atlantic pigtoe at only two stations - one in the Little River (one shell found) and the other in the Eno River (one live individual and four shells found). During recent years, Adams (unpubl. data) and Alderman (unpubl. data) have confirmed the Atlantic pigtoe's continuing existence in the Little River, Johnston County. This species has also been found in the Flat River, Person and Durham counties, during recent years (Alderman, unpubl. data).

In the Tar Drainage Basin, one healthy population exists in Swift Creek. Individuals are also found at various stations in the Tar River from the headwaters in Granville County to the Tarboro area in Edgecombe County. Individuals are also found on occasion in Fishing Creek (Alderman, unpubl. data). (This Fishing Creek has its confluence with the Tar River in Edgecombe County.)

The Atlantic pigtoe's status in the Roanoke and Chowan rivers is unknown.

Habitat. The preferred habitat for the Atlantic pigtoe is a yielding substrate composed of coarse sands and gravel at the downstream edge of riffle areas. In such habitats, which are becoming increasingly rare since sedimentation significantly affects such areas, as many as five live individuals have been found in a one meter square area. This species is less common in sands, cobble, and mixed substrates of sand, silt, and detritus.

Life History and Ecology. The fish host is unknown for this species (Fuller 1973) and little is known about other aspects of its life history or ecology. (See the systematics section below for a discussion of reproductive biology as it relates to the taxonomy of the Atlantic pigtoe.)

Special Significance. This is a close species associate of the Tar River spiny mussel. Also, it is our only representative of the genus Fusconaia in the southern Atlantic slope region.

Type Locality. The type locality is Savannah River, Richmond County, Georgia, and the holotype is ANSP 41333 (Johnson 1970).

Systematics. Unio subplanus was described by Conrad (1837), and the holotype (lost) was from the Maury River, Rockbridge County, Virginia. Ortmann (1914) found a gravid female of this species on June 7, 1912 at the type locality. On the basis of this one individual exhibiting a digenous marsupial condition, he assigned the species to the genus Lexingtonia.

Fuller (1973) examined Unio masoni Conrad, 1834 from the Cape Fear, Savannah, and Ogeechee river systems and determined that this species should be assigned to the genus Fusconaia based upon the tetragenous marsupial condition found in gravid females.

Upon examination of female Fusconaia masoni in North Carolina, it appears that this species becomes fully and rapidly gravid during the first week of July (Alderman, unpubl. data). Before and after this period, gravid females can be found; however, the tetragenous marsupial condition is not adequately expressed until around July 1. During such non-peak periods of gravidity, it would be easy to misdiagnose the marsupial condition. Ortmann may have made such a misdiagnosis based upon the examination of one female. Until further studies can verify the species status of Lexingtonia subplana, it should be synonymized under Fusconaia masoni.

Status. Vulnerable, Category 1.

Rationale for Evaluation. Only the Tar River's Swift Creek population of the Atlantic pigtoe is considered relatively healthy. It is an extremely rare species elsewhere in the state.

Current Protection. The Atlantic pigtoe is currently protected in the Tar River in Edgecombe County and in Swift Creek, Franklin through Edgecombe counties. These river and creek reaches provide habitat for the federally endangered Tar River spiny mussel. Protection of Tar River spiny mussel habitat also protects habitat for the Atlantic pigtoe. The Atlantic pigtoe has no protection outside of this area.

Recommendations. Swift Creek should be protected as an Outstanding Resources Water to prevent further degradation of this extremely important drainage. Such a status will help protect many rare species. We need to have much more biological information about the Atlantic pigtoe.

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Prepared by JOHN M. ALDERMAN

Elliptio lanceolata (I. Lea, 1828)
YELLOW LANCE

Description. This elongate, freshwater mussel grows to approximately 86 mm long. Shells are over twice as long as tall. The periostracum is usually bright yellow over the entire surface in younger individuals. Older individuals may have a brown discoloration at the posterior end of the shell. (Uniformly brown individuals are also found; however, yellow and brown individuals are not found at the same stations.) The nacre may range from salmon to white to an iridescent blue color. The posterior ridge is distinctly rounded and curves dorsally toward the posterior end. Rays are usually never present; however, one individual has been observed with three wide, prominent green rays on the posterior third of the shell in the Tar River Drainage Basin. Brownish growth rests are clearly evident on the periostracum. The pallial line and adductor muscle scars are distinct. The posterior adductor muscle scars are less impressed than the anterior adductor muscle scars. The lateral teeth are long - two on the left valve and one on the right valve. Two pseudocardinal teeth are on each valve. On the left valve one is before the other with the posterior tooth tending to be vestigial. On the right valve, the two pseudocardinal teeth are parallel with the more anterior one rather vestigial.

Range. Johnson (1970) considers the range of the yellow lance to extend from the Escambia Drainage Basin, east through parts of Florida and north to the Susquehanna River in Pennsylvania. However, Johnson synonymized many species under Elliptio lanceolata. Using the above description, the yellow lance is known from the Tar, Roanoke, James, and Rappahannock drainages (A. Gerberich, pers. comm.).

In North Carolina, the existence of the yellow lance in the Roanoke Drainage Basin has not been verified in recent years. In the Tar River, this species has declined (Alderman 1988) since A. Clarke (1983) completed his survey for the Tar River spiny mussel.

Habitat. Elliptio lanceolata prefers clean, coarse to medium size sands as substrate. On occasion, specimens are also found in gravel substrates. This species is found in the main channels of drainages down to streams as small as three feet across.

Life History and Ecology. Little is known of the life history and ecology of Elliptio lanceolata. Ortmann (1919) found gravid females during the spring in the James River. Gravid females have been found in the Tar River Drainage Basin in June (Alderman, unpubl. data). As verified by Tankersley (1988), the glochidia are hookless.

Mussel species associates of the yellow lance in the Tar River Drainage Basin include Fusconaia masoni, Elliptio steinstansana, Lampsilis cariosa, Villosa constricta, Alasmidonta undulata, Anodonta imbecilis, Lampsilis radiata, Strophitus undulatus, and one or more other Elliptio species. In this drainage, the presence of Fusconaia masoni is one of the best indicators of the potential presence of Elliptio lanceolata.

A symbiotic mite species (possibly undescribed) has been collected from the yellow lance in the Tar River Drainage Basin (Tankersley 1988).

Special Significance. This species appears to be declining in the Tar River Drainage Basin. In some areas which once supported the Tar River spiny mussel and the yellow lance, both species are now absent. The causes of decline for one species may be the same for the other.

Type Locality. Tarboro in Edgecombe County, North Carolina (USNM 85905, holotype).

Systematics. Using horizontal starch gel electrophoresis, Davis (1984) has determined the greatest genetic distance in *Elliptio* species to exist among the lanceolate taxa. He feels that there are at least seven lanceolate species. Some of these distinct species are *Elliptio folliculata*, *E. producta*, *E. lanceolata*, *E. shepardiana*, and *E. fisheriana*.

Status. Vulnerable, Category 1.

Rationale for Evaluation. The yellow lance is found throughout the Tar River Drainage Basin above Tarboro; however, a viable, reproducing population has been found in only one tributary - Swift Creek.

Current Protection. None. However, better stewardship of drainages providing habitat for the Tar River spiny mussel will also provide protection for the yellow lance.

Recommendations. The fish host for this species needs to be determined. Best management plans for land, water, and air resources need to be developed to prevent further loss of our aquatic species.

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Prepared by JOHN M. ALDERMAN

Elliptio marsupiobesa Fuller, 1972
CAPE FEAR SPIKE

Description. The Cape Fear spike may reach about three inches in length. The anterior third of the shell is considerably thicker than the posterior third, and the shell appears to significantly thicken as individuals grow. The shell is distinctly wedge shaped without sexual dimorphism. The swollen posterior ridge is keeled and the posterior slope is narrow and concave. Adults have one or two radial grooves on the posterior slopes. Growth rests are clearly expressed in the shells. The periostracum of young individuals is smooth with a shiny, yellow-brown color. Green rays may be present on the posterior half of the shell. Older individuals are a dark brownish-black with roughened margins and posterior slopes. A detailed description of the Cape Fear spike is provided by Fuller (1972).

Range. Elliptio marsupiobesa is only known from the Cape Fear River in Cumberland and Bladen counties. It was discovered by Samuel Fuller in 1969, recollected by him in 1970, and has not been seen since that time. I have surveyed throughout North Carolina for the past three years and have not seen this distinctive species at any other stations within the Cape Fear Drainage Basin or in other drainages.

Habitat. As provided by Fuller (1972), the Cape Fear spike was found in muddy, loose, sandy substrates below log jams. It was not found in firm, sandy substrates.

Life History and Ecology. Fuller (1972) found gravid females around the middle of June. Nothing is known about the fish hosts or ecology of the species.

Special Significance. Elliptio marsupiobesa is a North Carolina endemic species.

Type Locality. Cape Fear River, 0.1 miles downstream from Carvers Creek, Cumberland County, North Carolina.

Status. Vulnerable, Category 1.

Rationale for Evaluation. Elliptio marsupiobesa has a limited distribution in a river with significant water quality problems.

Current Protection. None.

Recommendations. A survey for the Cape Fear spike needs to be completed as quickly as possible. If its distribution is as limited as first described by Fuller (1972), this species should be listed as endangered by the U. S. Fish & Wildlife Service. If sufficient numbers of individuals can be found, life history information should be acquired as quickly as possible so a recovery plan can be written for the species.

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Prepared by JOHN M. ALDERMAN

Elliptio roanokensis (I. Lea, 1836)
ROANOKE SLABSHELL

Description. Individual Roanoke slabshells grow to greater than 150 mm total length. In North Carolina it is one of our largest freshwater mussel species. Of 13 specimens recently examined from the Tar River, the height to length ratio ranged from .458 to .544, and the width to length ratio ranged from .212 to .283. The posterior ridge varies from being well defined to being uniformly rounded. The periostracum is generally smooth except near the margins of the shell. Growth rests are distinct. Color of the periostracum is usually a yellow-reddish-brown which darkens with age. Narrow greenish rays are often present from the anterior end of the shell to the posterior ridge. The rays are less distinct in larger individuals. The nacre is usually purple.

Three distinctive characteristics of this species are the presence of small folds (plications) centrally located on the shell's periostracum of most individuals, certain of the incurrent papillae being subdivided into smaller papillae, and irregularly developed branchial septa.

Range. According to Walter (1954) the Roanoke slabshell ranges from the Connecticut River in Massachusetts to the Savannah River in Georgia. In recent years this species has been seen in the Tar River from Rocky Mount to the Tarboro area and in the Neuse River below Raleigh. The holotype for the species was collected from the Roanoke River by Lea during the nineteenth century. Its continued existence in the Roanoke River has not been confirmed during this century.

Habitat. In the Tar River, the Roanoke slabshell is usually found associated with the deeper channels near shore in relatively fast flowing water. The substrate consists of coarse to medium sized sands and small gravel (Alderman, unpubl. data).

Life History and Ecology. Little is known of the life history and ecology of this species. Mussel species associates in the Tar River include Fusconaia masoni, Alasmidonta undulata, Elliptio complanata, Elliptio icterina, Lampsilis cariosa, Elliptio lanceolata, Elliptio steinstansana, and Lampsilis radiata (Alderman 1988). Walter (1954) identified three mussel species associates of the Roanoke slabshell in the Neuse River: Lasmigona subviridis, Alasmidonta undulata, and Elliptio complanata.

Special Significance. The Roanoke slabshell appears to be restricted to the main channels of rivers. If true, this species is particularly vulnerable to extirpation caused by various forms of pollution.

Type Locality. Roanoke River, between Tarboro, North Carolina and Norfolk, Virginia.

Systematics. Johnson (1970) considered the Roanoke slabshell to be one of the many forms of Elliptio complanata found throughout the southern Atlantic Slope Region. However, the Roanoke slabshell has a centrally plicate shell, certain of the incurrent papillae being subdivided into smaller papillae, and irregularly developed branchial septa. These

characteristics distinguish the Roanoke slabshell from Elliptio complanata.

Clarke (1986) described Elliptio judithae from the Neuse River. His description of the species matched that of smaller individual Roanoke slabshells. To determine the validity of species status for Elliptio judithae, soft parts from the Roanoke slabshell in the Roanoke River (type locality) are needed to compare with soft parts of Elliptio judithae.

Status. Vulnerable, Category 1.

Rationale for Evaluation. In the Tar River, there are few signs of successful reproduction. Mostly larger individuals are found in the Tarboro area, and very few of the specimens collected from a mussel die-off near Rocky Mount in 1986 were juvenile Roanoke slabshells. Even in the 1950s, this species was rare in the Neuse River (Walter 1954).

Unlike many North Carolina mussel species, the Roanoke slabshell's known range appears to be limited to relatively short river reaches in each drainage basin where it is found. This increases the probability of extirpation from a particular drainage basin should chronic water quality problems develop or a catastrophic pollution event occur.

Current Protection. None.

Recommendations. The Roanoke slabshell may be threatened throughout its range. There is a need to survey for this species in each state and determine its global status. Its relationship with Elliptio judithae should also be investigated.

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Prepared by JOHN M. ALDERMAN

Elliptio waccamawensis (I. Lea, 1863)
WACCAMAW SPIKE

Description. This naiad has a moderately inflated elliptical shell with a prominent angular ridge on its posterior slope. The ventral margin is straight. The umbo has a trapezoidal beak sculpture. Pseudo-cardinal teeth are present on the hinge and variable in shape. There is a white to bluish nacre on the inner shell surface. A light to dark brown smooth periostracum covers the outer shell surface. On the gills of females a cream colored marsupium extends along most of the outer demibranch.

Largest E. waccamawensis specimens in the UNC-IMS (University of North Carolina, Institute of Marine Sciences mollusk collection) are: Lake Waccamaw - length = 71, height = 35, width = 25 mm (UNC-IMS #3306); canal surrounding Lake Waccamaw - length = 68, height = 43, width = 28 (E. waccamawensis - length = 77, height = 49, width = 36 mm) (both UNC-IMS, uncatalogued from A. G.-Gerberich collection); Big Creek - length = 80, height = 48, width = 33 mm (UNC-IMS, uncatalogued); and Waccamaw River near Lake Waccamaw dam - length = 60, height = 33, width = 23 mm (UNC-IMS #8557.1) and Waccamaw River near Conway, SC - length = 59, height = 35, width = 23 mm (UNC-IMS #10364.2).

The original 1863 description by Lea was in Latin. The following description is an English translation by Lea (1866) of the original: "Shell smooth, triangular, inflated, flattened at the sides, very inequilateral, subbiangular behind, rounded before; valves thin; beaks prominent; epidermis brownish green or olivaceous, obscurely rayed; cardinal teeth very small, compressed, oblique, double in both valves; lateral teeth long, lamellar and straight; nacre bluish white and iridescent."

Glochidia are suboval, hookless and marginally bilaterally asymmetrical in shape. Its hinge varies from straight to slightly concave in appearance. Dimensions, as reported in Porter and Horn (1980) are: length = 0.210 mm; height = 0.217 mm; hinge length = 0.144 mm; hinge length/length ratio = 0.69; height/length ratio = 1.04; and hinge length/height ratio = 0.66. Shape and size appeared identical to that of Elliptio fisheriana.

This species has been confused in Lake Waccamaw with Elliptio raveneli (Conrad, 1834) and Lampsilis fullerkati. Both differ primarily from waccamawensis by not having a prominent sharp ridge on the posterior slope of the shell. A rounded posterior slope ridge can be present on Lampsilis fullerkati. Further, E. raveneli has a clothlike, velvety, rough, dark periostracum which is unlike that on waccamawensis. The posterior portion of L. fullerkati is frequently green rayed; such green rays are rarely present on waccamawensis.

As mentioned in the above description, a cream colored marsupium extends along almost the entire length of the outer demibranch of the female. It similar to that of E. raveneli (Lake Waccamaw form) and that pictured by Fuller (1971) for E. icterina (=E. raveneli) except that it is not as broad (anterior view) as that pictured by Fuller. A most important distinction between E. waccamawensis and L. fullerkati is that in fullerkati, the marsupium has a dark ventral margin and occupies only the posterior half of the outer demibranch. E. waccamawensis marsupial length generally equals length of horizontal portion of ventral margin of outer demibranch.

Papillae on the branchial aperture of waccamawensis are similar to those in other Elliptio sps. as there are few mantle papillae following the posterior branchial papillae on the inner mantle margin (Porter, 1985). On the inner mantle margin of both male and female E. fullerkati mantle papillae extend anteriorly beyond the branchial papillae for about 1/5th the length of the ventral mantle margin.

Range. This species is known only from Lake Waccamaw related waters in North Carolina and possibly South Carolina.

Heard (1975) has reported finding "empty, well-worn shells in the lower Waccamaw River (Horry Co., South Carolina)." This site is one mile southwest of Conway, South Carolina. Living naiads resembling E. waccamawensis have been collected from the Conway, South Carolina site by A. G. Gerberich (1984, pers. comm.) and by this author (UNC-IMS, uncatalogued). No other non-North Carolina collections of this species are known.

In North Carolina Waccamaw River waters, the species is known to have been collected just below the Lake Waccamaw dam and five miles northeast of the South Carolina line where NC Route 904 crosses the river (Porter and Horn, 1984a).

Surrounding much of Lake Waccamaw is a canal. Within it, this Elliptio or something very similar to it was collected by A. G. Gerberich in May 1984 (UNC-IMS, uncatalogued). Additionally, the species has been collected by this author and others in Big Creek, a small stream that flows into the eastern side of Lake Waccamaw. There it seems restricted to a small area adjacent to a North Carolina Wildlife Resources landing ramp. A half a mile above and below the ramp area of Big Creek, naiads are no longer present.

Previous published records, besides the Lea (1863) account, recording E. waccamawensis from Lake Waccamaw or the Waccamaw River include: Simpson (1900, 1914); Hubbs and Raney (1946); Rehder (1949) (species listed as Elliptio complanatus quadrilaterus Lea, a probable misidentification); Dawley (1965); Johnson (1970); Jennewein (1971); Stansbery (1971); Fuller (1972b, 1977); Fuller and Imlay (1976); McDaniel and McDaniel (1972); Morrison (1972, 1973); Shelley (1972); Sepkoski and Rex (1974); Burch (1975); Emerson and Jacobson (1976); Heard (1975); Fuller (1979); Porter and Horn (1980); Davis and Fuller (1981); Davis et al. (1981); Horn and Porter (1981); Kat (1983); Porter and Horn (1983, 1984a (Waccamaw River), 1984b); Davis (1984); and Johnson (1984). UNC-IMS catalogued specimens and lots from Lake Waccamaw include (incomplete):#'s 2779, 2780, 3311, 3457, 3460, 7099, 8557, 8568, 8583, 8595, 8599, 9095, 9873, 9882, 10117, 10118, 10125, 10130, 10139, 10153, 10202-10219, 10351, 10364, 10473, 10481, 10483, 11008, 11023, 11031, 11062, 11075, 11081, 11098, 11102, 11108, 11118, 11123, and 11130.

Habitat. The 1978-1981 survey (Porter, 1985) found large numbers of E. waccamawensis throughout the lake including in the deepest depths where the substrate is peat. Average density of the species in the lake was $22.79/m^2$. Highest recorded density was $132.3/m^2$. Only 13.4% of the survey samples did not contain this mussel. It was found in all regions of the lake, but the distribution of it was not homogenous throughout the regions.

Lowest densities of it were in the shallow sand area of the lake. Here considerable area periodically becomes dry due to lowering of water depth probably related to periods of low rainfall. Living naiads are not in such areas of the lake. Highest average densities were from deep sand where densities were about 3.2 times densities from the shallow sand areas.

Mean values of physical data from samples containing E. waccamawensis were not significantly different from mean values of all Lake Waccamaw sample physical data. Mean physical data of all samples containing E. waccamawensis were (Porter, 1985):

% saturated dissolved oxygen = 86.9 (range = 13-132%); sediment total chlorophyll a (uncorrected) = 4.72 (range = 0.95-21.61); sediment total chlorophyll a (corrected) = 3.71 (range = 0.00-34.70); sediment pheo-pigments = 2.48 (range = -3.23-34.36); ph = 6.93 (range = 5.5-7.5); % sediment organic matter = 4.47 (range = 0.00-35.21); % sediment carbonate matter = 0.68 (range = 0.10-5.78); graphic mean sediment size = 2.06 Ø units (range = 0.46-4.40) (fine sand according to Folk, 1974); sediment inclusive graphic standard deviation = 0.79 (range = 0.09-1.66) (moderately sorted sand - note Folk, 1974); sediment graphic skewness = -0.09 (range = -0.66-0.52) (fine-skewed sand - note Folk, 1974); and sediment graphic kurtosis = 1.10 (range = 0.63-2.05) (platykurtic sand - note Folk, 1974).

Densities of E. waccamawensis were positively correlated with light penetration and pH; densities were negatively correlated with: sediment pheo-pigment and mean sediment size (Ø units).

Elliptio waccamawensis densities were lower within beds of the emergent plants Maidencane and Spatterdock than in areas not containing Maidencane and Spatterdock. It has been speculated (Porter, 1985) that the dense root mats present in Maidencane and Spatterdock beds hinder partial to complete submergence of the naiad thus preventing continued presence in the plant bed substrata by large naiads. This hindrance to substrate submergence could put such naiads under stress and consequently affect their survival.

Life History and Ecology. Strong correlations exist between densities of E. waccamawensis and the following other mollusks in Lake Waccamaw: Elliptio folliculata, Elliptio producta, Lampsilis Fullerkati, Lampsilis ochracea, Lioplax subcarinata, and Amnicola sp. A negative correlation with Campeloma decisa (5% level only) is interesting as it suggests that this large gastropod may be present optimally in Lake Waccamaw where E. waccamawensis is not optimally found (Porter, 1985; Porter and Horn, 1983).

The sympatric relationship of waccamawensis with members of the E. lanceolata group has been discussed in Davis et al. (1981). They saw no reason why waccamawensis could not live "with congeners in numerous other localities in North Carolina, South Carolina, or Georgia". They realized however, that there may be stringent environmental conditions, fulfilled only in Lake Waccamaw, that only waccamawensis could survive in.

A strong positive correlation in E. waccamawensis densities occurs with L. ochracea densities, - note both are the dominant naiads of the lake. Of possible ecological significance is that while both naiads are density correlated with each other, L. ochracea densities are negatively

correlated with pH, whereas, E. waccamawensis densities are not correlated with pH. A mechanism for a slight ecological habitat separation between the two species is indicated.

The recently introduced "Chinese Clam", Corbicula fluminea, was shown in the 1979-1981 study (Porter and Horn, 1984b) not to have any effect on existing E. waccamawensis populations. This is being discussed more fully in a paper being written by this author and which is expected to be submitted for publication in late 1990.

Shell lengths of folliculata collected randomly for tissue study analyses demonstrated that mussels from the "State Park" area (southern end of lake) had lengths generally significantly longer than those from other sampled locations and did not vary significantly between monthly samples. Some significant variation did occur between sampling months at the "Boys' Home" area (northeastern end of lake).

No significant (1% level) correlation was found between shell obesity (shell width/length) of E. waccamawensis and mean sediment size, percent organic matter or percent carbonate of the sediment (Horn and Porter, 1981).

Reproduction. This is a short-term breeder (tachytictic). Time of its reproductive cycle does vary from season to season. Marsupia have been observed from April into August. Glochidia have been found in May through July. Host fish for the glochidia are unknown.

Time of the reproductive cycle can also vary between regions within the lake (Porter and Horn, 1980). E. waccamawensis from the northern regions in the lake seem to have a shorter cycle than those from the southern area.

In both 1979 and 1980 the percent gravid condition 20% occurred one month after water temperatures had risen above 20 ^{o}C. No late fall presence of swollen marsupia was noted as occurred in 1979.

Special Significance. Elliptio waccamawensis is part of the endemic molluscan assemblage of Lake Waccamaw that makes the lake one of the most species rich lakes in the Western Hemisphere. The molluscan fauna of the lake generally is not known to occur anywhere else in North Carolina. Further, Lake Waccamaw and Orton Pond are the only lakes on the North Carolina coastal plain known to be able to support a diverse unionid fauna.

Type Locality. Lake Waccamaw, North Carolina (Lea, 1863).

Systematics. A study of the genetic relationships of some of the southern Atlantic Elliptio sps. using allozyme analyses by Davis (1984) additionally confirmed that waccamawensis was a valid species. It was found closest related to E. mcmichaeli and E. arcata from the Florida panhandle and an E. complanata from the Delmarva peninsula.

Status. Vulnerable, Category 1. Elliptio waccamawensis is endemic to the Waccamaw drainage. A large waccamawensis population of unknown age structure exists throughout the lake. Mean habitat characteristics for it in the lake have been determined. In the lake, E. waccamawensis may be best adapted to the deep sand area. There the reproductive potential has not been investigated. However, in the northern shallow sand areas of the

lake, an area bordering high human density and where human disturbance is at its maximum, length and intensity of reproductive potential (percent gravid condition) and mean length of mussels in the population are significantly lower than that known present in the southern shallow sand area - an area of lower human disturbance. An additional factor, relating to the present ecological balance, which permits the mussel to dominate the lake naiad fauna, is the positive correlation between pH density values of E. waccamawensis. Previous authors have suggested that the pH of Lake Waccamaw is the one factor permitting a mussel fauna to exist in it. It has also been proposed here that the existence of E. waccamawensis in Waccamaw River is pH related and exists there in diminished importance with a patchy occurrence.

Rationale for Evaluation. Elliptio waccamawensis is the most common naiad in Lake Waccamaw. In it, as mentioned earlier, it has an average density throughout the lake of $22.79/m^2$. It is suggested that while the E. waccamawensis population seems in no danger of extinction because of the numbers of it present, if the hydrography of the lake were changed, possibly through increased drainage of the surrounding swamp areas, or other man-caused changes in environment of reported habitat and hydrological variables, the continued existence of this endemic species in the lake would be threatened.

It has been suggested that reproductive capability of the species was less in the northern portion of the lake than in the southern lake areas. This condition may be normal or may be an indication that the waccamawensis population is already under stress. Such stress would affect the continuing replacement of the species within its overall population.

Current Protection. Lake Waccamaw is somewhat protected as it has been designated a "Critical Habitat" because of the presence in it of Menidia extensa, the Waccamaw Silversides - See: Threatened status for Waccamaw Silversides - Lake Waccamaw is critical habitat. Federal Register, Vol. 52, No. 67, pp. 11277-11286, April 8, 1987.

Recommendations. The Lake Waccamaw E. waccamawensis population needs periodic re-examination determining densities and reproductive condition from known habitat populations. The latter is important as it is needed to determine whether or not the reproductive capability of this species is decreasing.

An annual or biannual hydrological and benthic sampling program of several representative locations should be initiated within this "Critical Habitat" designated lake. The purpose of this program would be to attempt to identify and monitor changes occurring in the lake that may or are affecting the "Vulnerable" status of the unreplaceable molluscan fauna in Lake Waccamaw. The annual results of such a program must be made available to the public and interested scientific community.

Acknowledgments. The author acknowledges Karen Horn Mault aided by Lorilyn Howie Kipphut, Glenn Safrit, Kathin Venger, Lisa L. Wood, and Rod Reish who assisted in the 1978-1981 Lake Waccamaw study; Mr. A. G. Gerberich, U. S. National Museum of Natural History for information and South Carolina collected specimens; and Dr. David H. Stansbery, Museum of

Zoology, Ohio State University for taxonomic advice. This research was supported jointly by the North Carolina Wildlife Resources Commission, Project Number: E-1, Study Number: VI, Job Number: VI-7 (Federal aid grant funds available under provision of the Federal Endangered Species Act of 1973) (1978-1981) and the University of North Carolina at Chapel Hill, Institute of Marine Sciences.

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Prepared by HUGH J. PORTER

Alasmidonta undulata (Say, 1817)
TRIANGLE FLOATER

Description. The shell of this species is generally small, ranging between 50 mm and 80 mm. It is ovate to triangulate-ovate in outline, valves generally inflated and thin, although thickened anteriorly. The anterior of the shell is broadly rounded, with the posterior rounded below the midline while generally flattened above. Its umbos are generally inflated and raised above the hinge line, and located anterior to the middle of the shell. The pseudocardinal teeth are stumpy, numbering one in the right valve and two in the left, the anterior one being larger. The lateral teeth are vestigal, sometimes completely absent. Its periostracum is smooth, yellowish with green or black rays in juveniles, and brown or black in adults. The nacre is glossy throughout, generally bluish white but sometimes tinged with pink or salmon. Detailed description and illustration of adults is provided by Johnson (1970); Clarke (1981) figures and describes both adults and glochidia.

Range. This species is broadly distributed along the Atlantic slope, being recorded from most river basins from the St. Lawrence River in Canada to the Apalachicola River in Florida. In North Carolina, it has been confirmed from piedmont and inner coastal plain sections of following river systems: Yadkin-Pee Dee, Cape Fear, Neuse, Tar, Roanoke, and Chowan. An old record from the Catawba River (Santee River system) also exists (Johnson 1970) but the collection station was not recorded and may have been outside the state.

Habitat. The triangle floater is absent from mainstem sections of rivers, occurring primarily in their smaller tributary streams. Available evidence indicates that this species eschews rapids or riffles and, in North Carolina, appears to be most common in slow moving water on substrates of muddy sand. In other areas, it has also been reported from gravel substrates, and in ponds and canals (Ortmann 1919). Common associates of this species are Elliptio complanata, Strophitus undulatus, Elliptio angustata, and Villosa constricta.

Life History and Ecology. Ortmann (1919) found gravid individuals essentially throughout the year (18 July through 14 June). Clarke (1981) found gravid individuals in August and October. No host fish has been recorded.

Special Significance. North Carolina has populations of two forms of the triangle floater (see Systematics, below). Should these forms prove to be separate species, North Carolina populations of each will need to be evaluated.

Type Locality. Delaware River (precise location unknown). Type material is lost. Clarke (1981) designated USNM 86249 from the upper Chattahoochee River, Georgia, as the lectotype.

Systematics. Due to its distinctive characters, systematic treatment of this taxon has been stable. It was originally described as Monodonta undulata (Say, 1817) and established as the type species for the genus.

The genus name was changed to Alasmidonta by Say the following year after he found the generic name Monodonta was preoccupied. This species has two distinct forms which appear to geographically determined; Alasmidonta "triangulata" Lea, 1858 in the south and Alasmidonta undulata (sensu stricto) in the north. These forms are distinguishable in both soft-part anatomy and shell characters. North Carolina is in the zone of intergradation and both forms have been found in the state (Fuller 1977). Clarke (1981) clearly defined the differences but did not consider them sufficient to elevate A. triangulata to species rank. However, allozyme analyses should be conducted to confirm his findings as many others (e.g. Simpson 1900, Stansbery 1971, Burch 1973, Heard 1975, Fuller 1977) have considered A. triangulata to be distinct.

Status. Vulnerable, Category 1.

Rationale for Evaluation. While this species is known from virtually every Atlantic slope river system in the state, its populations are decining and it is no longer known from many locales where it was formerly collected. The entire genus Alasmidonta is rapidly declining in the state and every species of that genus in the state is being recommended for protection. The causes of this decline are unknown but are assumed to reflect a widespread decline in water quality. Obviously, some aspect of the physiology or life history of the genus renders it especially susceptable to an ongoing habitat change, therefore all species within the genus are being similarly affected. The genus Lasmigona is displaying a similar trend.

Current Protection. None.

Recommendations. Surveys to locate population centers for this species should be conducted and, once located, they should be monitored for trends in growth, mortality rates, and reproductive success. Basic information on the autecology of the species should also be obtained. In addition, allozyme analyses of the northern and southern forms of the species should be conducted.

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Prepared by WILLIAM F. ADAMS

Alasmidonta varicosa (Lamarck, 1819)
BROOK FLOATER

Description. Alasmidonta varicosa is a fairly small sized naiad with a rhomboidal or subelliptical shape. The thin shell can reach a length of 65 to 70 mm long, with a height of 35 - 40 mm and a width of 25-30 mm. The anterior end is evenly rounded, but the posterior end is biangulate below and flatly curved above. The ventral margin can be straight, but is frequently arcuate, especially in older individuals. The posterior ridge is broad, somewhat inflated and round. There is a second faint ridge above and together the posterior ridges end in a biangulate margin. The posterior slope is flat to slightly concave, usually with numerous short, low corrugations radiating toward the posterior margin. The umbos are large, a little inflated, projecting little above the anterior margin and are directed anteriorly. The periostracum is yellowish or brownish with numerous dark green or black rays. Each valve has one small thin, triangular pseudocardinal tooth. Lateral teeth are vestigal or lacking. The nacre is glossy, bluish white, and grades into a pale orange in the umbo cavity. More detailed descriptions can be found in Ortmann (1919), Johnson (1970) or Clarke (1981).

Range. The brook floater is found mainly along the Atlantic Coast from Nova Scotia and New Brunswick south to South Carolina (Clarke 1981). It has also been found in the Greenbriar River (Ohio-Mississippi River drainage) of West Virginia. In general the brook floater is rare south of Virginia.

In North Carolina, A. varicosa has been collected from the Linville and Catawba Rivers (Cooper-Santee River system), the Uwharrie River (Yadkin River system), Brown Creek and Little River (Pee Dee River system), and the Haw River, Bear Creek and Rocky River (Cape Fear River system). In 401 collection sites examined in 208 different streams and rivers of the Catawba and Pee Dee River systems in North Carolina and South Carolina, A. varicosa was found at only three sites in North Carolina (Keferl, unpubl. data). The Linville River was the only place where a large viable population of the brook floater was found. Shelley (1987) records A. varicosa from 5 sites in the Haw River, Deep River, Rocky River and Bear Creek of the Cape Fear River system. According to Johnson (1970) the brook floater is somewhat rare south of the Potomac River and this certainly seems to be the case.

Habitat. According to Ortmann (1919), A. varicosa is most abundant in small streams with gravelly bottoms, and prefers strong currents; thus it is frequently found in and near riffles. Johnson (1970) states that the brook floater "lives among rocks on gravel substrates; also on sandy shoals, especially in rapids and riffles of small rivers and creeks". According to Fuller (1977) the characteristic habitat of the brook floater is the sand floors or gravel riffles of small, upland, rapidly flowing, oxygen-rich streams in upper portions of river systems. The largest population of A. varicosa I have observed in North Carolina was near the mouth of the Linville River. Most of the naiades collected or observed were found in a sandy or silty substrate in the cracks between medium to large boulders along a steep bank in 1 to 3 feet of water. The current

was relatively slow along this bank. The Linville River is a trout stream which now flows into Lake James, an impoundment of the Catawba River.

Life History and Ecology. Ortmann (1919) states that the breeding begins in August, the glochidia appear in September and overwinter. The glochidia can still be found in the marsupium in May. Discharge of the glochidia was observed by Ortmann on May 3. According to Clarke (1981) the fish host is unknown. Fuller (1977) states that fish host for Alasmidonta marginata Say, 1818, a closely related species in the Mississippi River system, are known, and they should serve as guides in establishing the fish host for A. varicosa.

Clarke (1981) states that A. varicosa is most frequently found associated with Elliptio complanata (Lightfoot, 1786) and less frequently, Strophitus undulatus (Say, 1817), Alasmidonata undulata (Say 1817) and in New England and Canada, Margaritifera margaritifera (Linnaeus, 1758). This species is a preferred food for muskrats in the Linville River, North Carolina.

Special Significance. I am not aware of any special significance of the brook floater.

Type Locality. According to Simpson (1914), the type locality for A. varicosa is the Schuykill River near Philadelphia, Pennsylvania. The holotype is in the Geneva Museum, Geneva, Switzerland.

Systematics. The brook floater was originally described as Unio varicosa Lamarck, 1819. It was placed in the genus Alasmidonta by Simpson (1914). Alasmodon corrugata DeKay, 1843 and Mya rugulosa Wood, 1856 are synonyms (Simpson, 1914).

Status. Vulnerable, Category 1.

Rationale for Evaluation. As stated earlier, A. varicosa is rare in North Carolina. I found it in three localities in 401 sites of the Catawba and Pee Dee River drainages. Shelley (1987) records it from just 5 localities in the Cape Fear River System. Clarke (1983) did not find it in the Tar River system and Walter (1954) did not find it in the Neuse River system. It is evident that the brook floater is rare and should be considered threatened in North Carolina.

Current Protection. The brook floater is not protected at this time, but it was listed by Fuller (1977) under special concern.

Recommendations. The distribution, ecology and life history of the brook floater should be carefully examined in North Carolina.

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Prepared by EUGENE P. KEFERL

Strophitus undulatus (Say, 1817)
SQUAWFOOT

Description. Shells of the squawfoot tend to be rather thin and fragile. Specimens may reach 90 to 100 mm in length in North Carolina. Of the ten specimens examined, the height to length ratio ranged from 0.60 to 0.62, and the width to length ratio ranged from 0.34 to 0.41. Shells tend to be smooth and shiny. The color may range from yellowish to dark brown. Green rays may extend over the entire surface of the shell. The anterior end is rounded and the posterior end is rounded also except a straight margin may exist near the terminus of the posterior ridge. The dorsal margin is straight with the umbos extending above this margin. The ventral margin is regularly rounded. Growth rests are clearly evident when the shell is held toward a bright light. The posterior slope tends to be roughened even on shells tending to be smooth. Lateral teeth are absent and the pseudocardinal teeth are vestigial in each valve. The nacre tends to be iridescent and ranges in color from gray to blue. The nacre may be extensively colored salmon.

Range. The squawfoot is both an Atlantic Slope and an Interior Basin species. It is found throughout the Mississippi and Ohio drainages from Central Texas to Lake Winnipeg, Canada. In the Atlantic Slope it occurs from the Savannah River in South Carolina to the St. Lawrence River in Canada (Johnson 1970). During recent surveys of the Catawba Drainage Basin, Keferl and Shelley (1988) found no shells or live individuals of the squawfoot. Numerous streams, creeks, rivers and other areas in the Pee Dee Drainage Basin in North Carolina were surveyed by Keferl and Shelley (1988); however, only eight live individuals and some shells were found in 10 creeks. In the Cape Fear Drainage Basin, Shelley (1987) states that the squawfoot has only been found in Chatham County. The squawfoot has recently been identified from several upper-Neuse River tributaries by Adams (unpubl. data) and by Alderman (unpubl. data). During recent surveys of the Tar River Drainage Basin, live individuals have been identified from only 10 of 93 survey stations (Alderman 1988).

Habitat. This species has been taken from silt, sand, gravel and mixed substrates. Throughout its range it has been found from headwater streams to large rivers and lakes to a depth of 4 meters (Gordon and Layzer 1989).

Life History and Ecology. This is a long-term breeder with gravid females being found throughout the year (Gordon and Layzer 1989). Hermaphroditic squawfoots have occasionally been found (van der Schalie 1970). Ellis and Keim (1918) identified the green sunfish (Lepomis cyanellus) as one fish host, and Baker (1928) identified the creek chub (Semotilus atromaculatus) and the largemouth bass (Micropterus salmoides) as other fish hosts.

Special Significance. This is the only species of Strophitus found in both the Interior Basin and Atlantic drainages.

Type Locality. No type locality was listed by Say; however, Johnson (1970) restricts the type locality to the Schuylkill River, Philadelphia County, Pennsylvania (near Philadelphia).

Status. Vulnerable, Category 1.

Rationale for Evaluation. In the Tar Drainage Basin, where extensive surveys have been conducted during recent years, fewer than 30 live squawfoot mussels have been found. This is a very low number considering that several thousand live mussels have been identified to species throughout the basin. Also, few signs of successful reproduction have been observed in the basin. Additionally, this species appears to have declined since Clarke (1983) completed his recent survey of the Tar from 1977 through 1982. In general, throughout its range in North Carolina, the squawfoot is a relatively rare mussel and there are few signs of successful reproduction.

Britton and Fuller (1979) only found one station in the vicinity of the Savannah River Plant with the squawfoot mussel. In the upper Potomac River, West Virginia, Taylor (1985) considered the squawfoot to be uncommon. He only found one live individual while surveying 13 stations in this area.

Although widespread in the Interior Basin, the squawfoot is now an uncommon species in some areas. For example, Ortmann (1918) considered the squawfoot to be abundant throughout the Clinch River; however, Ahlstedt (1984) found the species to be an extremely rare species in the upper Clinch River in Tennessee and Virginia and to be extirpated from the main channel of the river. It has also been extirpated from the main channel of the Tennessee River.

Both before 1979 and after the 1983 mussel die-off in the Powell River, Virginia and Tennessee, Ahlstedt and Jenkinson (1987) found no squawfoot mussels. Up to 30 mussel species were found in the Powell River during the survey periods.

In the upper Ohio River, West Virginia, Zeto et al. (1987) found significant mussel diversity around some of the Ohio River islands. Of 379 mussels found in the Greenup pool, only one fresh shell of the squawfoot was found (0.26% relative abundance). At five stations in the Belleville Pool in the Ohio River, only two fresh dead shells were found (0.18% relative abundance). Twenty-four species of mussels were found in the two pools.

In a survey of 229 miles of the upper Mississippi River from Prescott, Wisconsin to Dubuque, Iowa in 1977 through 1980, Thiel (1981) found that only 0.6% of the 2,663 brail runs conducted in the area produced squawfoot mussels. In fact, the majority of the areas surveyed produced no squawfoot mussels. Also, the squawfoot has delcined from 1.5% of the total catch in the early years of this century (Grier 1920) to 0.2% during Thiel's (1981) survey period around 1980.

In 1987, Miller (1988) surveyed pool 7 in the Mississippi River, Minnesota. (This area is part of Thiel's survey area.) Of 2087 mussels found representing 23 species, only one squawfoot was found.

In Missouri, Buchanan (1987) found the squawfoot to be a relatively uncommon species in the Bourbeuse and Meramec rivers soon after and about seven years after a mussel die-off. Only one mussel out of 2,250 mussels found during the survey of the Meramec River in 1978 was a squawfoot. No

squawfoot mussels were found during the 1986 survey which totaled 1999 mussels. In the Bourbeuse River during 1978, 29 of 1090 total mussels found during the survey were squawfoot mussels. In 1986, only 6 of 2113 mussels were squawfoot mussels.

Finally, it should be noted that there are many references to the squawfoot in the recent literature, relatively speaking. However, many of the references do not give a sense of the relative abundance of the squawfoot at a particular station. Therefore, we do not know if it is common or not at that location.

Current Protection. Little protection currently exists for this species in North Carolina. Some protection is extended to the population occurring in Swift Creek, a tributary of the Tar River which provides habitat for the Tar River spiny mussel. Measures used to protect the Tar River spiny mussel should also protect the squawfoot in this creek.

Recommendations. Additional research is needed to determine the cause of the apparent low reproductive success rate for this species. Considering that both of its known fish hosts are relatively common species, it is unlikely that fish host availability is the cause of the apparent unsuccessful reproduction or survival of the young.

Additionally, a range-wide survey may be needed to determine if this species needs expanded federal protection.

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Prepared by JOHN M. ALDERMAN

Toxolasma pullus (Conrad, 1838)
SAVANNAH LILLIPUT

Description. Toxolasma pullus has a small, oval or elliptical shell. A large specimen would be 30 to 35 mm long, with a height of 19-20 mm and a width of 15-16 mm. The shell is somewhat inflated. The shells are sexually dimorphic. The females have a broader more truncated posterior end, whereas the males have a narrower rounded posterior end and a point below the median line. The ventral margin is curved in males and straight in females. The posterior ridge is double, sometimes broadly rounded, but usually angular. The umbos are prominent. The perostracum is satiny and coarse because of the numerous closely spaced growth lines. The periostracum is most frequently blackish. Johnson (1970) reports that the periostracum is sometimes brownish, greenish or olivish and with obscure very fine green rays. The left valve has two triangular pseudocardinal teeth. The right valve has a fairly large triangular tooth. The nacre is bluish white with a pink to purplish iridescence at the posterior end.

Range. The range of the Savannah lilliput is from the Altamaha River System in Georgia to the Neuse River System in North Carolina (Johnson, 1970). In North Carolina, it has been recorded from the Catawba River drainage of the Cooper-Wateree-Santee River System, the New Hope River drainage of the Cape Fear River System and the Neuse River System (Johnson, 1967). Shelley (1987) recorded T. pullus from University Lake at Chapel Hill, Orange County and Rocky River, Chatham County. Gerberich (pers. comm.) found T. pullus in the Tar River and Porter and Horn (1980) from the Waccamaw River System. I found T. pullus in the Little River drainage of the Pee Dee River. In most cases the naiad is rare. According to Fuller (1977) the only thriving population in North Carolina occurred in University Lake, near Chapel Hill, Orange County.

Habitat. The Savannah lilliput lives in still shallow water near the banks of streams and ponds in mud or sand (Johnson, 1970). I have always found the Savannah lilliput near the shore in less than 6 inches of water usually in a sandy or silty sand substrate. They seem to exist in small colonies. They are easiest to find when the water is low and still dropping.

Life History and Ecology. Nothing is known about the life history of the Savannah lilliput.

Special Significance. The genus Toxolasma is distinctive because of the well-developed caruncle on the inner edge of each side of the mantle in front of the branchial opening. Toxolasma pullus is the only member of the genus along the mid-Atlantic slope and it is the smallest of the Atlantic slope naiades.

Type Locality. The type locality for Toxolasma pullus is the Wateree River, South Carolina (Johnson, 1970). Johnson also states that the type is lost.

Systematics. Toxolasma pullus was originally describes as Unio pullus by Conrad. The only synonym of T. pullus is Carunculina patrickae Bates,

1966. Johnson (1967) synonymized C. patrickae with C. pullus. The real debate concerning the name of the Savannah lilliput has been over the validity of the genus name Toxolasma. Rafinesque introduced the name Toxolasma in 1831 with Unio lividus as the type species. Carunculina was introduced as a subgenus in Lampsilis by Simpson (in Baker 1898). Frierson (1914) replaced the subgenus Carunculina Baker, 1898 with the subgenus Toxolasma Rafinesque, 1831 and stated that it should be a genus. Ortmann (1914) elevated Carunculina to generic rank. Ortmann (1919) used the genus Toxolasma and then Ortmann and Walker (1922) disregarded Toxolasma because the type species Unio lividus is a nomen dubium. Since that time researchers have used both Carunculina and Toxolasma. Stansbery (1976) states that the generic name Toxolasma is valid because U. lividus is identifiable from the original type. For additional background on this taxonomic problem see Johnson (1970) and Bogan and Parmalee (1983).

Status. Vulnerable, Category 1.

Rationale for Evaluation. Fuller (1977) stated that Carunculina (Toxolasma) pullus was rare and that was sufficient justification for considering it endangered. Since that time very few other populations of this species have been found. Keferl (1981) found it at a few sites in the Ohoopee River in the Altamaha River System and there probably several good populations elsewhere in that system. In North Carolina it is definitely a rare naiad. In a 1986-1987 survey (Keferl, unpublished) of the Catawba River System, Lynches River System, Saluda River System and Pee Dee River System in North Carolina and South Carolina, which included some 452 sites in 237 different creeks, streams and rivers, only two specimens of Toxolasma pullus were found in the Little River drainage of the Pee Dee River System. As Fuller (1977) concluded, this is a rare naiad. The Savannah lilliput should be considered threatened in North Carolina.

Current Protection. The Savannah lilliput is not under any protection at this time.

Recommendations. This species is particularly vulnerable because it lives very close to the shore. Many streams and rivers are receiving a lot more pressure by people riding ORV's (Off Road Vehicles) up and down river beds. These shoreline habitats are very easily disturbed. Surveys are needed to locate the widely scattered populations throughout the southeast. Once good viable populations are found, large sections of the river or stream around these populations will need to be protected. Putting the species on a list and giving it protection will not save the species. The delicate shoreline habitat will need to be protected and that may entail protecting an entire section of the stream or river.

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Prepared by EUGENE P. KEFERL

Villosa vanuxemensis (I. Lea, 1838)
MOUNTAIN CREEKSHELL

Description. The mountain creekshell reaches a length of 60 mm, a height of 36 mm and width of 24 mm. According to Simpson (1914) the shell is elliptical or irregularly obovate, somewhat inflated, with a poorly developed posterior ridge and low beaks. The male has a long elliptical shell and a moderately sharp point midway up the posterior margin. The female has a large prominent marsupial swelling at the base of the posterior margin and the shell is truncated from the base of the posterior margin to the point which is two-thirds up the margin. The periostracum is dull, varying from dirty tawny through olive to nearly black. There are two stumpy pseudocardinal teeth in the left and right valves. One of the pseudocardinal teeth in the right valve is vestigial. There are two curved lateral teeth in the left valve and one in the right valve. The nacre color varies from dirty purplish-white, salmon to dark purple.

Range. According to Simpson (1914), Villosa vanuxemensis is found in the Cumberland and Tennessee River systems and the upper Coosa River drainage. Starnes and Bogan (1988) recorded V. vanuxemensis from numerous drainages in the upper, middle and lower Tennessee River system. Starnes and Bogan (1988) also recorded this species from the Connasauga River in the upper Coosa River drainage. Dawley (1965) listed V. vanuxemensis from the Hiwassee River drainage. Starnes and Bogan (1988) also recorded V. vanuxemensis from the Hiwassee River drainage and the French Broad River drainage since 1960. Both the Hiwassee River and French Broad River drainages include North Carolina. It was not listed from the Little Tennessee River, a third drainage which includes North Carolina.

Habitat. The mountain creekshell has been recorded from all sizes of rivers, streams and creeks. Van der Schalie (1938) recorded Micromya vanuxemensis from the Cahaba River drainage in a creek, a medium-sized river and a large river. Van der Schalie (1981) recorded M. vanuxemensis from mostly creeks in the upper Coosa River drainage. Even though some of the general conditions have been recorded for streams and creeks that contained V. vanuxemensis (Neves and Zale 1982, Starnes and Bogan 1982), the specific habitat has not been described.

Life History and Ecology. Neves, Weaver and Zale (1985) found that gravid females could be found in Big Moccasin Creek, Russell County, Virginia in spring and fall. They also found that glochidia from V. vanuxemensis would encyst and metamorphose on three species of sculpin (Cottus baileyi, C. bairdi and C. cognatus).

Special Significance. The mountain creekshell does not have any apparent special significance.

Type Locality. The type locality for Unio vanuxemensis Lea, 1838 is the Cumberland River, Tennessee (Lea 1838). The holotype is USNM 85146 (Hurd, 1974).

Systematics. Unio vanuxemensis has been placed in the genus Micromya by numerous 20th century investigators. Hurd (1974) discusses why

Micromya cannot be used. Frierson (1927) put this species in the genus Lampsilis and the subgenus Villosa. There are numerous synonyms for V. vanuxemensis. Frierson (1927) gives the most complete list of synonyms for this species.

Status. Vulnerable, Category 1.

Rationale for Evaluation. Since the mountain creekshell appears to be restricted to the French Broad River and Hiwassee River drainages in North Carolina, the species is vulnerable. The mountain creekshell should be considered threatened in North Carolina.

Current Protection. The mountain creekshell does not currently receive any federal or North Carolina protection. Linzey (1978) includes V. vanuxemensis on a list of endangered species in Virginia.

Recommendations. As mentioned previously, it is important to survey all the Tennessee system drainages in North Carolina. The results of that survey should satisfy any doubts about the abundance or distribution of this species in North Carolina.

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Prepared by EUGENE P. KEFERL

Lampsilis cariosa (Say, 1817)
YELLOW LAMPMUSSEL

Description. The periostracum is smooth, shiny, and usually yellow with some brownish freckling or patches on some surface areas. Rays may be present - usually on the posterior slope but may extend toward the anterior end resulting in over half the shell being rayed. Females are obovate or subovate resulting in a rather short high shape. Males are elongate and elliptical. Shells may reach 130 mm in length (Johnson 1970); however, during recent surveys in North Carolina, shells ranged from 35 to 87 mm in length for live L. cariosa (Alderman 1988; Alderman, unpubl. data). The nacre is usually white to bluish white.

L. cariosa can be easily confused with L. ochracea. However, a reliable distinguishing characteristic for L. cariosa is the presence of a narrow interdentum between the lateral and pseudocardinal teeth - a feature absent in L. ochracea shells. Additional descriptive information is available in Johnson (1947, 1970).

Britton and Fuller (1979) and Fuller and Bereza (1974) add that a distinguishing characteristic of female yellow lampmussels is the development of the mantle, anterior to a large darkly pigmented "eyespot," into a strongly developed flap of tissue on each mantle lobe. Also, the ventral margin of the marsupium is darkly pigmented (Britton and Fuller 1979).

Morrison (1975) believed that L. ochracea belonged in the genus Leptodea because females have no mantle flaps as in yellow lampmussels.

Range. The yellow lampmussel is found from the lower Ottawa River, Canada eastward to the Sydney River, Nova Scotia then south to the Ogeechee River Drainage Basin in Georgia (Johnson 1970). At one time this species probably ranged throughout most of the Atlantic drainages in North Carolina; however, historical records provided by Johnson (1970) come from the Cooper-Santee, Waccamaw, Cape Fear, Neuse, Pamlico, and Chowan drainages.

In a recent survey for Lasmigona decorata and Alasmidonta robusta in the Cooper-Santee and Pee Dee drainages, Keferl and Shelley (1988) found no live individuals or shells of L. cariosa in North Carolina.

Shelley (1987) identifies the Haw and Deep Rivers in the upper Cape Fear as sites producing L. cariosa. Recent evidence indicates that L. cariosa is no longer present in this area; however, a large nonreproducing Lampsilis sp. can be found in some areas of the upper Cape Fear (Adams, pers. comm.). Johnson (1970) examined a specimen of L. cariosa from the Cape Fear in Cumberland County; however, no recent surveys have been undertaken to verify its continued existence in that area of the river.

Specimens from the Neuse River Drainage Basin examined by Johnson (1970) came from the Eno River in Durham County and from the Neuse River and Swift Creek in Wake County. Surveys were conducted by Alderman during 1988 and 1989 in Neuse River tributaries. Lampsilis cariosa specimens were found in the South Flat River in Person County, the Flat River in Durham County, the Little River in Durham County, and the Little River in Johnston County.

Within the Tar River Drainage Basin, approximately 40 live yellow lampmussels have been found at 17 stations from around Tarboro upriver to the headwaters in Person County and in Swift and Fishing Creeks (Alderman

1988; Alderman, unpubl. data). It is undetermined whether this species has declined significantly within the basin since Clarke (1983) completed his surveys for the Tar River spiny mussel from 1977-1982.

Records from the Roanoke and Chowan rivers in North Carolina are unknown at this time.

Habitat. The yellow lampmussel exists in many different habitats; however, it appears to slightly prefer the shifting sands in relatively fast flowing, medium sized rivers and medium to large creeks. Although never common at any station in North Carolina, it is not unusual to find an individual yellow lampmussel in shifting gravel/coarse sand substrates or in gravel/cobble habitats. In fact, this species is a relatively good indicator of the potential presence of *Elliptio steinstansana*, a species which prefers gravel/coarse sand habitats in the Tar River Drainage Basin.

Life History and Ecology. Ortmann (1919) believes that the yellow lampmussel is bradytictic. This belief is supported from findings of gravid females from June, July, and September in the Tar River (Alderman 1988). Limited survey activity has been completed in the Tar River during August; however, it can be assumed that gravid females are present during August. Additionally, gravid females were found in the Flat River, Durham County in late September and in the Tar River, Edgecombe County in mid-October (Alderman, unpubl. data). Richard Tankersley (1988) examined the glochidia of a gravid female taken from the Tar River in Granville County around the beginning of July. The glochidia are typical of many other *Lampsilis* species' glochidia when comparisons are made with figures provided by Coker et al. (1921). Johnson (1947) believes that the host for *L. cariosa* may be the alewife or other migratory fish. This may be true for some populations of this mussel species, but there must also be freshwater host(s) since the yellow lampmussel is found in isolated creeks and rivers in the Neuse and Tar Drainage Basins.

In the Tar and Neuse river drainages, the yellow lampmussel can be found associated with virtually every other mussel species found in those basins as long as some sand, gravel, or cobble habitat is available in the area. In general, if other rare species such as *Alasmidonta undulata*, *Alasmidonta heterodon*, *Strophitus undulatus*, *Elliptio lanceolata*, *Lasmigona subviridis*, *Elliptio steinstansana*, *Lampsilis radiata* or *Fusconaia masoni* are present at a station, the yellow lampmussel will often be present there also.

Special Significance. Most of the eight species in the genus *Lampsilis* are declining throughout North Carolina. For unknown reasons, entire genera of freshwater mussels are declining throughout their ranges - some more than others. In the case of the yellow lampmussel, only larger individuals have been found as a result of recent surveys. Even in muskrat middens, only adults have been found throughout their range in the Tar and upper Neuse drainages. Before the species becomes extirpated throughout much of its range in North Carolina, we need to know why it is failing to reproduce successfully. It may be found that the yellow lampmussel is one of the more sensitive aquatic species affected by acid precipitation.

Type Locality. Schuylkill River, near Philadelphia, Pennsylvania. The original type was lost; however, the neotype is at Harvard University (MCZ 178839) and is a female (Johnson 1947).

Status. Vulnerable, Category 1.

Rationale for Evaluation. Because reproduction is not evident in this species in North Carolina, we can anticipate a major decline in its range in this state.

Current Protection. None. However, better stewardship of drainages providing habitat for listed endangered species (such as the Tar River spiny mussel) will also provide a degree of protection for the yellow lampmussel.

Recommendations. The host for this species is unknown. There is a need to determine the host species and develop a better understanding of the yellow lampmussel's present range and status in North Carolina. Also, as with the other rare mussel species, there is a need to monitor the yellow lampmussel's populations regularly. Additionally, a better understanding of the species' biology and ecology will provide insight into why successful reproduction is not present in this species.

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Prepared by JOHN M. ALDERMAN

Lampsilis fullerkati R. I. Johnson, 1984
WACCAMAW FATMUCKET

Description. The shell of Lampsilis fullerkati is elliptical and moderately inflated. Shape of males is somewhat similar to that of Elliptio waccamawensis but with the posterior ridge not as angular as on waccamawensis; the female fullerkati is broadly rounded posteriorly. Exteriorly the periostracum is medium to dark brown with the posterior third tending to yellow with green rays. There is a double-looped beak sculpture on the umbo. Nacre color on the inner shell surface is pink-lavender in varying shades of brightness. The pseudo-cardinal teeth on the hinge are pyramidal.

No difference in obesity (shell width/length) was noted between male and female L. fullerkati (Horn and Porter 1981).

A difference in the shell shape variable "height-length ratio" of female L. fullerkati from Waccamaw River and from Lake Waccamaw was suggested - a higher ratio being present in the river specimens than in the lake specimens; river data was insufficient for significant comparison (Horn and Porter 1981).

The marsupium of the female has a dark margin and occupies only the posterior half of the outer demibranch. A small postbasal mantle flap is on mantle margin slightly anterior of incurrent siphon (branchial aperture) of the female. On the inner mantle margin of both male and female, mantle papillae extend anteriorly beyond the branchial papillae for about 1/5th the length of the ventral mantle margin.

The rays and lessened sharp angular ridge on the posterior shell slope of L. fullerkati help separate it from E. waccamawensis (the latter generally is without rays on its posterior surface). Internally, several mantle differences between the species are observable. The branchial aperture in waccamawensis seems compressed into a semi-tubelike structure, this convolution (which can be noted without magnification) has not been noted in L. fullerkati. Further, the mantle papillae near but slightly anterior of the branchial aperture of L. fullerkati are not present on the mantle margin of waccamawensis. These papillae may not be as strongly developed on male L. fullerkati as on female L. fullerkati. The postbasal mantle flap present in female L. fullerkati is not present on E. waccamawensis. Soft part anatomy of fullerkati is further described in Kat (1983).

Largest L. fullerkati specimens in the UNC-IMS (University of North Carolina, Institute of Marine Sciences mollusk collection) are: Lake Waccamaw: male - length = 61, height = 32, width = 22 mm (UNC-IMS #10183; length = 70, height = 40, width = 23 mm (UNC-IMS uncatalogued). female - length = 54, height = 33, width = 21 mm (UNC-IMS #10270); length = 62, height = 35, width = 24 mm (UNC-IMS uncatalogued). Waccamaw River (North Carolina): female - length = 61, height = 35, width = 24 mm (UNC-IMS #8550). Waccamaw River (South Carolina): male - length = 31, height = 20, width = 13 mm (UNC-IMS #8592).

The original Johnson (1984) description is as follows: "Shell small, seldom exceeding 60 mm in length. Outline elongated rhomboidal to long elliptical. Valves subinflated, thin, inequilateral. Anterior end regularly rounded; posterior end slightly biangulate and pointed toward the base in the male; female broadly rounded and somewhat expanded in the postbasal region. Ventral margin straight, slightly curved, or

occasionally arcuate roughly parallel to the almost straight dorsal margin which forms an angle with, or merges imperceptibly with the obliquely descending margin. Posterior ridge high somewhat angular, usually with a faint second ridge above it ending behind in a broad point in the male. Umbos rather sharp but not full or high, located in the anterior quarter of the shell, their sculpture not observed. Periostracum rather smooth with delicate growth lines, generally yellowish or brownish green, with rather fine dark greenish rays of varying width often visible over the entire surface.

Left valve with two stumpy pseudocardinal teeth, one in front of the other, often of almost equal height. Hinge line short and narrow, two short almost straight lateral teeth. Right valve with one triangular pseudocardinal, and a vestigial one before it; one lateral tooth. Beak cavities very shallow, with a few dorsal muscle scars. Anterior and posterior adductor muscle scars and pallial line distinct. Nacre purplish often lurid and spotted, somewhat iridescent."

Glochidia have valves that are bilaterally symmetrical, hookless and purse shaped. There are eye spots near the ventral border. The hinge line is straight with the umbos extending slightly above the hinge line giving this line sometimes a false convex appearance. Dimensions, as reported in Porter and Horn (1980) (under Lampsilis sp.) are: length = 0.222 mm; height = 0.276 mm; hinge length = 0.120 mm; hinge length/length ratio = 0.76; height/length ratio = 1.24; and hinge length/height ratio = 0.44. Separation of glochidia of this species from the very similar glochidia of Leptodea ochracea and Lampsilis crocata can be accomplished through comparison of their hinge lengths and the following ratios: hinge length/length, hinge length/height. Lampsilis crocata is the largest in all three of the above data categories, Lampsilis fullerkati is intermediate in data range, and Leptodea ochracea has the smallest values.

Range. Non-North Carolina: Species is not known outside of Waccamaw River. One specimen was collected by this project (in non-North Carolina waters) near Longs, South Carolina in the Waccamaw River by Porter and Horn (1984) (UNC-IMS #8592).

North Carolina - Non-Lake Waccamaw or Waccamaw Drainage Area: Species is not known outside of the Waccamaw drainage area.

North Carolina - Lake Waccamaw and Drainage Area: Previous published accounts include: Fuller (1977), (1978 -lists lower Waccamaw River as recorded in an unpublished manuscript); Fuller, et al. (1976 - Lake Waccamaw) (Fuller accounts record the species as one of the Lampsilis radiata group); Porter and Horn (1980); and Horn and Porter (1981); Kat 1983); Porter and Horn (1983) (Porter accounts record the species as Lampsilis sp.); Johnson (1984); Porter and Horn (1984) - Waccamaw River (UNC-IMS #8550). UNC-IMS Lake Waccamaw catalogued specimens and lots include (incomplete): #3309, 8547, 8561, 9089, 9100, 9872, 9874, 9833, 10116, 10119, 10123, 10133, 10138, 10183-10199, 10253, 10254, 10257, 10259, 10262, 10266, 10270-10272, 10276, 10283, 11009, 11109, and 11121.

Habitat. Average density of Lampsilis fullerkati in the lake was 1.6 m^2 - note 75% of the samples did not contain the species. Only E. waccamawensis and L. ochracea had higher average naiad densities in the lake than this species. The Deep Sand region had the highest density, whereas, the lowest density was in the Shallow Sand Region.

The average depth of L. fullerkati in Lake Waccamaw was significantly deeper than the average depth of all 1978-1981 Lake Waccamaw samples (Porter, 1985) (the latter, because of sampling design, was assumed to be an average for the lake). Average habitat depth for this naiad was 2.07 m with a range of 0.4-3.5 m (average lake depth = 1.72 m).

All other physical data from L. fullerkati samples in the above study were not significantly different from average physical values collected from the lake. Average physical values of Lake Waccamaw samples containing this naiad were (Porter, 1985):

% saturated dissolved oxygen = 81.9 (range = 13-132%); sediment total chlorophyll a (uncorrected) = 5.25 (range = 1.99-10.83); sediment total chlorophyll a (corrected) = 3.25 (range = 0.00-5.66); sediment pheo-pigments = 2.01 (range = -0.27-4.56); ph = 6.49 (range = 6.1-7.4); % sediment organic matter = 4.49 (range = 0.00-35.21); % >sediment carbonate matter = 0.76 (range = 0.00-4.28); graphic mean sediment size = 2.01 Ø units (range = 0.88-3.93) (fine sand according to Folk, 1974); sediment inclusive graphic standard deviation = 0.76 (range = 0.35-1.66) (moderately sorted sand - note Folk, 1974); sediment graphic skewness = -0.10 (range = -0.57-0.52) (fine-skewed sand - note Folk, 1974); and sediment graphic kurtosis = 1.10 (range = 0.63-1.93) (platykurtic sand - note Folk, 1974).

Life History and Ecology. There is no indication that the species has a density related to a vegetated type in Lake Waccamaw (Porter, 1985).

A strong positive correlation was found to exist between densities of this species and of E. waccamawensis (Porter, 1985). Both species similarly had a non-homogenous distribution throughout the regions of the lake.

A highly significant correlation between obesity (shell width/length) of fullerkati and percent organic matter (in sediment of Lake Waccamaw habitat). In other words, L. fullerkati from habitats having a high organic content in their sediment were more obese than L. fullerkati from habitats with sediments of low organic content Horn and Porter (1981).

Reproduction. This species is a typical lampsilid bradytictic (slow term or winter) breeder (Porter 1985, Porter and Horn 1983). Evidence of breeding condition (female gills containing a swollen marsupia) by this lampsilid were observed in Lake Waccamaw waters during the 1979-1981 investigative period (Porter 1985): April, June 1979; March, June, September, December 1980. Tedla and Fernando (1969) discussing the breeding cycles of Lampsilis radiata radiata and Lampsilis radiata siliquioides found that marsupial condition began in August and continued into the following June or July when spawning occurred; spawning time was variable and possibly extending from spring into summer. The September initiation of breeding in L. fullerkati (September) is earlier than the December beginning by L. ochracea (Porter and Horn 1983). Host fish for glochidia of this species are not known.

Special Significance. Lampsilis fullerkati is part of the endemic molluscan assemblage of Lake Waccamaw which contains four other endemic mollusks. The lake with its 21+ mollusk species is one of the most species rich lakes in the Western Hemisphere. The molluscan fauna of the lake generally is not known to occur commonly anywhere else in North

Carolina. Further, Lake Waccamaw and Orton Pond are the only lakes on the North Carolina coastal plain known to be able to support a unionid fauna.

Type Locality. Lake Waccamaw, North Carolina.

Systematics. The systematic problems of this species were first documented by Fuller (1977). The Lake Waccamaw form, which he then referred to as the 'Lampsilis' radiata Gmelin) complex, he believed different from a complex living in nearby Orton's Pond. A major difference was the reduced sexual dimorphism present in the Orton's Pond population vs. the striking sexual dimorphism present in the Lake Waccamaw population. In 1978, Fuller, following Johnson (1970), seemed to suggest that the name 'Lampsilis' radiata "splendida" was appropriate. Fuller realized at least two problems inherent with this belief: 1st. - The genus did not fit this group so he planned to give a new genus name for the group. 2nd. "Morphological variation within the complex is such that it is impossible to ascertain, accurately and with certainty, the relationships between biological entities and the extent (and potential) taxa that have been (and will be) applied to them." In other words, Fuller was still not certain if the coastal area contained at present one or more (closely related) distinct species resembling Lampsilis radiata splendida.

Johnson (1970) contains no reference to a Lampsilis of the radiata or closely related species from the Waccamaw drainage. Shells of Lampsilis sp., sent at Johnson's request, were subsequently identified as E. waccamawensis (pers. comm., 1981).

Kat (1983) compared L. fullerkati (=Lampsilis sp.) with Lampsilis radiata and Lampsilis splendida and found that Lampsilis sp. had more colored rays on its mantle edge which was thus darker than the mantle edge of L. radiata. Little other mantle or stomach differences were noted between the two species. Kat went to considerable length explaining why Lampsilis sp. (fullerkati) and L. radiata with their dissimilar shell shapes and their close biochemical similarity, are two good separate species. It was suggested that Lampsilis sp. diverged from L. radiata about 1.3×10^5 years ago, a time consistent with estimated age of Lake Waccamaw.

Johnson (1984) recognized the Lake Waccamaw Lampsilis sp. as a new species and named it. In his comparison of it with Lampsilis radiata radiata (Gmelin), fullerkati was described as "more diminutive" and with a "more delicate shell, a consistently sharp posterior ridge, and purplish nacre" than present with L. r. radiata. Lampsilis splendida (Lea) was stated to range between Georgia and South Carolina and not overlap either L. r. radiata or fullerkati. L. splendida was stated to have umbos that were "higher, fuller and more centrally located" than located on fullerkati.

Status. Vulnerable, Category 1.

Rationale for Evaluation. The total estimated Lake Waccamaw L. fullerkati population (based on an average density of 1.6 per m^2 and a 36,000 hm lake area) was believed to be approximately 57.6 million specimens during the 1979-1981 study period of Porter (1985). The species was thus considered the third most common naiad found in the lake.

However, juvenile recruitment to the population at that time seemed low. No ecological factors were noted that would account for the non-random distribution of this species seen throughout the lake. The large numbers present only in the lake suggest that fullerkati is highly adapted to living only under habitat or ecological variables present only in Lake Waccamaw waters.

Fuller (1977) previously suggested an "endangered" status for this species.

The habitat variables within which this species exists in Lake Waccamaw are documented herein. Outside the lake, these variables or their combination may not exist. If unknown of these restricted habitat and hydrological variables were changed within the lake, the continuing existence of this endemic species may be threatened.

Current Protection. Lake Waccamaw is somewhat protected as it has been designated a "Critical Habitat" because of the presence in it of Menidia extensa, the Waccamaw Silversides - See: Threatened status for Waccamaw Silversides - Lake Waccamaw is critical habitat. Federal Register, Vol. 52, No. 67, pp. 11277-11286, April 8, 1987.

Recommendations. The Lake Waccamaw L. fullerkati population needs periodic re-examination determining densities and reproductive condition from known habitat populations. Reproductive capabilities are not known and need to followed to determine if they are increasing or decreasing.

An annual or biannual hydrological and benthic sampling program of several representative locations should be initiated within this "Critical Habitat" designated lake. The purpose of this program would be to attempt to identify and monitor changes occurring in the lake that may or are affecting the "Vulnerable" status of the unreplaceable molluscan fauna in Lake Waccamaw. The annual results of such a program must be made available to the public and interested scientific community.

Acknowledgments. The author acknowledges Karen Horn Mault aided by Lorilyn Howie Kipphut, Glenn Safrit, Kathin Venger, Lisa L. Wood, and Rod Reish who assisted in the 1978-1981 Lake Waccamaw study; Mr. S. L. H. Fuller, for unpublished range information; and Dr. David H. Stansbery, Museum of Zoology, Ohio State University for taxonomic advice. This research was supported jointly by the North Carolina Wildlife Resources Commission, Project Number: E-1, Study Number: VI, Job Number: VI-7 (Federal aid grant funds available under provision of the Federal Endangered Species Act of 1973) (1978-1981) and the University of North Carolina at Chapel Hill, Institute of Marine Sciences.

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Prepared by HUGH J. PORTER

Cincinnatia sp.
WACCAMAW SILTSNAIL

Description. Members of this genus typically are small, have a simple conical shell, a simple complete peristome, are lacking umbilical or apertural shell modifications, and have protruding necular whorls (Thompson, 1968). The shell is translucent, dextral and very thin. Whorls and aperture are rounded with whorls gradually increasing in size. A paucispiral operculum is present. Approximate maximum shell length and width are: 2.5 and 1.8 mm.

Characteristics which help differentiate this species from Amnicola sp. in Lake Waccamaw are the protruding nuclear whorls, a width/length ratio of about 0.72 (in Amnicola sp. this ratio is about 0.90), and a paucispiral operculum.

Further differences between Amnicola and Cincinnatia genera include: nuclear whorls and radulae of Amnicola are larger than those of Cincinnatia; the verg of Cincinnatia has glandular processes whereas the verg of Amnicola does not have theses processes (Thompson, 1968).

This species is expected to be formally named and described by Dr. Fred Thompson, Florida State Museum during 1990 (pers. comm., Feb. 1990, F. Thompson).

Range. This hydrobid has been found only in Lake Waccamaw, NC and in Big Creek, a small stream flowing into Lake Waccamaw and there only near the NC Wildlife Resources boat-landing ramp (UNC-IMS (University of North Carolina, Institute of Marine Sciences mollusk collection) #10478). Catalogued UNC-IMS specimens and lots from Lake Waccamaw are: #8604, 10740-10748, 10839-10848, 11000, 11010, 11020, 11029, 11037, 11044, 11048, 11052, 11059, 11066, 11070, 11073, 11079, 11085, 11088, 11097, 11101, and 11107.

Habitat. During the period 1978-1981 this Cincinnatia species had an average density in Lake Waccamaw of 273.3/m^2 with densities ranging between 0.0 and 8141.7/m^2; 29.2% of samples did not contain this hydrobid. Density was noted to be significantly higher in 1979 than it was in 1980, no reason for this difference was indicated (Porter, 1985).

Highest densities of this snail were found in the near-shore shallow waters where mean values of "% sediment organic matter", "sediment inclusive graphic standard deviation", and "sediment graphic skewness" were lower than mean values for the total lake. The shallow sand region had highest density (431.1/m^2), whereas, the peat region of the lake had the lowest density (37.6/m^2). Density within the lake was also found to be negatively correlated with pH (Porter, 1985).

The following mean (average) physical characteristics were present where Cincinnatia occurred (Porter, 1985):

% saturated dissolved oxygen = 90.7 (range = 45-132%); sediment total chlorophyll a (uncorrected) = 4.32 (range = 0.00-14.97); sediment total chlorophyll a (corrected) = 3.54 (range = 0.00-34.70); sediment pheo-pigments = 1.90 (range = -4.99-34.36); ph = 6.89 (range = 5.1-7.5); % sediment organic matter = 2.18 (range = 0.00-4.28); %

sediment carbonate matter = 0.57 (range = 0.00-4.28); graphic mean sediment size = 2.03 Ø units (range = 0.46-3.93) (fine sand according to Folk, 1974); sediment inclusive graphic standard deviation = 0.72 (range = 0.24-1.66) (moderately sorted sand - note Folk, 1974); sediment graphic skewness = -0.15 (range = -0.66-0.52) (near-symmetrical sand - note Folk, 1974); and sediment graphic kurtosis = 1.11 (range = 0.58-2.05) (nearly symmetrical sand - note Folk, 1974). Percent sediment organic matter, sediment inclusive graphic standard deviation and sediment graphic skewness mean values were significantly less that mean values for the whole lake.

Life History and Ecology. Cincinnatia sp. densities were higher where the emergent plants maidencane, Panicum hemitomon, and spatterdock, Nuphar luteum sagittifolium, were present than where these plants were not present. A positive correlation was present between densities of this hydrobid and the hydrobid Amnicola sp. and the planorbid snail Helisoma trivolvis (Porter, 1985).

Reproduction. Note the single reference for this section in the species account for Amnicola sp. There is little known about reproductive strategies of this genus.

Special Significance. Cincinnatia sp. is part of the endemic molluscan assemblage of Lake Waccamaw which contains at least four other endemic mollusks. The lake with its 21+ mollusk species is one of the most species rich lakes in the Western Hemisphere. The molluscan fauna of the lake generally is not known to occur commonly anywhere else in North Carolina. Further, Lake Waccamaw and Orton Pond are the only lakes on the North Carolina coastal plain known to be able to support a unionid fauna.

Type Locality. Lake Waccamaw, North Carolina is presumed to be the type locality when the species is named.

Systematics. Part of the difficulty in describing hydrobid snails has been that much of the hydrobid taxonomy is based upon reproductive characteristics of the snails. Such characteristics have been difficult to observe in collected lots of this species. Note Berry (1943) in regards to difficulties present in preparing hydrobids of such observations. The latter being one of the reasons why this hydrobid has not been formally named.

Status. Vulnerable, Category 2.

Rationale for Evaluation. The habitat variables within which this species exists in Lake Waccamaw are documented herein. Outside the lake, these variables or their combination may not exist. If unknown of these restricted habitat and hydrological variables were changed within the lake, the continuing existence of this endemic species may be threatened.

Current Protection. Lake Waccamaw is somewhat protected as it has been designated a "Critical Habitat" because of the presence in it of Menidia extensa, the Waccamaw Silversides - See: Threatened status for

Waccamaw Silversides - Lake Waccamaw is critical habitat. Federal Register, Vol. 52, No. 67, pp. 11277-11286, April 8, 1987.

Recommendations. An annual or biannual hydrological and benthic sampling program of several representative locations should be initiated within this "Critical Habitat" designated lake. The purpose of this program would be to attempt to identify and monitor changes occurring in the lake that may or are affecting the "Vulnerable" status of the unreplaceable molluscan fauna in Lake Waccamaw. The annual results of such a program must be made available to the public and interested scientific community.

Acknowledgments. The author acknowledges Karen Horn Mault aided by Lorilyn Howie Kipphut, Glenn Safrit, Kathin Venger, Lisa L. Wood, and Rod Reish who assisted in the 1978-1981 Lake Waccamaw study; and Dr. Fred Thompson, Florida State Museum for taxonomic advice. This research was supported jointly by the North Carolina Wildlife Resources Commission, Project Number: E-1, Study Number: VI, Job Number: VI-7 (Federal aid grant funds available under provision of the Federal Endangered Species Act of 1973) (1978-1981) and the University of North Carolina at Chapel Hill, Institute of Marine Sciences.

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Prepared by HUGH J. PORTER

Amnicola sp.
WACCAMAW AMNICOLA

Description. The shell of this hydrobid is minute to moderately small, dextral, globose, thin, and translucent. A conspicuous umbilical perforation is one-sixth to one-tenth the diameter of the shell. The spire is flattened with subsequent whorls abruptly increasing in size. A multispiral operculum is present. Approximate maximum shell length and width is: 2.8 and 2.5 mm.

Characteristics which differentiate this species from Cincinnatia sp. in Lake Waccamaw are the flattened non-protruding nuclear whorls, a width/length ratio of about 0.90 (in Cincinnatia sp. this ratio is about 0.72), and a multispiral operculum.

Further differences between Amnicola and Cincinnatia genera include: nuclear whorls and radulae of Amnicola are larger than those of Cincinnatia; the verg of Cincinnatia has glandular processes whereas the verg of Amnicola does not have theses processes (Thompson 1968).

This species is expected to be formally named and described by Dr. Fred Thompson, Florida State Museum during 1990 (pers. comm., Feb. 1990, F. Thompson).

Range. Non-North Carolina: Fuller (1979) has suggested that this hydrobid may be in the lower Waccamaw basin in South Carolina.

North Carolina - Non-Waccamaw drainage: This species has not been found in any non Lake Waccamaw drainage waters.

North Carolina - Waccamaw drainage: Lyogyrus dalli Pilsbry, recorded by Dawley (1965) from Lake Waccamaw waters is believed to be this Amnicola sp. This species has been collected from Big Creek, a tributary flowing into Lake Waccamaw, only from near the NC Wildlife Resources boat-landing ramp (UNC-IMS (University of North Carolina, Institute of Marine Sciences mollusk collection) #19477). Catalogued UNC-IMS specimens and lots from Lake Waccamaw are: #8603, 9878, 10720-10738, 11006, 11015, 11021, 11024, 11032, 11036, 11042, 11043, 11047, 11050, 11057, 11063, 11064, 11068, 11072, 11078, 11084, 11093, 11096, 11099, 11106, 11112, 11125, and 11131.

Habitat. During the period 1978-1981 (Porter 1985) this Amnicola species had an average density in Lake Waccamaw of 305.2/m^2 with densities ranging between 0.0 and 4566.7/m^2; only 18.9% of samples did not contain this hydrobid. Density was noted to be significantly higher in 1979 than it was in 1980, no reason for this difference was indicated.

Highest Lake Waccamaw densities of this snail were found in the southeast intermediate depth sand region (745.8/m^2), the area with the lowest density (66.7/m^2) was the south peat area. Low densities seem to run in a band starting in the southwest shallow sand region, into the southwest intermediate sand, south and north peat, east deep sand and ending the the northwest-northeast shallow sand area. As noted above, one high density population was found existing in Big Creek (Porter, 1985).

Density in Lake Waccamaw was significantly correlated with depth and negatively correlated (5% level only) with light penetration. Density of Amnicola was uncorrelated with changes in sediment characteristics including total Chlorophylls, pH, % organic matter, and % carbonate in the lake. Thus, the following mean (average) physical characteristics of the lake are considered as optimal for the species (Porter, 1985):

% saturated dissolved oxygen = 87.8 (range = 13-132%); sediment total chlorophyll a (uncorrected) = 4.40 (range = 0.14-14.97); sediment total chlorophyll a (corrected) = 3.39 (range = 0.33-34.70); sediment pheo-pigments = 1.81 (range = -3.26-34.36); ph = 6.90 (range = 5.1-7.4); % sediment organic matter = 3.39 (range = 0.00-35.21); % sediment carbonate matter = 0.74 (range = 0.00-5.78); graphic mean sediment size = 2.02 Ø units (range = 0.99-3.93) (fine sand according to Folk, 1974); sediment inclusive graphic standard deviation = 0.77 (range = 0.24-1.66) (moderately sorted sand - note Folk, 1974); sediment graphic skewness = -0.12 (range = -0.66-0.52) (near-symmetrical sand - note Folk, 1974); and sediment graphic kurtosis = 1.11 (range = 0.58-2.05) (mesokurtic sand - note Folk, 1974).

Life History and Ecology. Baker (1928) and Thompson (1968) indicate that both *Amnicola* and *Cincinnatia* sps. are frequently found on submerged vegetation in quiet waters of streams, rivers, and lakes. Substrates listed were from rocky to fine silt, however, species of these genera did not seem to be habitat restricted.

Amnicola limosa (Say) in McCargo Lake (western New York) has been extensively studied by Horst and Costa (1975). These *Amnicola* had a seasonal migration being concentrated in shallow waters during summer months and then concentrated in deep waters during winter months. This migration was related to temperature of the water at the sediment interface and seasonal variation in the hydrophyte community. The *Amnicola* had two periods of high mortality - just following hatching and during the post reproductive period. Some individual *Amnicola* survived through two winters.

Berry (1943) reports that *Amnicola* feed on algae supported by aquatic vascular plants.

Amnicola limosa porata (Say) egg capsules have been described by Baker (1928); capsules similar to these have been seen frequently on Lake Waccamaw snails. Horst and Costa (1975) found egg capsules of *A. limosa* only in shallow waters where they were laid on vegetation.

Amnicola sp. densities in Lake Waccamaw vegetative zones were generally lower, not significantly, than *Amnicola* sp. densities from non-vegetative areas. Similarly, where the submergent plant *Najas quadalugensis* occurred, *Amnicola* densities were significantly less than densities where the plant was not present. However, *Amnicola* sp. densities from areas of an unknown plant community were higher than densities from other vegetative or non-vegetative areas. The latter was due to a sample from Big Creek which flows into Lake Waccamaw (Porter, 1985).

No clear pattern of association between *Amnicola* and other Lake Waccamaw mollusks has been noted except for a possible one between it and the closely related *Cincinnatia* sp.

Reproduction. Baker (1928) records capsules of *Amnicola limosa* being present between April and August (location not mentioned). Little else seems known about reproductive strategies of this genus.

Special Significance. *Amnicola* sp. is part of the molluscan assemblage of Lake Waccamaw which contains at least four other endemic mollusks. The lake with its 21+ mollusk species is one of the most

species rich lakes in the Western Hemisphere. The molluscan fauna of the lake generally is not known to occur commonly anywhere else in North Carolina. Further, Lake Waccamaw and Orton Pond are the only lakes on the North Carolina coastal plain known to be able to support a diverse molluscan fauna.

Type Locality. Lake Waccamaw, North Carolina is presumed to be the type locality when this species is named.

Systematics. The gastropod family Hydrobiidae, which includes the genus Amnicola, is taxonomically a difficult, confused group. It has many forms, now considered endemic, that may eventually be synonymized into only a few species.

Lyogyrus dalli Pilsbry listed by Dawley (1965 from Lake Waccamaw) is probably a wrong identification. Thompson (1968) discussing Amnicola dalli dalli (Pilsbry and Beecher) (= L. dalli Pilsbry), lists the distribution of it as only Florida and there it is confined to spring-related waters. The Thompson figure of A. dalli dalli does look very similar to the Lake Waccamaw Amnicola. sp. but is considerably larger than the Waccamaw Amnicola.

It has been suggested by Thompson (pers. comm.) that a second, also undescribed Amnicola species, might be present in Lake Waccamaw waters. Amnicola lots from the 1978-1981 Waccamaw survey (Porter, 1985) frequently contain a form considerably larger than typical Amnicola sp. specimens from the lake. It has not yet been determined if these are a continuing growth phase of the Waccamaw Amnicola sp. or a different species.

Part of the difficulty in describing hydrobid snails has been that much of the hydrobid taxonomy is based upon reproductive characteristics of the snails. Such characteristics have been difficult to observe in collected lots of this species. Note Berry (1943) in regards to difficulties present in preparing hydrobids of such observations. This is one of the reasons this hydrobid has not been formally named.

Status. Vulnerable, Category 2.

Rationale for Evaluation. Of all molluscan species living in Lake Waccamaw waters, this species is there in the highest densities. The habitat variables within which this species exists in Lake Waccamaw are documented herein. Outside the lake, these variables or their combination may not exist. If unknown of these restricted habitat and hydrological variables were changed within the lake, the continuing existence of this endemic species may be threatened.

Current Protection. Lake Waccamaw is somewhat protected as it has been designated a "Critical Habitat" because of the presence in it of Menidia extensa, the Waccamaw Silversides - See: Threatened status for Waccamaw Silversides - Lake Waccamaw is critical habitat. Federal Register, Vol. 52, No. 67, pp. 11277-11286, April 8, 1987.

Recommendations. An annual or biannual hydrological and benthic sampling program of several representative locations should be initiated within this "Critical Habitat" designated lake. The purpose of this program would be to attempt to identify and monitor changes occurring in

the lake that may or are affecting the "Vulnerable" status of the unreplaceable molluscan fauna in Lake Waccamaw. The annual results of such a program must be made available to the public and interested scientific community.

Acknowledgments. The author acknowledges Karen Horn Mault aided by Lorilyn Howie Kipphut, Glenn Safrit, Kathin Venger, Lisa L. Wood, and Rod Reish who assisted in the 1978-1981 Lake Waccamaw study; and Dr. Fred Thompson, Florida State Museum for taxonomic advice. This research was supported jointly by the North Carolina Wildlife Resources Commission, Project Number: E-1, Study Number: VI, Job Number: VI-7 (Federal aid grant funds available under provision of the Federal Endangered Species Act of 1973) (1978-1981) and the University of North Carolina at Chapel Hill, Institute of Marine Sciences.

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Prepared by HUGH J. PORTER

Ferrissia hendersoni (Walker 1908)
BLACKWATER ANCYLID

Description. This is a small, light horn-colored limpet with a thin and delicate shell. It is long-oval in outline, slightly wider anteriorly, the right side nearly straight and the left side straight to slightly rounded. Its apex is very obtuse, slightly deflected to the right, and clearly marked with radial striae. It is fully described and figured by Walker (1908), Walter (1954), and Basch (1963).

Range. The range of this taxon is unknown. It may be a North Carolina endemic as it has been recorded only from Lake Waccamaw in Columbus County (Walker 1908), Lake Singletary in Bladen County (Basch 1963), various locales in the upper Neuse River basin (Walter 1954), and undisclosed locations in Carteret and Guilford Counties (Dawley 1965). Basch (1963) could not locate it at the type locality at Lake Waccamaw and attributed the loss of that population to lakeside development. He did find it living abundantly at Lake Singletary, a locale which has recently been reconfirmed (W. F. Adams, unpubl. data).

Habitat. This taxon was first collected by J. B. Henderson and G. W. H. Soelner in the fall of 1906 from "pools in the swampy woods around the shore of Lake Waccamaw" (Walker 1908). Walter (1954) located it primarily on leaf litter in slow moving waters of moderate depth and circumneutral pH. C. R. Wilson and I found it on stems of aquatic plants in the low pH waters of the outfall canal at Lake Singletary in 1987. Water depths at the site ranged from .5 m to 1 m, and the bottom was organic. Due to natural water level fluctuations, much of the shoreline area of Lake Singletary offers only temporary habitat.

Life History and Ecology. Nothing specific is known of the life history or ecology of this taxon. Like other Ancylidae, it is a pulmonate with a vestigial lung. A secondary gill-like structure called a pseudobranch has evolved to perform respiration. Most Ancylidae are hermaphroditic, although in some populations the male genatalia are absent. In such populations, sperm production takes place in the ovotestis and cross-fertilization is impossible.

Special Significance. This species can survive in low pH waters which other mollusks find inhospitable. No other species of mollusks are known from the acid waters of Lake Singletary. How this taxon has adapted to these conditions is unknown.

Type Locality. Lake Waccamaw, Columbus County, North Carolina. Walker (1908) described this taxon from specimens provided by J. B. Henderson and G. W. H. Soelner.

Systematics. Poor systematic treatment of this taxon in the past has engendered understandable confusion today. Walker (1908) described the taxon and named it Ancylus (Ferrissia) hendersoni, in honor of John B. Henderson. In 1918, Walker reviewed North American limpet snail systematics and determined that this taxon should be placed in the genus Ferrissia Walker 1903. Why, during his description of the taxon, he did

not recognize it as a member of a genus which he had established 5 years earlier is unclear. After his 1918 revision, Walker (1925) reemployed the name Ancylus hendersoni, applying it to a species collected from Eldora Lake, Colorado, by Junius Henderson. Today we can only speculate why this was done. Apparently he either believed that, as a result of his revision, the species' name hendersoni within the genus Ancylus was unoccupied or else he simply forgot that the name had previously been used. Junius Henderson (1930) recognized the confusion which could result and, in conformance with established rules of zoological nomenclature, resolved the conflict by renaming the Colorado species Ancylus coloradensis. In spite of Henderson's efforts, nomenclatural confusion shadows this taxon to this day.

In his landmark monograph on North American limpet snails, Basch (1963) expressed reservations that Ferrissia hendersoni (Walker 1908) was distinct and referred to it as a variety of Ferrissia fragilis (Tryon 1863). Turgeon et al. (1988) retained full species rank for the taxon; however, its description was incorrectly ascribed to Walker 1925.

Status. Vulnerable, Category 2.

Rationale for Evaluation. This taxon is apparently a North Carolina endemic and, in recent years, has been found in only one locality. Neither Walter's (1954) or Dawley's (1965) collection sites have been reconfirmed in recent years and, given the development which has taken place in these areas since their records, its distribution has almost certainly diminished. Given its restricted range and the development which has occurred within it, prudence dictates that it be considered vulnerable.

Current Protection. None.

Recommendations. Surveys should be conducted in attempts to reconfirm historic locations and locate additional populations for the species.

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Prepared by WILLIAM F. ADAMS

Elliptio dilatata (Rafinesque, 1820)
SPIKE

Description. The spike is a large, elongate, dark-chocolate brown freshwater mussel. Maximum shell length is around 100 mm in the Little Tennessee River, North Carolina. Height to length ratios range from 0.45 to 0.53 and the width to length ratios range from 0.25 to 0.31 for eleven specimens examined. The posterior ridge is well rounded and close to the dorsal margin. Both the anterior and posterior ends are rounded. In younger individuals, the periostracum is a lighter tan color with narrow green rays extending over the entire surface. In the right valve, the more posterior pseudocardinal tooth is large and prominent; while, the more anterior pseudocardinal tooth is vestigial. The lateral tooth in the right valve is large and prominent especially toward the posterior end. Both pseudocardinal teeth and the two lateral teeth are prominent in the left valve. The anterior adductor muscle scars are well impressed; however, the posterior adductor muscle scars are present but less impressed. The pallial line is distinct. The color of the nacre is a rich deep purple.

Range. As described by Burch (1973), the spike has an extensive range throughout the entire Mississippi Drainage Basin and extends into the St. Lawrence Drainage Basin and into the Alabama Drainage Basin in Florida and into Texas in the Guadalupe Drainage Basin. In North Carolina, an extant population is only known from the lower Little Tennessee River between Franklin and Fontana Reservoir.

Habitat. In the Little Tennessee River, specimens have been taken from most substrate types - sand, gravel, and mixed sand/gravel/cobble. The spike is found in small to large rivers where it may be locally common (Ahlstedt 1984; Gordon and Layzer 1989). Other biologists have also found the spike in various substrates down to about 3 m depths (Ortmann 1919; Baker 1928; Parmalee 1967). Specimens from the Indian River, Michigan occurred in greatest densities in 2.5 cm gravel bottoms with currents between 0.40 and 0.54 meters per second; however, in a laboratory setting the spike showed no substrate preferences (Huehner 1987). From Huehner's work, it appears that water velocity is a more important habitat requirement for the spike than substrate type. Strayer (1981) also found that the spike as well as 20 other freshwater mussel species in small Michigan streams occupied a wide range of microhabitats.

Life History and Ecology. Ortmann (1919) considers the spike to be a short-term (tachytictic) breeder. Gravid females have been found from April through September. On occasion, the spike may be hermaphroditic (Van der Schalie 1970). Wilson (1916) identified gizzard shad (Dorosoma cepedianum) as one fish host for the spike. Additionally, Howard (1914) identified flathead catfish (Pylodictis olivaris), white crappie (Pomoxis annularis), and black crappie (Pomoxis nigromaculatus) as fish hosts. Each of these species is found in the Little Tennessee River in North Carolina.

Special Significance. As discussed for the slippershell mussel, the spike is part of a mussel community which is North Carolina's best extant example of the Mississippi Drainage Basin's diverse mussel assemblage.

Type Locality. Kentucky River, Kentucky.

Status. Vulnerable, Category 2.

Rationale for Evaluation. Although common throughout most of its range, in North Carolina the spike only occurs in a relatively short stretch of the Little Tennessee River above Fontana Reservoir. The spike is not a reservoir species; therefore, the population in the Little Tennessee River is isolated from other local populations.

Current Protection. As with the other endangered, threatened, and special concern mussel species found in North Carolina's lower Little Tennessee River, there is a certain degree of protection provided since they are found in spotfin chub critical habitat. The spotfin chub is listed as threatened by the U.S. Fish & Wildlife Service.

Recommendations. Recommendations suggested for the slippershell mussel apply for the spike. Additionally, for all the species found in North Carolina's Little Tennessee River, an effort should be developed to establish another viable community in the French Broad River. Records exist documenting the presence of most of these species in the French Broad River.

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Prepared by JOHN M. ALDERMAN

Elliptio folliculata (I. Lea, 1838) (Lake Waccamaw form)
POD LANCE

Description. This is a narrow, uninflated, elongated naiad that in its lake form resembles a straight-edged razor. The umbo is flat and the dorsal and ventral shell margins are parallel to each other. The anterior-dorsal margin is angular in shape. The shell is covered by a rough dark-brown to black periostracum. The shell nacre of inner shell surface varies from bluish to pink. The hinge has pyramidal pseudo-cardinal teeth. As in all Elliptio species, the cream colored marsupium of the female extends along the ventral margin of the entire outer demibranch.

The several UNC-IMS (University of North Carolina, Institute of Marine Sciences mollusk collection) specimens of this species from Big Creek and upper Waccamaw River (just below the Lake Waccamaw dam) are similar in shape to UNC-IMS Lake Waccamaw specimens. However, specimens believed of the species, collected from the mid and lower areas of the Waccamaw River and from the canal draining out of Orton Pond, are larger with height and width measurements proportional greater than length measurements of Lake Waccamaw specimens.

Largest specimens in the UNC-IMS collection have the following measurements: Lake Waccamaw - length 83, height 27, width 13 mm (UNC-IMS #3458.1); Waccamaw River - length 105, height 38, width 23 mm (8589.1); and Orton Pond canal - length 116, height 44, width 26 mm (UNC-IMS uncatalogued); Savannah River, GA - length 71, height 27, width 17 mm (UNC-IMS uncatalogued) (unpublished UNC-IMS data).

The original description by Lea (1838) is as follows: "Shell narrow-elliptical, very transverse, very inequilateral, behind subbiangular, before rounded, flattened at the side; valves rather thin; beaks scarcely prominent; epidermis dark brown; cardinal teeth small; lateral teeth long and somewhat curved; nacre purple and iridescent.

.....

Shell narrow-elliptical, very transverse, very inequilateral, subbiangular behind, rounded before, rather compressed, flattened at the side; substance of the shell rather thin; beaks scarcely prominent; ligament long and curved; epidermis very dark brown; cardinal teeth small and lobed; lateral teeth long and somewhat curved; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices in the center of the cavity of the beaks; cavity of the shell small; cavity of the beak very small; nacre purple and iridescent."

Given measurements in the above Lea description were: "Diam. = 0.5 (13 mm), Length = 0.8 (20 mm), Breadth = 2.4 (61 mm)."

Papillae on the branchial aperture of E. folliculata are similar to those in other Elliptio sps. as there are few mantle papillae following the posterior branchial papillae on the inner mantle margin (Porter, 1985). There are no known gross anatomical characteristics that would help in distinguishing E. folliculata from other Elliptio species.

Glochidia of this species were not seen in collected specimens of the 1987-1981 survey (Porter, 1985). They are believed to be similar in shape and size to glochidia of Elliptio waccamawensis (Porter and Horn, 1980). Host fish for these glochidia are unknown.

Range. Non-North Carolina: The type of this species is recorded from Savannah River, Georgia. Simpson (1914), who synonymizes U. attenuatus, U. exacutus, and U. rostellum with E. folliculata, lists only a Georgia distribution. Both Davis et al. (1981) and Johnson (1984) record the type locality - Savannah River, Georgia. Live specimens were collected near the GA Route #119 crossing of the Savannah River in June, 1988 during a field trip participated in by this author and others (one specimen donated to the UNC-IMS collection - note acknowledgments).

A specimen of E. exacutus (note above synonymy) (E. exactus, a lapsus calami) is recorded from South Carolina by Lea in 1872 (according to Johnson, 1970); an E. folliculata labeled specimen, CMSC #43.28.4709, collected from Wateree, Clarendon County, South Carolina was found and viewed at the Charleston Museum, Charleston, SC by this author.

The species has additionally been collected in the Waccamaw River near Brookville, South Carolina (crossing of SC Route #9) (Porter and Horn, 1984) (UNC-IMS# 8789.1-8589.5).

North Carolina - Non-Lake Waccamaw area: Morrison (pers. comm., 1971) listed North Carolina collected specimens of folliculata (existing in the U.S. National Museum) from: Sprunt's Pond (collector: P. Bartsch, Aug. 20, 1934) (Sprunt's Pond is probably Orton Pond), Livingston Creek (Lea Collection - Unio perlatus), and the outlet to Orton Pond (Morrison collected specimens (examples are believed to be in the Ohio State Museum of Natural History as other naiads from the Morrison Orton Pond collection have been viewed by this author in that collection)). Forms believed to be this species were collected from an Orton Pond canal in July, 1986 by Kurt Wright and this author (UNC-IMS# 19463.1-19463.16).

The above Livingston Creek and Orton Pond localities are in the Cape Fear River drainage system. Morrison (1972) stated that E. folliculata was living sympatrically in the Cape Fear River system with other Elliptio species. Fuller (1972a) discussed a Cape Fear River E. lanceolata, Elliptio arctata (Conrad, 1834) complex, which may be this species.

North Carolina - Lake Waccamaw and Drainage Area: The species folliculata has been previously recorded from Lake Waccamaw and associated waters by: Dawley (1965 (listed as E. perlatus Lea)); Jennewein (1971); Morrison (1972); Fuller (1977 (listed as Elliptio sp. - "WACCAMAW LANCE")); Porter and Horn (1980); Davis et al. (1981); Johnson (1984); and Porter (1985). The species has been collected in Big Creek near the NC Wildlife Resources boat ramp, and in Waccamaw River (just below the dam - UNC-IMS #8551 and uncatalogued) (Porter and Horn, 1984). UNC-IMS catalogued specimens and lots from Lake Waccamaw include (incomplete): #3301, 8548, 8560, 9096, 9102, 9871, 10032-10035, 10049, 10129, 10176, and 10177.

Habitat. Average depth of E. folliculata in Lake Waccamaw, where it occurred, was 2.24 m; this is greater than the average lake depth of all samples collected during the 1978-1981 survey. Habitat depth ranged between 1.4-3.0 m in the lake.

Sediment inclusive graphic standard deviation values from samples of this naiad in Lake Waccamaw were significantly less than mean values for all samples taken in the lake (mean for folliculata was 0.58 (moderately well-sorted sediment - Folk, 1984); mean for the lake was 0.74. All other physical data from samples containing E. folliculata was not significantly

different from average total lake data. Average physical values of all Lake Waccamaw samples containing this naiad were (Porter, 1985):

% saturated dissolved oxygen = 76.8 (range = 60-104%); sediment total chlorophyll a (uncorrected and corrected) and pheo-pigments = insufficient data; ph = 7.05 (range = 6.4-7.3); % sediment organic matter = 1.37 (range = 0.00-3.53); % sediment carbonate matter = 0.56 (range = 0.00-3.39); graphic mean sediment size = 2.07 Ø units (range = 1.78-2.52) (fine sand according to Folk, 1974); sediment graphic skewness = -0.12 (range = -0.32-0.06) (near-symmetrical sand - note Folk, 1974); and sediment graphic kurtosis = 1.05 (range = 0.66-1.19) (platykurtic sand - note Folk, 1974).

Average density of E. folliculata found in Lake Waccamaw during the 1978-1981 study (Porter, 1985) was 0.09 per m^2 with a maximum density of 3.2 per m^2 from the East Intermediate Sand subregion. Because of the unusual razor-like shape, the large size of it, and because a significant proportion of it projects out of the habitat substrate of it, the species may seem more common that it really is - note that 97.3% of the Lake Waccamaw samples did not contain the species. Distribution in the lake seems primarily in the Intermediate and Deep Sand regions.

Generally the species was found in a sand substrate at greater than one meter depths in Lake Waccamaw waters (Porter, 1985). Davis et al. (1981) were only partly correct when they suggested that it was found in "sandy-bottom shallows". Specimens from Big Creek and Waccamaw River were collected in conditions similar to that from Lake Waccamaw except that some downstream Waccamaw River specimens were extracted from a clay bank in a semi-swift flowing river segment. On the other hand, the Orton Pond canal habitat was a muddy high-sided bank with considerable vegetation near by in sluggishly moving water (unpublished author data).

No dominant plant community was noted associated with the species in Lake Waccamaw (Porter, 1985). Fuller (1977) stated that this species was "especially common in slightly muddy sand among submerged vascular plants," - no association in the lake like this was noted but this comes close to the Orton Pond canal habitat where a large growth form of folliculata occurred.

Life History and Ecology. There seemed in the 1978-1981 Lake Waccamaw study (Porter, 1985) to be no relation or clustering of this naiad to other mollusca in the lake. No growth or other ecological studies are known relating to this species.

The species is easily found or seen as it typically is found perpendicular to its substrate with a considerable portion of the posterior half extending above the substrate. Examples found in the Waccamaw River near S.C. Route 9 crossing, where a noticeable water current is present, were embedded partly in hard clay burrows.

Reproduction. This species, like most Elliptio sp., is believed to be tachytictic (short-term breeder). Of the few specimens collected in Lake Waccamaw waters during the 1978-1981 sampling period (Porter, 1985), gravid conditions were seen only in June, 1980 and August, 1980. Since then, gravid specimens have been collected in July (1986) from a canal exiting Orton Pond, Brunswick County, North Carolina by this author and K. Wright (UNC-IMS #'s 19463.2-19463.6 - unpublished data).

Special Significance. This E. folliculata form is part of the endemic molluscan assemblage of Lake Waccamaw which contains at least four other endemic mollusks. The lake with its 21+ mollusk species is one of the most species rich lakes in the Western Hemisphere. The molluscan fauna of the lake generally is not known to occur anywhere else in North Carolina. Further, Lake Waccamaw and Orton Pond are the only lakes on the North Carolina coastal plain known to be able to support a unionid fauna.

Type Locality. Savannah River, Georgia (Lea, 1838). Figured holotype is USNM #85861 in the U. S. National Museum of Natural History (Johnson, 1970). An uncatalogued topotype is in the UNC-IMS collection.

Systematics. The species status of this naiad has and may still be confused. The scientific name used here, Elliptio folliculata, is the accepted name by this author, Morrison (pers. comm., 1971), Stansbery (pers. comm., 1979-1981), Davis et al. (1981), Stansbery and Borror (1983), Davis (1984), Johnson (1984) and most recently Turgeon et al. (1988).

The species is closely related to Elliptio shepardiana (Lea, 1834) (Davis, 1984) but as Lea (1838) points out, it (folliculata) "is by no means as transverse a species" (as shepardiana is). The latter, restricted to the Altamaha River system in Georgia (Johnson, 1970) is considerably longer and narrower than folliculata gets to be.

Johnson (1970) synonymized E. folliculata, U. attenuatus, U. exacutus, and U. rostellum under E. lanceolata. In 1984, he (Johnson, 1984) recognized that E. folliculata was a distinct species.

Fuller (1977) listed this species in Lake Waccamaw as Elliptio sp. but recognized that it belonged "conchologically" to the E. lanceolata group or complex where it may be confused with its members. He believed that in this group the Lake Waccamaw population is probably a morphologically and genetically unique entity.

Morrison (pers. comm, 1971) synonymized specimens of Unio perlatus (USNM #86008; including the figured holotype of U. perlatus Lea collected from Livingston Creek) with E. folliculata (Livingston Creek is only a few miles from Lake Waccamaw but drains into the Cape Fear River). Of two specimens labeled E. folliculata in the U.S. National Museum (USNM#514903 - from Sprunt's Pond (Orton Plantation Pond also draining into the Cape Fear River)), one is conchologically similar and of a similar size to E. folliculata from Lake Waccamaw; the other, a larger specimen, has a shape approaching that of the U. perlatus Lea of Livingston Creek. Specimens collected by Morrison at the outlet to Orton Pond and called E. folliculata (Morrison, pers. comm. 1971) could not be located in the USNM (Rosewater, pers. comm.; 1982) and thus their descriptive identity could not be substantiated. Specimens from the latter collection may be in the Ohio State Museum of Natural History as naiads from a July, 1971 Morrison Orton Pond collection have been viewed there by this author. This species may have again been collected from an Orton Pond canal in July, 1986 by Kurt Wright and this author (UNC-IMS# 19463.1-19163.16).

A labeled E. folliculata specimen in the Charleston Museum in Charleston, SC (CMSC #43.28.4709) and collected from Wateree, South Carolina, is more similar to the U. perlatus than to the Lake Waccamaw E. folliculata shape. The Dawley (1965) record of E. perlatus in Lake Waccamaw (MZUM) was not seen and thus can not be commented on.

Johnson (1970) stated that U. perlatus was a synonym of Elliptio arcata (Conrad, 1834) which exists mainly in the Cape Fear River drainage but also from the Catawba and Savannah River drainages. But in 1972, Fuller (1972a) suggested that Johnson did not have enough evidence to separate Cape Fear E. arcata (=U. perlatus) from E. lanceolata. Then in 1984, Johnson (1984) suggested that Davis and Fuller were probably correct in calling E. perlatus a synonym of E. folliculata.

An early comparison of holotype material of U. perlatus (USNM #86008) and the Sprunt's Pond specimen (USNM#515903) with Lake Waccamaw E. folliculata specimens (UNC-IMS specimens) suggested at least one possible difference between the two forms - Lake Waccamaw E. folliculata had parallel dorsal and ventral margins whereas the dorsal and ventral margins of the Cape Fear drainage U. perlatus were not parallel but had their greatest shell height near the posterior third of the shell.

An additional difference may relate to the presence of a longitudinal rib on the marsupium of E. lanceolata (syn. = U. perlatus) from the Cape Fear region (Fuller, 1972b). A less developed, but similar, feature was stated present on E. lanceolata from the Patuxent River in Maryland. This feature, so far, has not been noted in E. folliculata from Lake Waccamaw, or forms of it from Big Creek, or Waccamaw River.

Little morphometric variability has been seen between specimens of E. folliculata collected in Lake Waccamaw and its nearby waters. One specimen from Big Creek, similar in size and shape to Lake Waccamaw specimens, differed slightly by having a light brown and rayed periostracal color, whereas, Lake Waccamaw specimens are unrayed and dark brown in color.

Elliptio folliculata collected in Waccamaw River just below the dam are morphologically similar to those in the lake.

Specimens believed to be E. folliculata and found downstream near the crossing of SC Route # 9, about 30 miles SSW of the Lake Waccamaw dam, are larger and not as narrow in shape as those from Lake Waccamaw. This former shape is reminiscent of that of Unio perstriatus Lea, 1852 - Savannah River drainage (synonym of Elliptio arctata Conrad, 1834) as figured in Johnson (1970). Further, as mentioned above under 'Range, North Carolina, Non-Lake Waccamaw', a recent collection, believed of folliculata, was taken in 1986 from a canal exiting Orton Pond by this author and Kurt Wright. These, in shape, were also larger, not as narrow as material from Lake Waccamaw, and resembled that taken from the SC Route 9 crossing of Waccamaw River (note above). The shape of the Orton Pond examples varied between the Waccamaw River shape and that of E. perlatus.

Morphometric data of folliculata specimens in the UNC-IMS collection has been re-examined. Shell measurement data (in mm) presented below includes a mean value ($\bar{x}$) and a $\bar{x} \pm 2$ (S.E.) (standard error) value for each of the following measurements: Shell length (maximum length taken perpendicular to hinge axis), height (maximum height between lines running parallel to hinge axis), width (maximum width of both valves along a line running perpendicular to shell axis), rib-height (taken perpendicular to hinge axis and from top of lateral hinge tooth to ventral shell edge), and rib-length (from anterior side of pseudocardinal to posterior edge of lateral hinge teeth).

COLLECTION LOCATION	SHELL LENGTH	HEIGHT	WIDTH	RIB-HEIGHT	RIB-LENGTH
Lake Waccamaw (21 specimens)	68.4 65.1-71.7	23.2 21.6-24.6	12.8 10.9-14.7	19.9 18.6-21.2	35.6 33.9-37.3
Waccamaw River (5 specimens)	100.4 97.3-103.5	35.2 31.0-39.4	21.3 19.7-22.9	32.6 30.7-34.4	57.0 54.0-60.0
Orton Pond Canal (16 specimens)	93.4 88.8-98.0	36.2 34.5-37.9	20.4 19.0-21.8	31.2 29.4-33.0	49.1 46.3-51.9
Savannah River (1 specimen)	71	27	17	23	40

South Carolina Route 9 Waccamaw River and Orton Pond folliculata form specimens are not significantly different from each other but both are significantly larger than the folliculata from Lake Waccamaw. If this data is presented in ratio form, the results are more complex: Shell height/length and width/height ratio values are similar from all three collection sites, rib-height/length ratios from the Waccamaw River and Orton Pond areas are significantly larger than those from Lake Waccamaw, etc. More data is needed before this data is more than just suggestive in importance.

Davis (1984) used allozyme analyses "to assess the molecular genetic relationships among 39 populations (North American - east coast) representing 25+ species of unionid clams." Four of his populations address the above folliculata problem; these are: E. folliculata from Lake Waccamaw; an unknown Elliptio from the Savannah River (his Fig. 1-B strongly resembles the Lea (1838) type figure (Pl. XI Vol. 6 #33), UNC-IMS E. folliculata from the Savannah River, and some UNC-IMS specimens from the Waccamaw River and Orton Pond canal); an unknown Elliptio from Ochmulgee River drainage in Georgia (its Fig. 1-G also resembles some UNC-IMS specimens from the Waccamaw River and Orton Pond canal); and E. shepardiana from Ochmulgee River, Georgia. Davis found that while the Lake Waccamaw folliculata is part of the clade involving E. shepardiana and the above two unknown Elliptio forms, it must be considered separate from them as it does not group closely with shepardiana and these two unknown Elliptio sps. He implies that Lake Waccamaw folliculata is a species separate from the two or three species the two unknown Elliptio forms and shepardiana represent. Davis does acknowledge that conchologically the Savannah River Elliptio is the closest of the shepardiana group to E. folliculata of Lake Waccamaw.

The UNC-IMS data and the Davis (1984) results suggest that: 1) Elliptio folliculata from Lake Waccamaw, while related with a group of Elliptio shepardiana species, is distinct from these other species and may be endemic to Lake Waccamaw; 2) The river form of folliculata, as found in downstream Waccamaw River and Cape Fear drainage waters (including Orton Pond canal) may be the E. folliculata that Lea described from the Savannah

River and which is still to be found in that river; 3) If the above is proven to be true, than the naiad called folliculata from Lake Waccamaw needs to be given a new species name.

Davis (1984) suggests that it is highly probable that the Lake Waccamaw folliculata form "arose from a lineage ancestral to E. mcmichaeli and E. crassidens."

Status. Vulnerable, Category 2. Stansbery (1971) was the first to list Elliptio folliculata as a "rare and endangered species"; Heard (1975), later, did not include it in his endangered status report - this may have been since the Heard listing is based on Johnson (1970) concepts which did not recognize E. folliculata as a separate species. Fuller (1977) (as Elliptio sp.) recommended that in North Carolina waters this species be given a "threatened" but quite likely an "endangered" status.

Rationale for Evaluation. The Elliptio folliculata form in Lake Waccamaw quite possibly is an endemic species of the upper Waccamaw drainage. In there it is found only in low density. No juveniles of it were seen in the lake during the 1978-1981 sampling.

This naiad, because of its unusual razor shape and it habit of having a significant proportion of its posterior end sticking above its substrate, is very vulnerable to shell collectors and other interested amateur or professional naturalists.

The Porter (1985) study documented habitat variables within which the species exists in Lake Waccamaw. Outside the lake, these variables or their combination may not exist. If unknown of these restricted habitat and hydrological variables were changed within the lake, the continuing existence of this species may be threatened.

Current Protection. Lake Waccamaw is somewhat protected as it has been designated a "Critical Habitat" status because of the presence in it of Menidia extensa, the Waccamaw Silversides - See: Threatened status for Waccamaw Silversides - Lake Waccamaw is critical habitat. Federal Register, Vol. 52, No. 67, pp. 11277-11286, April 8, 1987.

Recommendations. More study is needed on the systematics of this form and its taxonomic closeness to the folliculata forms from the Waccamaw River, Cape Fear and Savannah River drainages. The Lake Waccamaw E. folliculata form population needs periodic re-examination determining its continued presence, general density, and chonchological size of specimens within it (possibly including growth ring counts). Such observations should be done from known habitat populations in the field and done with minimal damage to living specimens by returning examined specimens to their habitat. This author would suggest a moratorium to collection of living specimens of this species within the lake, Big Creek, and the upper Waccamaw River.

An annual or biannual hydrological and benthic sampling program of several representative locations should be initiated within this "Critical Habitat" designated lake. The purpose of this program would be to attempt to identify and monitor changes occurring in the lake that may or are affecting the "Vulnerable" status of the unreplaceable molluscan fauna in Lake Waccamaw. The annual results of such a program must be made available to the public and interested scientific community.

Acknowledgments. The author acknowledges Karen Horn Mault aided by Lorilyn Howie Kipphut, Glenn Safrit, Kathin Venger, Lisa L. Wood, and Rod Reish who assisted in the 1978-1981 Lake Waccamaw study; W. F. Adams, U. S. Army Corps of Engineers, Wilmington, NC for aid in this report and donation into the UNC-IMS collection of a E. folliculata collected June, 1988 from the Savannah River (during a field trip accompanied by A. H. Gerberich, this author and others); the late Dr. Joseph Rosewater, U. S. National Museum of Natural History for collections information; the late Dr. J. P. E. Morrison, U. S. National Museum of Natural History and Dr. David H. Stansbery, Museum of Zoology, Ohio State University for taxonomic advice. Appreciation is noted to the Charleston Museum, Charleston, SC for permitting this author to research this species in their collection. This research was supported jointly by the North Carolina Wildlife Resources Commission, Project Number: E-1, Study Number: VI, Job Number: VI-7 (Federal aid grant funds available under provision of the Federal Endangered Species Act of 1973) (1978-1981) and the University of North Carolina at Chapel Hill, Institute of Marine Sciences.

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Prepared by HUGH J. PORTER

Anodonta implicata Say, 1829
ALEWIFE FLOATER

Description. This species is typical of the genus. The hinge plate and teeth are lacking. Anodonta implicata is easily distinguished from Anodonta cataracta by the former having a pronounced thickening of the shell below the pallial line in the anterior-ventral region. For additional descriptions, see Johnson (1970).

Range. The alewife floater ranges from Nova Scotia and New Brunswick, Canada, to the Potomac River in Virginia and Maryland (Johnson 1946, 1970; Burch 1975). A disjunct population is also known from the Chowan River in North Carolina (Shelley 1983). Bill Adams (pers. comm.) found live individuals in the Chowan River during the summer of 1989.

Habitat. Johnson (1970) states that this species appears to prefer clean sand/gravel substrates in relatively fast flowing water. However, at the Chowan River site the water has an almost imperceptible flow (Bill Adams, pers. comm.)

Life History and Ecology. The alewife (Alosa pseudoharengus) appears to be the alewife floater's dominant glochidial host (Johnson 1946). Therefore, this mussel species is probably restricted to the lower reaches of drainage basins.

Special Significance. The alewife floater population in the Chowan River is disjunct by 175 miles from any other known population of the species.

Type Locality. Agawam River, Plymouth County, Massachusetts. A neotype, MCZ 176769 was selected by Johnson (1946).

Systematics. Johnson (1970) synonymized Anodonta newtonensis Lea, 1838 and Anodonta housatonica Linsley, 1945 with Anodonta implicata.

Status. Vulnerable, Category 2.

Rationale for Evaluation. This is a disjunct population threatened by eutrophication.

Current Protection. None.

Recommendations. This species, along with other mollusks known from the Chowan River, should be monitored regularly.

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Prepared by JOHN M. ALDERMAN

Villosa nebulosa (Conrad, 1834)
ALABAMA RAINBOW

Description. The Alabama rainbow has an elliptical or subrhomboid shell. A large specimen from the Clinch River, Hancock Co., Tennessee, can be 65 mm long, about 32 mm high and 20 mm wide. A typical male from the Paint Rock River, Jackson Co., Alabama, is 54 long, 27 mm high and 18 mm wide. The shell is somewhat compressed with moderately small beaks protruding a little above the dorsal margin. The male has a posterior point which may be faintly biangulate and the female has a slight marsupial swelling and a rounded posterior end. The periostracum is greenish-yellow to olivaceous and brown with numerous, generally broken green rays. The rays may be narrow or wide, faint or dark, cover 2/3 or all of the shell. The left valve has two stout pseudocardinal teeth and two straight lateral teeth. The right valve may have one or two pseudocardinal teeth, the upper one being quite small or absent in some specimens. The beak cavity is shallow. The nacre can be bluish-white with a purplish cast or salmon color, and somewhat iridescent posteriorly. Other descriptions can be found in Conrad (1834) and Simpson (1914).

Range. The range of V. nebulosa is quite extensive, especially in the Tennessee River system. Simpson (1914) records V. nebulosa from: Cumberland and Tennessee River system; Green River, Kentucky; Tombigbee and Alabama River drainage; Columbus, Georgia (Chattahoochee River); and Wolfsville, North Carolina. I am inclined to doubt the Columbus, Georgia record. Ortmann (1924) states that Wolfsville, Union County, North Carolina is in the Catawba-Wateree drainge and that the record appears doubtful. Starnes and Bogan (1988) summarized Unionidae records for Tennessee. However, they choose to combine all V. nebulosa records with V. iris records. Consequently, it is difficult to be more specific about the distribution of V. nebulosa. Neves and Widlak (1988) recorded V. nebulosa from the North Fork Holston River, Virginia. Neves and Zale (1982) recorded V. nebulosa from Big Moccasin Creek (North Fork Holson River drainage) in Virginia. Ahlstedt (1981) found V. nebulosa very common in Copper Creek (Clinch River drainage). Dawley (1965) recorded V. nebulosa from the Hiwassee River, North Carolina. J. M. Alderman and R. G. Biggins collected V. nebulosa from the North Carolina portion of the Little Tennessee River in 1989. There do not appear to be any recent records for V. nebulosa in the French Broad or Hiwassee river drainages in North Carolina.

Ortmann (1924) recorded Micromya nebulosa (V. nebulosa) from Othcalooga Creek, Gordon Co., Georgia; Euharlee Creek, Bartow County, Georgia; Swamp Creek, Whitfield County, Georgia; Coosa River, Elmore County, Alabama; Conasauga River, Polk County Tennessee; and the Cahaba River, Bibb County, Alabama. Ortmann (1924) stated that this species was widely distributed in the Alabama River System.

Habitat. The Alabama rainbow can be found in fairly large rivers to small creeks. It is particularly common in small streams such as Big Moccasin Creek and Copper Creek. Neves and Zale (1982) described the general characteristics of Big Moccasin Creek. Very little has been published about the specific habitat for the Alabama rainbow.

Life History and Ecology. Zale and Neves (1982) determined that glochidia from Villosa nebulosa parasitized the smallmouth bass (Micropterus dolomieus) and the rock bass (Ambloplites repestris). Neves, Weaver and Zale (1985) found that V. nebulosa could successfully parasitize on, and produce juvenile mussels from, the following bass species; M. punctulatus, M. salmoides, M. s. floridanus and M. notius. Neves, Weaver and Zale (1985) also successfully obtained juvenile V. nebulosa from the mosquitofish (Gambusia affinis). Neves, Weaver and Zale (1985) collected gravid female V. nebulosa in the spring and autumn.

Neves and Widlak (1987) studied the habitat ecology of all the juvenile mussels in Big Moccasin Creek. This study included Villosa nebulosa which is common in the creek. The study did not differentiate between V. nebulosa and V. vanuxemi. Neves and Widlak (1987) collected 92 juvenile mussels in qualitative and quantitative studies and found that 50 belonged to either V. nebulosa or V. vanuxemi. They also found that Age 0 juveniles of all species studied were most often found behind boulders and never in pool samples.

The Alabama rainbow has been found associated with many other naiad species. Several studies of the Alabama rainbow were conducted in the Big Moccasin Creek were it is associated with Medionidus conradicus (Lea), Villosa vanuxemi (Lea), Pleurobema oviforme (Conrad), Fusconaia barnesiana (Lea), Lampsilis fasciola Rafinesque, and Alasmidonta virdidis Rafinesque. Ahlstedt (1981) found the Alabama rainbow associated with several other species in Copper Creek.

Special Significance. No special significance of V. nebulosa is known.

Type Locality. The type locality for Unio nebulosus Conrad, 1834 is "the mountainous region of Alabama, in the Black Warrior River" (Conrad 1834).

Systematics. The Alabama rainbow was originally described as Unio nebulosus by Conrad in 1834. Simpson (1914) lists some eleven synonyms for the species. Ortmann (1924) adds V. plancus Lea, 1868 and V. difficilis Lea, 1868 to Simpson's synonyms. Frierson (1927) lists fifteen synonyms for Lampsilis nebulosa (V. nebulosa).

Status. Vulnerable, Category 2.

Rationale for Evaluation. Villosa nebulosa is probably still common in several streams in Alabama, Tennessee and Virginia. Very few records exist for this species in North Carolina. The French Broad River, the Hiwassee River and the Little Tennessee River are all part of the Tennessee River system that extends into North Carolina. V. nebulosa has been recorded from all these river drainages, but not always in North Carolina. It appears as if the species does occur in North Carolina, but it is uncommon or rare and its distribution is definitely limited. This species should be listed under special concern until more information is known.

Current Protection. The Alabama rainbow currently does not have any protection.

Recommendations. It is important to survey all the waters of the Tennessee River system that extend into North Carolina. The results of such a survey could indicate the precise status of this species in North Carolina.

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Prepared by EUGENE P. KEFERL

Villosa vaughanianus (I. Lea, 1838)
CAROLINA CREEKSHELL

Description. With the exception of the original description by Lea in 1838, the only other description found for V. vaughanianus was in Simpson (1914). The description in Simpson (1914) is accurate, but it was based on two female specimens. The following description of the Carolina creekshell is based upon twenty specimens (male and female) from Densons Creek, Montgomery County, North Carolina.

The somewhat inflated shell is elliptical in the male and obovate in the female. The largest male was 60 mm long, 33 mm high and 22 mm wide. The largest female was 54 mm long, 30 mm high and 20 mm wide. The anterior margin of both sexes is rounded. The posterior end is pointed about 2/3 of the way from the ventral margin. In the male, the posterior margin below the point is a gradual curve and above the point it is straight in older males, but a gradual curve that blends with the dorsal margin in younger individuals. In the female, there is a distinct posterior basal swelling. There can also be a slight constriction between the basal swelling and the posterior point. The ventral margin in males is generally a gentle curve, but in females, it is usually straight. The beaks extend a little above the dorsal margin. The shell is moderately shiny with strong irregular growth lines. The periostracum is a greenish yellow to a dark brownish yellow with numerous, continuous dark green rays covering most of the shell. The overall appearance of the shell can sometimes be a uniform dark brown, but actual color is a dark brownish yellow with numerous dark green rays.

The left valve has two moderately large, triangular, serrated pseudocardinal teeth. The anterior tooth is more pointed and directed slightly towards the anterior end. When the left valve is viewed from the dorsal side both pseudocardinal teeth protrude noticeably. The right valve also has two pseudocardinal teeth. The larger posterior tooth is either like a thick blade or is pointed; it is also usually parallel to the dorsal margin. There are two well developed lateral teeth in the left valve and one in the right valve. The nacre is shiny, iridescent white or bluish-white, frequently with a pale salmon shade deepening toward the ventral margin. Some specimens do not show any salmon shading.

Villosa vaughanianus is quite distinct from any other Villosa in North Carolina or South Carolina. It is sympatric with both V. delumbis (Conrad, 1834) and V. constricta (Conrad, 1838).

Range. The only published record found for the Carolina creekshell is Sawney's Creek (Catawba River system), near Camden, South Carolina, its type locality. The Carolina creekshell has been collected in the following North Carolina streams: Densons Creek, Montgomery County; Big Bear Creek, Stanly County; Goose Creek, Union County; Second Creek, Randolph County; Toms Creek, Randolph County; and Jackson Creek, Randolph County. All these streams are in the Pee Dee River system (Keferl, unpublished records).

Habitat. Most of the Carolina creekshells I have collected were found near the bank in the shaded pools of small streams. They were usually in muddy or silty gravel and in shallow water.

Life History and Ecology. Gravid females were found on August 23, 24 and 26, 1987 in Second Creek, Goose Creek and Lick Creek of the Pee Dee River system. The Carolina creekshell was frequently found associated with V. delumbis and some Elliptio. In the streams examined this species of Villosa was not usually associated with V. constricta which was usually found in shallow running water.

Special Significance. This is the only Villosa endemic to the Carolinas.

Type Locality. According to Simpson (1914) and Johnson (1970) the type locality is Sawney's Creek, near Camden (Kershaw County), South Carolina. Two syntypes (USNM 86106) are found in the National Museum of Natural History, Smithsonian Institution, in Washington, D. C.

Systematics. The Carolina creekshell was originally described as Unio vaughanianus Lea, 1838. It was placed in the genus Lampsilis by Simpson (1914). Johnson (1970) synonymized it under Villosa delumbis (Conrad, 1834).

Status. Vulnerable, Category 2.

Rationale for Evaluation. The Carolina creekshell cannot be found in its type locality. Viable populations can be found in six different streams of the Pee Dee River system. I examined 205 different sites in the Pee Dee River system and I found the species in only six sites. The Carolina creekshell should be considered of special concern until more information concerning its distribution is known.

Current Protection. The Carolina creekshell does not currently receive any protection.

Recommendations. Much more survey work needs to be done in the small streams of the lower Catawba River system and the Pee Dee River system to accurately assess this species' vulnerability. If no more populations can be found, the species is definitely threatened. I recommend that Densons Creek, Montgomery County and Goose Creek, Union County be given some type of protection from development. Alasmidonta varicosa and Toxolasma pullus along with Villosa vaughanianus can be found in Densons Creek. Lasmigona decorata and V. vaughanianus can be found in Goose Creek.

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Prepared by EUGENE P. KEFERL

Ligumia nasuta (Say, 1817)
EASTERN PONDMUSSEL

Description. Johnson (1970) states that the eastern pondmussel may reach over 110 mm in some localities. Clarke (1983) found living specimens in the Cashie River, Bertie County, North Carolina which he considered the largest specimens on record (no length given). Shells are elongate and look somewhat like the yellow lance; however, the eastern pondmussel appears to have more height relative to length than the yellow lance. Specimens provided by Bill Adams are dark brown with fine rays visible on the posterior half of the shell. The posterior ridge is distinct and angular. The posterior slope is concave toward the umbos and tends to become convex toward the posterior end of the shell. The umbos are low and extend only slightly above the hinge line. The nacre is an irridencent blue to salmon color. Two pseudocardinal teeth are located in each valve. The left valve has two long, straight lateral teeth, and the right valve has one lateral tooth. Additional descriptive information is provided by Johnson (1970).

Soft-part anatomy is distinctive. Darkly pigmented papillae are found along the posterior third of the mantle margins (Adams, pers. comm.).

Range. Pamlico Drainage Basin north to the St. Lawrence Drainage Basin, Canada and westward through the northern parts of the Interior Basin. In North Carolina, this species is known from the Chowan, Roanoke, and Pamlico drainage basins.

Habitat. The eastern pondmussel is found in silts and sands in areas with limited currents such as in lakes, ponds, and protected areas of rivers and creeks (Johnson 1970). Bill Adams and Andy Gerberich (pers. comm.) found this species in a coarse sand substrate with significant amounts of fine organic matter. Also in the area were occasional patches of fragrant waterlily (Nymphaea odorata) and spatterdock (Nuphar luteum).

Life History and Ecology. Ortmann (1919) considers the eastern shoremussel to be a bradytictic species with the breeding season extending from August until the following June.

Mussel species associates of the eastern pondmussel in the Chowan River include Lampsilis ochracea, Lampsilis radiata, Elliptio complanata, Elliptio angustata, Anodonta implicata, and Anodonta cataracta (Adams and Gerberich, pers. comm.).

Special Significance. The eastern pondmussel reaches its southern range limit in North Carolina. Therefore, significant genetic differences may exist in our local populations of this species.

Type Locality. Delaware and Schuylkill rivers, near Philadelphia, Pennsylvania. The type specimen has been lost.

Status. Vulnerable, Category 2.

Rationale for Evaluation. During the summer of 1989, I surveyed four areas identified by the N.C. Natural Heritage Program as eastern

pondmussel habitats. Also surveyed was the Chashie River, which A.H. Clarke (1983) identified as an area which produced this species. No eastern pondmussels were found in any of these areas. Adams and Gerberich (pers. comm.) did find this species in the Chowan River, Gates County during 1989. This indicates that the species is still present in North Carolina; however, it appears that its range is being significantly reduced in the state.

Current Protection. None.

Recommendations. The molluscan fauna of the Chowan and Roanoke rivers need to be thoroughly surveyed. Areas with significant diversity or species need to be identified and protected.

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Prepared by JOHN M. ALDERMAN

Lampsilis crocata (I. Lea, 1841)
OVAL LAMP MUCKET

Description. The shell of L. crocata is ellipital, thin, moderately inflated, not posteriorly broadly rounded. The umbo of it is located and directed anteriorly. It has a periostracum that is light green to dark brown with thin green rays and dull shiny to rough in texture. The nacre of the inner shell surface is white to bluish in color. On the hinge there are lamellar pseudo-cardinal and straight lateral teeth. The marsupium on the posterior half of the outer female demibranch has a dark ventral margin. A mantle flap is on the mantle margin of the female just below the incurrent siphon - an area highly pigmented.

Largest L. crocata specimens in the UNC-IMS (University of North Carolina, Institute of Marine Sciences mollusk collection) are: Grissett Swamp, Columbus Co., NC (UNC-IMS #9864) - length = 48, height = 33, width = 18 mm. Orton Pond canal, NC (Cape Fear drainage) (male - UNC-IMS #10462) - length = 86, height = 56, width = 31 mm. Waccamaw River, Conway, SC (female and male - UNC-IMS #10363) - length = 73, height = 51, width = 35; length = 69, height = 46, width = 31 mm. Lake Waccamaw (female - UNC-IMS #10114) - length = 58, height = 42, width = 22 mm; (male - UNC-IMS #10182) - length = 55, height = 38, width = 21 mm.

The original Lea (1841) description has not been seen by this author. The Lea (1843) description for U. crocatus is as follows: "Diam. .8, Length 1.2, Breadth 1.8 inches. Shell elliptical, inflated, inequilateral, angular behind, substance of the shell thin, thicker before; beaks prominent; ligament rather thin and short; epidermis saffron-coloured, smooth and shining, with linear rays and numerous regular lines of growth; cardinal teeth small, single in the right and double in the left valve; lateral teeth long and curved; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices placed in the center of the cavity of the beaks; cavity of the shell deep; cavity of the beaks deep and angular; nacre salmon-colored and iridescent. It may be distinguished by the colour of the epidermis, by the teeth being thicker, and by the inflation of the umbones. The posterior slope is without rays, and is somewhat rough."

Lea (1963) gives the following descriptions of the soft parts of this species: "Branchial uterus occupies, very much like ochraceus, more than half of the posterior portion of the outer branchiae, one of the specimens having about forty ovisacks on each side,. . . .The whole lobe is nearly semicircular, and the lower portion is black, with a bright brown border. . . Mantle rather thin, with a very broad margin, slightly colored on the lower edges, much thickened below the branchial opening, where it is black and reddish brown and furnished with papillae on the inner edges. Branchial opening rather large, black and reddish brown, with numerous papillae. . ." Further on Lea noted that the ovisacks extended below the line of the branchiae. Lea, however, made no mention of the mantle flap present on the mantle margin.

Glochidia of L. crocata were described in Porter and Horn (1980). They have valves that are bilaterally symmetrical, hookless and purse shaped. There are eye spots near the ventral border. The hinge line is straight with the umbos occasionally extending just beyond the hinge line. Glochidial size and shape approximates that of Lampsilis fullerkati though its hinge length is generally larger than that of L. fullerkati.

Dimensions, as reported in Porter and Horn (1980) are: length = 0.227 mm; height = 0.280 mm; hinge length = 0.132 mm; hinge length/length ratio = 0.58; height/length ratio = 1.23; and hinge length/height ratio = 0.48.

Separation of glochidia from this species from the very similar glochidia of Leptodea ochracea and Lampsilis fullerkati can be accomplished through comparison of their hinge lengths and the ratios: hinge length/length, hinge length/height. Lampsilis crocata is the largest in all three of the above data categories, Lampsilis fullerkati is intermediate in data range, and Leptodea ochracea has the smallest values.

Range. Non-North Carolina: The type locality for crocata is listed as Savannah River, Georgia. Gibbes (1848 -no data included) listed the species from South Carolina. Lea additionally (1863) listed Columbus, Mississippi. Johnson (1984) lists two specimens resembling this species from the Waccamaw River near Murrells Inlet, South Carolina. UNC-IMS collection near Conway SC on Waccamaw River (UNC-IMS #10363).

North Carolina - Non-Lake Waccamaw or Waccamaw Drainage Area: Naiads believed to be this species were collected from an Orton Pond canal in July, 1986 by Kurt Wright and this author (UNC-IMS #10462).

North Carolina - Lake Waccamaw and Drainage Area: Published records of this species from Lake Waccamaw and its drainage area include: Porter and Horn (1980) and (1983), Johnson 1984, and Porter (1985). Catalogued UNC-IMS Lake Waccamaw specimens and lots include (incomplete): #8477, 9092, 9093, 9099, 10114, 10120, 10121, 10136, 10140, 10144-10150, 10178-10182, 10200, 10201, and 10275. One specimen has been collected from the Waccamaw River just below the Lake Waccamaw-Waccamaw River dam (UNC-IMS #8554).

Habitat. Average density of L. crocata in Lake Waccamaw during the 1978-1981 study of Porter (1985) was 0.4 specimens per m^2; 91.9% of the samples did not contain the species. Density values collected during this study were not normally distributed. Maximum sampled density was 12.9 crocata per m^2; this density was found both in the Southeast and West Intermediate Sand subregions.

Lampsilis crocata seems restricted to the intermediate - deep sand regions of the lake. Its average depth (2.05 m, range = 0.6-3.1 m) though is not significantly different from the average depth of the lake. Average sediment graphic skewness values of samples containing this naiad (0.01, range = -0.46-0.36 (fine-skewed sediment according to Folk, 1984)) were significantly greater that similar values for the lake (-0.10). All other average values of physical data from L. crocata containing samples were similar to average values of the lake. Mean physical data of all samples containing this naiad were (Porter, 1985):

% saturated dissolved oxygen = 91.1 (range = 55-130%); sediment total chlorophyll a (uncorrected) = 4.11 (range = 2.27-6.33); sediment total chlorophyll a (corrected) = 2.85 (range = 0.00-5.23); sediment pheo-pigments = 1.55 (range = -3.23-4.49); ph = 6.88 (range = 6.1-7.3); % sediment organic matter = 0.08 (range = 0.08-21.19); % sediment carbonate matter = 0.76 (range = 0.00-3.73); graphic mean sediment size = 2.03 Ø units (range = 1.10-2.81) (fine sand according to Folk, 1974); sediment inclusive graphic standard deviation = 0.81 (range = 0.31-2.05) (moderately sorted sand - note Folk, 1974);

sediment graphic kurtosis = 1.12 (range = 0.81-1.89) (mesokurtic sand - note Folk, 1974).

Correlation analysis of 1978-1981 data (Porter 1985) was suggestive only that density correlations with sediment chlorophyll a (corrected) and pheo-pigment values may exist. When variables were analyzed by cluster analyses, no variable (either physical or molluscan) were clustered with L. crocata. Lack of a strong correlation of crocata densities to analyzed hydrographic variables hindered development of an explanation for the non-homogenous distribution of the naiad within Lake Waccamaw.

Life History and Ecology. Little relationship is discernible between crocata densities and habitat vegetation in Lake Waccamaw except that no crocata were found in the Maidencane or Plectonema sp. habitats - both habitats generally were restricted to shallow sand.

Reproduction. Glochidia were collected from Lake Waccamaw waters in June, 1979 and 1980 (Porter 1985, Porter and Horn 1980, Porter and Horn 1983). No other information is available on time of reproductive cycle in this Lampsilid, thus, the typical bradytictic cycle of Lampsilids could not be verified for it. Host fish for L. crocata glochidia is unknown.

Special Significance. Lampsilis crocata is part of the molluscan assemblage of Lake Waccamaw which contains five endemic mollusks. The lake with its 21+ mollusk species is one of the most species rich lakes in the Western Hemisphere. The molluscan fauna of the lake generally is not known to occur commonly anywhere else in North Carolina. Further, Lake Waccamaw and Orton Pond are the only lakes on the North Carolina coastal plain known to be able to support a unionid fauna.

Type Locality. Savannah River, Georgia (Lea, 1841 according to Johnson, 1970).

Systematics. Identification of L. crocata has not been well understood or accepted. Simpson (1914) listed it as a synonym of Lampsilis ochracea. Johnson 1947) believed it to be closer to Lampsilis constricta (Conrad, 1938) (now Villosa constricta). In 1970, Johnson made Unio crocatus a synonym of Lampsilis cariosa (Say, 1817) which he listed as present in the Waccamaw River drainage near Murrells Inlet, South Carolina. Burch (1975) accepted the Johnson synonymy. Johnson (1984), partly as the result of the glochidial documentation in Porter and Horn, (1980), now accepts L. crocatus from Waccamaw drainage as a species separate from L. cariosa. The species, however, is not listed in Turgeon, et al. (1988).

Neither L. crocata or cariosa were listed in the Waccamaw records of Dawley (1965), Jennewein (1971), Fuller (1977, 1978), or Fuller et al. (1976). Presence or absence of specimens collected in Lake Waccamaw in the major museum collections has not been possible and is unknown at present. Specimens identified by Stansbery exist in the Ohio State University Museum of Zoology (MZOSU).

Stansbery (pers. comm. 1982) agrees that male L. crocata and L. ochracea are very similar and at times extremely difficult to separate. Using the concepts of Stansbery, material in the MZOSU, and crocata series

collected during this study, we believe that crocata can be separated from ochracea by the following: there is a color tendency towards a dull rough brown surface in crocata, whereas ochracea is generally light olive green and very shiny (this roughened condition in crocata is due to a greater prominence of concentric growth lines on the shell of it than on the shell of ochracea - these growth lines are mentioned in the 1843 description by Lea); anterior dorsal shell margin of crocata is rounded but angular in ochracea; a smaller shell height/length ratio is present in crocata than in ochracea (generally <0.75 in crocata and >0.75 in ochracea (this data is incomplete at present and is complicated by probable sexual dimorphism in both species in regards to this characteristic).

Johnson (1984), in commenting that Lake Waccamaw crocata were difficult to separate from ochracea, stated that these naiads could be separated by the their pseudocardinal teeth which are lamellate in ochracea and pyramidal in crocata.

Female crocata can be differentiated from female ochracea by the previous characteristics plus the presence of a dark band on the ventral margin of the marsupium of crocata, a characteristic noted by Lea (1863); this dark band was not seen on ochracea nor was reported in the anatomical descriptions of the latter by Lea (1838, 1863) and Reardon (1929). The presence of a small mantle flap on female crocata (may be shrunken in size in non-gravid individuals) and the absence of it in ochracea is an additional trait separating the two species; the absence of this flap in ochracea is one of the primary reasons why the species was transferred out of the Genus Lampsilis by some investigators. No consistent differences were seen in the between the branchial apertures (incurrent siphon), the papillae, or the ribbon-like areas on the mantle edge just anterior to the incurrent siphon in either crocata or ochracea from Waccamaw waters.

Status. Vulnerable, Category 2.

Rationale for Evaluation. This imperfectly understood naiad species is not considered endemic to the Waccamaw drainage. The known distribution of crocata seems restricted to the southern coastal Atlantic drainage of the United States between the Savannah River (Georgia) and the Waccamaw drainage with no known occurrences between these river systems (Johnson, 1984). The recent collection of it in Orton Pond canal (Cape Fear drainage) is an exception here. Because of the probable prior taxonomic confusion between it and Lampsilis cariosa and L. ochracea, both more common naiads, it is possible that crocata is not as rare as records indicate. Thus densities of it outside the Waccamaw drainage may not be critically low. The average density of crocata in Lake Waccamaw is 0.4 m^2 and is suggestive that the estimated Lake Waccamaw population is about 14.4 million living specimens.

Several reasons could account for this crocata population being previously unreported from the lake. The species crocata, by many was not recognized as a discrete taxonomic unit. Additionally, most early collections (before SCUBA capabilities), were made only in shallow depths; as has been shown, crocata in Lake Waccamaw is scarce in shallow waters and most common in the intermediate to deep depths of the lake. It is not here believed that crocata is a recent addition to the fauna of the lake.

The crocata population in the Waccamaw River is of low density and from only several known locations - presence in other Waccamaw drainage waters is unknown.

Until presence of populations of this uncommon species are reported on from other drainages, the status of this species will be in question; therefore, the species should be accorded at least the status of "Vulnerable".

The Porter (1985) study documented habitat variables within which the species exists in Lake Waccamaw. Outside the lake, these variables or their combination may not exist. If unknown of these restricted habitat and hydrological variables were changed within the lake, the continuing existence of this species may be threatened.

Current Protection. Lake Waccamaw is somewhat protected as it has been designated a "Critical Habitat" because of the presence in it of Menidia extensa, the Waccamaw Silversides - See: Threatened status for Waccamaw Silversides - Lake Waccamaw is critical habitat. Federal Register, Vol. 52, No. 67, pp. 11277-11286, April 8, 1987.

Recommendations. An annual or biannual hydrological and benthic sampling program of several representative locations should be initiated within this "Critical Habitat" designated lake. The purpose of this program would be to attempt to identify and monitor changes occurring in the lake that may or are affecting the "Vulnerable" status of the unreplaceable molluscan fauna in Lake Waccamaw. The annual results of such a program must be made available to the public and interested scientific community.

Acknowledgments. The author acknowledges Karen Horn Mault aided by Lorilyn Howie Kipphut, Glenn Safrit, Kathin Venger, Lisa L. Wood, and Rod Reish who assisted in the 1978-1981 Lake Waccamaw study; and Dr. David H. Stansbery, Museum of Zoology, Ohio State University for taxonomic advice. This research was supported jointly by the North Carolina Wildlife Resources Commission, Project Number: E-1, Study Number: VI, Job Number: VI-7 (Federal aid grant funds available under provision of the Federal Endangered Species Act of 1973) (1978-1981) and the University of North Carolina at Chapel Hill, Institute of Marine Sciences.

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Prepared by HUGH J. PORTER

Lampsilis fasciola Rafinesque, 1820
WAVY-RAYED LAMPMUSSEL

Description. The shell of this species is normally about 70 mm in length, ovate to oblong in outline, with the anterior end rounded and the posterior end rounded to roundly pointed. The posterior ridge is broadly rounded, not angular, and the beaks are elevated only slightly above the hinge line. The periostracum is shiny, usually with many raised growth lines, has a background color of light yellow to yellowish-green, and has dark-green wavy rays covering most of the shell. Complete descriptions and illustrations can be found in Burch (1973) and Parmalee (1967).

Range. This species has a broad distribution, occurring essentially throughout the Ohio River drainage and in the Great Lakes drainages. Historically, it occurred in North Carolina in the French Broad River, Big Pigeon River and the Little Tennessee River (Ortmann 1918). Today, it is known in the state only from the Little Tennessee River above Fontana Lake (Macon and Swain Counties). Recent observations of the Little Tennessee River in that area show that it still exists there in good numbers (R. G. Biggins and J. M. Alderman, pers. comm.).

Habitat. Little is known about the habitat requirements of this species in the state. It normally occurs in rivers and creeks in coarse sand or gravel.

Life History and Ecology. Nothing is known of the life history of this species. In North Carolina, it occurs with Elliptio dilitata and Alasmidonta viridus.

Special Significance. None.

Type Locality. Kentucky River, Kentucky (precise location unknown).

Systematics. For almost a century, this species was known as Lampsilis multiradiatus (I. Lea, 1829). However, Ortmann (1918) determined that Rafinesques' description of L. fasciola was adequate to discern the species and gave that name priority over Lea's L. multiradiatus. Systematic treatment of this species has been stable since that time.

Status. Vulnerable, Category 2.

Rationale for Evaluation. This species is believed to have been extirpated from most of its former range in North Carolina, being known today only from the Little Tennessee River. Declines in water quality, chemical spills, impoundments, or many other forms of stream disturbance could adversely affect the species.

Current Protection. The known North Carolina population of this species occurs within part of the the critical habitat of the spotfin chub (Hybopsis monacha) and, therefore, receives incidental protection from that species.

Recommendations. The Little Tennessee River population of this species should be closely monitored for population trends and the water quality of the river jealously guarded. Surveys for additional populations of this species should undertaken.

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Prepared by WILLIAM F. ADAMS

Lampsilis ochracea (Say, 1817) (Leptodea ochracea accepted name in Turgeon, et al. (1988))
TIDEWATER MUCKET

Description. The tidewater mucket has a round shell that is thin, translucent and highly inflated or obese. The anterior and posterior dorsal shell margins are angular. The umbo is centrally located and pointed in a dorsal direction. The exterior periostracum is olive green or yellow to light brown with thin narrow green rays. The nacre of the interior shell surface is pinkish and sometimes white. There are lamellar pseudo-cardinal teeth on the hinge; the lateral teeth on the hinge are curved.

Females have a cream colored marsupium on the posterior half of the outer demibranch. There is no mantle flap on the mantle margin anterior to the incurrent siphon.

Say (1819) - "Shell thin, fragile, translucent, subovate, hinge margin somewhat rectilinear, colour from a pale reddish orange to a pale olive; generally radiate with dull green and with minute wrinkled radii; anterior margin very finely wrinkled; beaks decorticated and approximate, with two or three small concentric undulations; within bluish-white or ochraceous, tinged with red near the base; teeth very oblique and much compressed. Length, one inch and a quarter: breadth, one and three quarters."

Largest Lampsilis ochracea specimens in the UNC-IMS (University of North Carolina, Institute of Marine Sciences mollusk collection) are: Lake Waccamaw - length = 50, height = 41, width = 21 mm (female) #10160; length = 59, height = 48, width = 27 mm (male) #10172. Chowan River (near Gatesville, NC) - length = 76, height = 53, width = 32 (female); length = 96, height = 70, width = 41 (male) #9892.

Both Johnson (1970) and Morrison (1975) mention sexual dimorphism being present in this species. This dimorphism and the ecophenotypic conchological variability of this species (Fuller 1977) has not been well documented; but, from ongoing problems in distinguishing L. ochracea males from Lampsilis crocata, L. cariosa, and etc., an understanding of this conchological variation is essential to the accurate identification of naiad fauna wherever L. ochracea may be present. Johnson (1970) states, without including morphometric data, that Lampsilis ochracea "have a posterior end more broadly rounded and somewhat pointed in the male, truncated in the female." This characteristic but subtle difference between males and females of most Lampsilids is not always present in L. ochracea, particularly in juveniles. Shell height/length ratios (obesity) were examined in the Lake Waccamaw L. ochracea (Horn and Porter 1981). No significant sexual dimorphism was found within this species in the lake.

Considerable variation is present in the length of gravid marsupia in Lake Waccamaw L. ochracea but no marsupia were seen having a length greater than one half the length of the outer demibranch in these naiads (Porter 1985).

Lea (1863a) mentions that the ovisacks in marsupia of Lampsilis crocata are are extended below the branchiae. Gravid marsupia of L. ochracea and L. crocata, found in Lake Waccamaw, when examined were both found containing ovisacks extended below their branchiae.

Glochidia have valves that are bilaterally symmetrical, hookless and purse-shaped. There are eye spots near the ventral border. The hinge line is slightly convex with the umbos generally not quite reaching the

hinge line. Dimensions, as reported in Porter and Horn (1980) are: length = 0.227 mm; height = 0.277 mm; hinge length = 0.109 mm; hinge length/length ratio = 0.48; height/length ratio = 1.22; and hinge length/height ratio = 0.40. The latter authors point out that their Lake Waccamaw glochidial measurements for this species differ from those taken from a glochidial picture of Leptodea ochracea published by Reardon (1929). Separation of glochidia from this species from the very similar glochidia of Lampsilis crocata and fullerkati can be accomplished through comparison of their hinge lengths and the ratios: hinge length/length, hinge length/height. Lampsilis crocata is the largest in all three of the above data categories, Lampsilis fullerkati is intermediate in data range, and Leptodea ochracea has the smallest values.

Range. Non-North Carolina: Mazyck (1913) mentions a Ravenel collection specimen from the Cooper River, South Carolina. The distribution listed by Johnson (1970) and as discussed by Fuller (1971, 1977) is the Savannah River system of Georgia north into Nova Scotia. Johnson (1947, 1970) listed specimens from specific ponds and lakes in Maine and Massachusetts; Connecticut and Housatonic Rivers (Connecticut); Champlain Canal and Hudson River (New York); Delaware and Passaic River (New Jersey); Schuylkill and Delaware Rivers (Pennsylvania); Seaford (Delaware); Potomac and Anacostia Rivers (District of Columbia); Mill Pond, Radcliff and Susquehanna Rivers (Maryland); Little Hunting Creek, James, Matapike, and York Rivers (Virginia); and Savannah River (Georgia) systems. Conrad (1836), Johnson (1947, 1970), and Fuller (1971, 1977, 1978) mention the presence of Lampsilis ochracea in the upper tidal regions of rivers. Kat (1983) lists a population of the species from Sydney River, Nova Scotia.

The Johnson (1970) record of lower Waccamaw River specimens from Wachasaw Landing, South Carolina may be Lampsilis crocata. A Lampsilis collection by this author from the Waccamaw River near Conway, South Carolina probably includes only L. crocata (UNC-IMS #10363).

North Carolina - Non-Lake Waccamaw or Waccamaw Drainage Area: Walter (1956) recorded the species from the Neuse River. Dawley (1965) included the latter record and added the Tar and Roanoke Rivers to the known North Carolina Distribution. Johnson (1947, 1970) state that he examined specimens of the species from the Tar River and Roanoke River Systems. Morrison (1975) mentioned specimens of the species which he collected from the Tar River. Fuller (1977) stated that besides the Waccamaw population, the "only additional and extent known populations in North Carolina apparently occur in the tidal Chowan River near Eure, Gates County, and in the Tar River near Pinetops, Edgecombe County." Clarke (1984) reports collecting the species in the Tar River during a recent survey. In addition, Plate 22, Fig. 3 in Johnson (1970) of Lampsilis radiata radiata (Gmelin) from Greenfield Pond (near Wilmington, North Carolina) is L. ochracea instead of L. radiata (Morrison; pers. comm., 1971). UNC-IMS collection includes specimens collected by this author from the Chowan River (Gates County) (UNC-IMS #9892, 9893).

North Carolina - Lake Waccamaw and Drainage Area: The species has been recorded present in Lake Waccamaw by Ortmann (1919), Dawley (1965), Johnson (1947, 1970), McDaniel and McDaniel (1972), Morrison (1975), Porter and Horn (1980), Horn and Porter (1981), Kat (1983), Porter and Horn (1983), and Johnson (1984). Porter and Horn (1984a) reported a

specimen believed to be this species from the Waccamaw River just below the Lake Waccamaw dam (UNC-IMS #8553). No specimens were found living in Big Creek which empties into Lake Waccamaw.

UNC-IMS catalogued specimens and lots from Lake Waccamaw include (incomplete):#'s 598, 2776, 2777, 3307, 3310, 3459, 8562, 8594, 9094, 9875, 10115, 10124, 10132, 10137, 10142, 10143, 10151, 10157-10175, 10269, 10282, 10350, 11056, 11082, 11103, and 11122.

Habitat. Mean values of physical data from samples containing L. ochracea were not significantly different from mean values of all Lake Waccamaw sample physical data. Mean physical data of all samples containing L. ochracea were (Porter 1985):

depth = 1.73 m (range = 0.4-3.6 m); % saturated dissolved oxygen = 86.7 (range = 13-132%); sediment total chlorophyll a (uncorrected) = 4.47 (range = 1.36-21.61); sediment total chlorophyll a (corrected) = 3.34 (range = 0.00-25.62); sediment pheo-pigments = 2.35 (range = -4.99-27.02); ph = 6.91 (range = 5.1-7.5); % sediment organic matter = 4.07 (range = 0.00-35.21); % sediment carbonate matter = 0.63 (range = 0.00-4.30); graphic mean sediment size = 2.05 Ø units (range = 0.88-4.40) (fine sand according to Folk, 1974); sediment inclusive graphic standard deviation = 0.77 (range = 0.09-1.59) (moderately sorted sand - note Folk, 1974); sediment graphic skewness = -0.10 (range = -0.57-0.52) (fine-skewed sand - note Folk, 1974); and sediment graphic kurtosis = 1.12 (range = 0.58-1.93) (mesokurtic sand - note Folk, 1974).

Average density of Lampsilis ochracea in Lake Waccamaw during the 1978-1981 Porter (1985) survey was 2.9 specimens per m^2; 51.3% of the samples did not contain the species. Density level was suggestive that L. ochracea was the second most common naiad in the lake, the first being Elliptio waccamawensis and the third being Lampsilis fullerkati. Maximum sampled density was 25.8 L. ochracea per m^2; this density was found in the Northwest Shallow Sand subregion (Porter, 1985).

Density data and distributional data of L. ochracea, by subregions confirm the regional homogenous nature of density of this species in Lake Waccamaw. Samples containing the species were spread evenly throughout the lake in contrast to the uneven patterns present for E. folliculata, Lampsilis fullerkati, Lampsilis crocata, Anodonta teres, and Corbicula fluminea.

Johnson (1970) and Fuller (1977) characterized this species as living in a habitat of: weak water currents near or in a tidal area of sandy floor to mud bottom in small streams, tidal rivers, canals, ponds or lakes. Lake Waccamaw fits the above habitat description for Leptodea ochracea in the lake and seems to occur randomly throughout it.

Life History and Ecology. A comparison of the density of this naiad to habitat plant association suggests: that the data here is quite variable; lower than average L. ochracea densities may be present where Maidencane and Najas are present; no L. ochracea is present in the blue green algal (Plectonema sp.) area; and higher than average densities of L. ochracea are present where Spatterdock and an unknown grass-like plant were.

The 1978-1981 data was suggestive that a negative relationship (correlation analyses) was present between L. ochracea densities and pH. A strong positive correlation in L. ochracea densities occurs with E. waccamawensis densities, - note both are the dominant naiads of the lake. Of possible ecological significance is that while both naiads are density correlated with each other, L. ochracea densities are negatively correlated with pH, whereas, E. waccamawensis densities are not correlated with pH. A mechanism for a slight ecological habitat separation between the two species is indicated.

A positive correlation between L. ochracea obesity and percent organic matter in habitat sediment was suggested (data correlated only at 5% level of significance). Thus, possibly L. ochracea obesity is greater in high organic sediments that in sediments having low organic levels.

The recently introduced "Chinese Clam", Corbicula fluminea, was shown in the 1979-1981 study (Porter and Horn 1984b) not to have any effect on existing L. ochracea populations. This is being discussed more fully in a paper being written by this author and which is expected to be submitted for publication in late 1990.

Reproduction. Gravid condition by this naiad was present in Lake Waccamaw in 1979 during February, April-June, and December; in 1980 it was found during March, May, June, and again in December (Porter 1985; Porter and Horn 1983). Ortmann (1919), repeating the Lea 1836 records, mentions that the species was gravid or charged with eggs in June, October, and November. Johnson (1970) found gravid individuals in May in Plymouth, Massachusetts waters. This evidence supports the belief that this species is bradytictic (long-term breeder) (Johnson, 1970). Thus, breeding, occurring at the beginning of a gravid condition, begins during late fall; spawning would be completed near June of the following year. This initiation of breeding also seems beginning later (December) than the September beginning of Lampsilis sp. (Lampsilis fullerkati) (Porter and Horn 1983).

The host fish of L. ochracea glochidia are not known. Fuller (1977) suggests that because of the tide water affinities of this species, the dominant glochidial host must be an anadromous fish. Herring and members of the genus Menidae (Atherinidae) are anadromous fish known from Lake Waccamaw waters. Herring are rarely infected with glochidia but Menidae species are likely glochidial hosts (F. J. Schwartz; pers. comm., 1982). Menidia extensa Hubbs and Raney is common in Lake Waccamaw (Hubbs and Raney, 1946).

Special Significance. This species is part of the endemic molluscan assemblage of Lake Waccamaw which contains at least four other endemic mollusks. The lake with its 21+ mollusk species is one of the most species rich lakes in the Western Hemisphere. The molluscan fauna of the lake generally is not known to occur anywhere else in North Carolina. Further, Lake Waccamaw and Orton Pond are the only lakes on the North Carolina coastal plain known to be able to support a unionid fauna.

Type Locality. Schuylkill River, Pennsylvania (Johnson, 1947).

Systematics. The existing and continuing problem in separating this species, particularly males of it, from Lampsilis crocata is discussed in

the species discussion for L. crocata. Important differences between L. ochracea and L. crocata (in Lake Waccamaw) are: shell height/length ratio is greater in L. ochracea than in L. crocata (>0.75 vs. <0.75); generally light to dark brown vs. dull or rough periostracum; central umbo vs. umbo on anterior half of dorsal surface; no mantle flap anterior to incurrent siphon vs. presence of small mantle flap anterior of incurrent siphon, pigmentation lacking vs. pigmentation present on ventral margin of marsupium.

Johnson (1970) discussed taxonomic similarities between Lampsilis ochracea L. cariosa, and Lampsilis splendida (Lea, 1838), the latter, a species presently known existing between Georgia and South Carolina. This latter species has wide green rays whereas L. ochracea has thin rays; L. splendida additionally has a considerably heavier shell than that of L. ochracea. Kat (1983) at length discussed the relationships between Lampsilis ochracea, L. splendida, L. radiata, and Lampsilis sp. (fullerkati).

Both the generic and the specific name of this naiad are presently questioned. The genus Leptodea was proposed for this species by Morrison (1975) and use of it was continued by Stansbery (pers. comm., 1979) and Turgeon et al. (1988). Morrison (1975) states "With smaller glochidia, and a complete lack of `mantle flaps' or papillae on the mantle margins of the females, ventral to the siphonal area, it is clearly a species of Leptodea. This genus, of the subfamily Lampsilinae, has not previously been recognized as including any species living in the Atlantic Slope rivers." At present, the genus Leptodea is still considered by many to be restricted to the Mississippi and Gulf of Mexico drainages. Bereza and Fuller (1975) concluded that Unio ochraceus do not fit either the published concepts of Lampsilis or Leptodea; however, primary sexual characteristics (glochidium and marsupium) of the species are more in harmony with those of Lampsilis than with those in Leptodea, if Lampsilis concepts can be expanded to include forms without a postbasal mantle flap.

Fuller (1977) states that a new genus for Lampsilis ochracea was in preparation. More recently, Clarke (pers. comm., 1984) has stated that he will shortly propose a new genus (named after Morrison) for this species. The Morrison (1975) assumption that L. ochracea belonged in the genus Leptodea because of its small glochidia was questioned in Porter and Horn (1980). Published dimensions of glochidia of the type species of Leptodea fragilis (Rafinesque, 1820), were 1/3rd the size of Lake Waccamaw L. ochracea glochidia. In both size and shape, glochidia of Lake Waccamaw L. ochracea were more similar to glochidia of the genus Lampsilis than Leptodea. Considerable difference was present between the height/length ratios of Lake Waccamaw L. ochracea glochidia and similar ratios taken from illustrations of L. ochracea glochidia by Reardon (1929). Stansbery (pers. comm., 1981) however, believed this variation in glochidial size not of generic importance.

Kat (1983) discussed the Leptodea vs. Lampsilis controversy. His studies have shown that within accepted Lampsilis species there is a considerable amount of variation in degree of development of the mantle flap. Further, the structure of the stomach and characteristics of the female demibranchs of ochracea are typically lampsiline. Kat also cites our studies showing the glochidia characteristics of L. ochracea to be closer to Lampsilis than to Leptodea.

This recent evidence by Kat (1983) has led to the present acceptance by this author of Lampsilis as the most acceptable present genus name for ochracea. This is done realizing the probability that a new genus name for this species may be in order.

Morrison (1975) additionally made the statement that there was a complete lack of "papillae on the mantle margins" of ochracea. Fuller (1977) showed photographs of a gravid Lampsilis ochracea from the Chowan River and made a distinct point concerning the absence of the `broad, papillose and usually highly pigmented postbasal mantle margin (commonly bearing a "ribbon" of tissue) which is characteristic of the radiata group". This was not the case in Lake Waccamaw specimens examined during this project. While the mantle flap was not present, a small area, ribbon-like sometimes, containing small papillae was present just anterior to the incurrent siphon on the ventral mantle edge of all female L. ochracea examined - this area generally had some dark pigmentation. Small papillae, generally not on a ribbon-like area, were also present just anterior to the incurrent siphon on the ventral mantle edge of most male L. ochracea examined. These papillae may correspond to the crenulate pigmented area just anteriad from the incurrent siphon as reported by Bereza and Fuller (1975) for the species. The Morrison specimens and those from this study both included material collected from the same area but during a different time frame. It is believed that our finding of papillae on the mantle edge near the incurrent siphon of L. ochracea is both a clarification of the Morrison statement and an indication of possible ecophenotypic mantle variability.

The species name ochracea, used here, is that name which is generally accepted (Stansbery; pers. comm., 1979) and Turgeon et al. (1988). Morrison (1975) presented considerable evidence that the name Leptodea fluviatilis (Gmelin) is the name which should be used. No attempt has been made in this study to justify the merits of the use of the name L. fluviatilis over L. ochracea as suggested by Stansbery.

Kat, in his most interesting 1983 paper, compared L. ochracea from Lake Waccamaw with specimens from Sydney River, Nova Scotia (specimens from the extremes of the ochracea range). Anatomy and allele frequencies of specimens from both populations were similar. There was some shell shape difference between populations. The low level of biochemical differentiation he stated was consistent with the hypothesis "that host type affects levels of genetic divergence among widely-separated populations and divergence among such populations than do species with territorial and/or strictly freshwater hosts."

Status. Vulnerable, Category 2.

Rationale for Evaluation. This non-endemic Lake Waccamaw naiad is the second most common mussel in the lake. Based on an average density of 2.9 specimens per m^2, it is estimated that 104.4 million Leptodea ochracea existed in Lake Waccamaw during the time of the 1987-1981 survey. The enormity of this population was that which caused Fuller (1977) to suggest that the species be given a status of "Special Concern". He asserted that the Waccamaw population had special significance to North Carolina and natural science because it was the only large Lampsilis ochracea population really known.

The species seems remarkably adapted to Lake Waccamaw in spite of its suggested tidal water affinities. Outside of Lake Waccamaw waters, but within its drainage, only a few L. ochracea specimens have been collected from the Waccamaw River and these were from very close to the lake dam. No specimens were found in Big Creek. There continues to be no record of other large populations of L. ochracea in North Carolina or other Atlantic coastal drainage waters. Again the special nature of Lake Waccamaw is presupposed.

The correlation noted between densities of the Lake Waccamaw population and pH would be evidence of one environmental factor which if changed by disruption of the lake water quality, could affect a destruction of this large naiad population. If other unknown environmental factors or their combinations presently in Lake Waccamaw were changed, the continuing existence of this large naiad population may be threatened. While this species seems to be a common Atlantic coastal drainage naiad, the population existing in Lake Waccamaw is the only large one known in the drainage; thus, the existence of it in Lake Waccamaw must be treated with concern and should be accorded a status of "vulnerable".

Current Protection. Lake Waccamaw is somewhat protected as it has been designated a "Critical Habitat" because of the presence in it of Menidia extensa, the Waccamaw Silversides - See: Threatened status for Waccamaw Silversides - Lake Waccamaw is critical habitat. Federal Register, Vol. 52, No. 67, pp. 11277-11286, April 8, 1987.

Recommendations. An annual or biannual hydrological and benthic sampling program of several representative locations should be initiated within this "Critical Habitat" designated lake. The purpose of this program would be to attempt to identify and monitor changes occurring in the lake that may or are affecting the "Vulnerable" status of the unreplaceable molluscan fauna in Lake Waccamaw. The annual results of such a program must be made available to the public and interested scientific community.

Acknowledgments. The author acknowledges Karen Horn Mault aided by Lorilyn Howie Kipphut, Glenn Safrit, Kathin Venger, Lisa L. Wood, and Rod Reish who assisted in the 1978-1981 Lake Waccamaw study. He is also appreciative to Dr. A. H. Clarke, Mattapoisett, MA; the late Dr. J. P. E. Morrison, U. S. National Museum of Natural History; and Dr. David H. Stansbery, Museum of Zoology, Ohio State University for taxonomic advice. This research was supported jointly by the North Carolina Wildlife Resources Commission, Project Number: E-1, Study Number: VI, Job Number: VI-7 (Federal aid grant funds available under provision of the Federal Endangered Species Act of 1973) (1978-1981) and the University of North Carolina at Chapel Hill, Institute of Marine Sciences.

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Prepared by HUGH J. PORTER

Lampsilis radiata (Gmelin, 1791)
EASTERN LAMPMUSSEL

Description. This description is for the eastern lampmussel (L. r. radiata). Differences between the eastern lampmussel and the Carolina fatmucket (L. r. conspicua) will be discussed in the systematics section of this report.

Maximum length for this elliptical species is approximately 100 mm in North Carolina. The posterior ridge is rounded. Umbos are swollen and extend above the hinge line. Both the posterior and anterior ends of the shell are rounded. In general, the shells are roughened on the outer half of the shells. The periostracum is brown with dark greenish black rays over most of the shell. The nacre is usually pinkish or salmon with some iridescent blue showing through the pink toward the posterior end of the shell. The lateral teeth are long - two on the left valve and one on the right valve. Two pseudocardinal teeth are found on both the left and right valves. Additional descriptions are available in Johnson (1970).

Range. The eastern lampmussel is generally thought to be a tidewater subspecies with a discontinuous range from the Cape Fear Drainage Basin north to the St. Lawrence Drainage Basin. The eastern lampmussel has recently been found in the lower Chowan River (W. Adams, pers. comm.; Alderman, unpubl. data) and in Swift Creek, Fishing Creek, and the main channel of the Tar River in the Pamlico Drainage Basin (Alderman 1988). In the Tar River Drainage Basin it is one of the least common mussel species. It is undetermined whether this species has declined in the Tar River Drainage Basin since Clarke (1983) completed his survey of the drainage.

The Carolina fatmucket has recently been found in the Little and Uwaharrie rivers which are tributaries in the Pee Dee Drainage Basin in North Carolina (Keferl and Shelley 1988). Walter's (1956) finding of the Carolina fatmucket in the upper Neuse Drainage Basin has recently been confirmed from the Flat River in Durham County (Alderman, unpub. data).

Habitat. The eastern lampmussel is usually found in medium to coarse sands. The Carolina fatmucket is found in gravel, cobble, or bounder substrates as well as in impounded habitats such as Lake Michie (Walter 1956). The Carolina fatmucket was not found during a recent survey of Lake Michie (Alderman, unpub. data).

Life History and Ecology. The eastern lampmussel is a bradytictic breeder. Ortmann (1919) has found that the breeding season extends from August to the following August. The Carolina fatmucket is also a bradytictic breeder. Walter (1954) found gravid Carolina fatmucket females during the fall and early winter months. Fish hosts for the eastern lampmussel and Carolina fatmucket are unknown.

Special Significance. The Carolina fatmucket may be a North Carolina endemic species. Further research is needed to determine if this is true.

Although the eastern lampmussel is considered a northern species, its range extends through the coastal drainages of North Carolina to the Cape Fear Drainage Basin in New Hanover County.

Type Locality. Potomac River, District of Columbia.

Systematics. Two subspecies of Lampsilis radiata are recognized by the American Malacological Union (Turgeon et al. 1988), Lampsilis radiata radiata and Lampsilis radiata conspicua. L. r. conspicua is known only from the Yadkin and Neuse drainage basins. Shells of this subspecies are much larger and heavier than the shells of L. r. radiata. Also, the posterior ridge is much more broadly rounded in L. r. conspicua and, in general, the umbos are not as inflated. Because of these differences and because L. r. radiata is thought to parasitize an anadromous fish host and L. r. conspicua is found in areas without such fish species being present, it is possible that L. r. radiata and L. r. conspicua are separate species.

Status. Vulnerable, Category 2.

Rationale for Evaluation. There are few signs of successful reproduction in either the Carolina fatmucket or the eastern lampmussel.

Current Protection. None.

Recommendations. The Carolina fatmucket and eastern lampmussel may be separate species. Research needs to be undertaken to determine if this is true. A thorough survey of all North Carolina tidewater streams, creeks, and rivers needs to be completed. Such a survey will further expand our knowledge of the distribution and status of the eastern lampmussel as well as other species present in these waters. A status survey is also needed for the Carolina fatmucket.

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Prepared by JOHN M. ALDERMAN

Glyphyalinia clingmani (Dall, 1890)
FRAGILE GLYPH

Description. Glyphyalinia clingmani has a very thin, and fragile shell. It is about 6.5 mm in diameter and 2.9 mm in height with about 5.5 whorls. The umbilicus fits in the diameter about 6 times. According to Burch (1962), the color of the greenish glossy shell varies from greenish-yellow to a reddish horn. The suture is well marked. The upper part of the shell has widely spaced, radiating indented lines which become obsolete on the base. The spire is low and the periphery rounded. The shell is similar to Glyphyalinia vanattai (Pilsbry and Walker 1902), but somewhat larger in size. A more complete description and figures can be found in Pilsbry (1946).

Range. According to Hubricht (1985) the fragile glyph is known only from Yancey County, North Carolina. Walker and Pilsbry (1902) state that Vitrea clingmani (G. clingmani) "is peculiar to Black Mountain range". Walker and Pilsbry (1902) records this species from Mt. Clingman, Mt. Mitchell, Wilson's Cove, Cat-Tail and Potato Top.

Habitat. Walker and Pilsbry (1902) records the fragile glyph from under a log. Hubricht (1985) records this species from under logs, rocks and moist leaf litter at high elevations.

Life History and Ecology. Nothing is known about its life history and ecology other than a few habitat notes.

Special Significance. The fragile glyph is one of the largest species in the genus Glyphyalinia. The snail has a very restricted distribution.

Type Locality. The type locality of the fragile glyph is Mt. Clingman, north of the summit (Walker and Pilsbry 1902). The type (38910 USNM) is in the United States National Museum (Pilsbry 1946).

Systematics. Dall described this species from specimens collected by Hemphill as Vitrea clingmani in 1890. Baker (1933) placed the species in the genus Retinella. Hubricht (1974) replaced the genus Retinella with genus Glyphyalinia for this species. According to Hubricht (1985) Retinella approxima (Walker and Pilsbry 1902) is a synonym.

Status. Vulnerable, Category 1.

Rationale for Evaluation. According to Walker and Pilsbry (1902) this species was rare. Since that time it has not been recorded from any area outside of the Black Mountain range. It appears to be restricted to Yancey County, North Carolina. Since this species is naturally rare within a restricted range, it is definitely a candidate for endangered status.

Current Protection. *Glyphyalinia clingmani* does not have any federal or state protection at this time.

Recommendations. It is recommended that the original localities and other similar high elevation habitats in the Black Mountain range be surveyed.

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Prepared by EUGENE P. KEFERL

Catinella waccamawensis Frazen 1981
WACCAMAW AMBERSNAIL

Description. The shell is light amber colored, glossy, translucent, imperforate, very thin and fragile, with 2 1/2 to 3 whorls and a sharply incised suture; height 5.9 mm to 7.5 mm and width 3.5 mm to 5.9 mm. The nuclear whorl is knoblike; spire short; whorls increase rapidly in size, culminating in an elongate, tumid ultimate whorl. The shell of this species is so thin that the mantle shows through it, giving living specimens a dark overall appearence. For a complete description, including soft-tissue anatomy and photographs of the holotype and a paratype, the reader should consult Franzen (1981). Genitalia of this species are also figured in Pilsbry (1948) under his discussion of Quickella vagans (Pilsbry).

Range. Currently known only from Lake Waccamaw, Columbus County, North Carolina.

Habitat. Like other ambersnails (Family Succineidae), this species probably never occurs far from water. Type material was collected from "wet, sandy ground, moist boards and dead leaves" from a shaded portion of the shoreline (Franzen, 1981). I collected topotypic specimens in June, 1989, and found the species restricted to a narrow band of shoreline, ranging between 1 and 3 feet from the water's edge. The soil in this band was continually damp and the area was very heavily shaded. Almost all specimens were found under leaf litter, probably due to its stabilizing influence on their microclimate. Heavy shading of the shoreline may be an essential habitat element for the species.

Life History and Ecology. Nothing is known of the life history and ecology of this species.

Special Significance. Based on available information, this species must be considered a North Carolina endemic; therefore, proper conservation and stewardship of this species in the state is essential for its survival.

Type Locality. North shore of Lake Waccamaw near the intersection of Lake Shore Drive and McRae Lane, Columbus County, North Carolina.

Systematics. Pilsbry (1948) considered Lake Waccamaw specimens of this taxon to be variants of Catinella vagans (Pilsbry, 1900). Franzen (1981) examined specimens of C. vagans from its type locality (Cape May Point, New Jersey) and Lake Waccamaw and, using detailed observations of conchology and soft-part anatomy, determined that the Lake Waccamaw specimens represented a distinct species and named it Catinella waccamawensis. However, while recognizing C. vagans as distinct, Hubricht (1983, 1985) synonymized C. waccamawensis with Catinella avara (Say, 1824) with no supporting argument. Based on the support for separation from C. vagans provided by Franzen (1981) and the lack of any supporting argument

for synonymy with C. avara by Hubricht (1983, 1985), C. waccamawensis is being treated as a valid species here. Should Hubricht's (1985) assertion eventually prove correct, this taxon will need to be removed from protection lists because C. avara is abundant in the state.

Status. Vulnerable, Category 1.

Rationale for Evaluation. This species is currently known only from the shoreline of Lake Waccamaw, an area which has undergone substantial shoreline development. Primary and secondary impacts of this development (shoreline clearing, bulkheading, boat wakes, foot traffic, etc.) on the species has probably been severe. The combination of a restricted range and heavy human use pressure on its habitat make this species particularly vulnerable.

Current Protection. None. Some measure of protection is provided to the habitat of this species through federal designation of the Waccamaw silversides (Menidia extensa), an insular aquatic neighbor, as a threatened species. However, such protection is purely incidental and important components of the Waccamaw ambersnail's habitat are certainly unprotected.

Recommendations. Ambersnails are difficult to identify and in great need of systematic revision. Future revisions will probably rest on allozyme analyses and characters of soft-tissue anatomy, especially the genitalia. While such studies may clarify the phylogeny of the group, field identifications will certainly remain difficult. In spite of this obstacle, survey work for the ambersnails is greatly needed and should be undertaken. Occurring as they do in the ecotone between aquatic and terrestrial habitats, they are frequently overlooked by collectors investigating one habitat or the other. Future survey work on ambersnails in North Carolina should attempt to clarify both the status and systematic placement of Catinella waccamawensis.

Remarks. This species has no recognized vernacular name. The name assigned in this report was derived from the type locality and the cognomen ambersnail, which is applied to all species in the family Succineidae.

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Prepared by WILLIAM F. ADAMS

Paravitrea ternaria Hubricht, 1978
SCULPTED SUPERCOIL

Description. The only information available for the sculpted supercoil comes from Hubricht (1978, 1985). The following description is an abbreviated version of Hubricht's original description. The holotype has a diameter of 6.8 mm and a height of 3.4 mm. The sculpted supercoil is a small, shiny, pale brownish, subhyaline shell with 8.5 slowly increasing whorls. The umbilicus is deep, well like and contained in the shell diameter about five times. The aperture is narrowly lunate and simple. The top of the whorls are sculptured with numerous, irregularly spaced, impressed growth lines. There are usually 2 or 3 radial rows of 3 large teeth.

Range. The sculpted supercoil is found in Unicoi County, Tennessee and Madison County, North Carolina (Hubricht 1985).

Habitat. The sculpted supercoil is "found under moist leaf litter on wooded hillsides and in ravines" (Hubricht 1985).

Life History and Ecology. Nothing is known of the life history or ecology of this species.

Special Significance. None.

Type Locality. The type locality of Paravitrea ternaria is a ravine, 0.5 miles northeast of Ernstville, Unicoi County, Tennessee, Holotype 171668, and Paratypes 171669 FMNH (Hubricht 1978).

Systematics. No synonyms or taxonomic problems are evident.

Status. Vulnerable, Category 1.

Rationale for Evaluation. The sculpted supercoil is known from two counties in the United States, one of those counties is in North Carolina. This snail is apparently rare and has a very limited distribution, it should be listed as threatened.

Current Protection. None.

Recommendations. It is recommended that extensive survey work be done on forest litter gastropods in the Appalachian Mountains. If the sculpted supercoil is still rare with a limited distribution then it should be federally listed as endangered.

LITERATURE CITED

Hubricht, Leslie. 1978. Thirteen new species of land snails from the southeastern United States with notes on other species. Malacol. Review, 1977, 10(1-2):37-52.

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Prepared by EUGENE P. KEFERL

Paravitrea varidens Hubricht, 1978
ROAN SUPERCOIL

Description. The only information available for the Roan supercoil comes from Hubricht (1978, 1985). The following description is an abbreviated version of Hubricht's original description. The holotype has a diameter of 7.6 mm and a height of 4.6 mm. The Roan supercoil has a shiny pale brownish, subhyline shell with 8.5 to 9 slowing increasing whorls. The umbilicus is deep, well-like and contained in the shell diameter about five times. The aperture is lunate and simple. The top whorls are sculptered with numerous irregularly spaced, impressed growth lines. The adults are toothless and the immature shells have 2 or 3 radial rows of 3 or 4 large teeth within the last whorl.

According to Hubricht (1978), Paravitrea varidens is probably more closely related to P. ternaria Hubricht, 1978, differing in frequently having 4 teeth in a row, and in having them present only in immature shells.

Range. The Roan supercoil is found in Carter County, Tennessee and in Mitchell and Yancey counties, North Carolina.

Habitat. The Roan supercoil has been "found in leaf litter on wooded mountainsides. On the summit of Roan Mountain, it was found in a bramble patch" (Hubricht 1985).

Life History and Ecology. Nothing is known of the life history and ecology of P. varidens.

Special Significance. None.

Type Locality. The type locality of P. varidens is the summit of Roan Mountain (6250 ft), Mitchell County, North Carolina, Holotype 171664, Paratype 171665, FMNH (Hubricht 1978).

Systematics. No synonyms or taxonomic problems are evident.

Status. Vulnerable, Category 1.

Rationale for Evaluation. The Roan supercoil is apparently rare and has a very limited distribution. This snail is known from only three localities in three counties in the United States. This species should be considered threatened.

Current Protection. None.

Recommendations. It is recommended that extensive survey work be done on forest litter gastropods in the Appalachian Mountains. If the Roan supercoil is still rare with a limited distribution then it should be federally listed as threatened.

LITERATURE CITED

Hubricht, Leslie. 1978. Thirteen new species of land snails from the southeastern United States with notes on other species. Malacol. Review, 1977, 10(1-2):37-52.

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Prepared by EUGENE P. KEFERL

Mesodon clarki nantahala (Clench and Banks, 1932)
NOONDAY GLOBE

Description. The noonday globe has a subglobose, imperforate shell of about 5 1/2 whorls. It measures 17-18 mm wide but with its low spire is only 11 mm high. It is dark reddish and quite shiny when fresh. According to Burch (1962), Mesodon clarki varies from pale buff to tan and is less glossy. Pilsbry (1940) described the lip as sharply reflected and the peristome as white. The basal peristome is thickened to form an almost blade-like tooth. The parietal surface bears a long recurved tooth. The shell (even the embryonic whorl) is sculptured with rather coarse striae. Both Burch (1962) and Pilsbry (1940) point out that Mesodon clarki clarki resembles a small, flattened Mesodon elevatus; but the noonday globe is most likely to be mistaken for M. c. clarki or M. wheatleyi. These three are imperforate, have around 6 whorls, parietal teeth, and animals with dark bodies (Van Devender 1984). M. wheatleyi has only a small parietal tooth, lacks the blade on the basal edge of the aperature and always lacks the spiral lines found in many Mesodons. M. c. nantahala differs from M. c. clarki in that it is larger and more depressed with a rounded body whorl.

Range. The noonday globe is endemic to the Natahala Gorge near the junction of Cherokee, Swain, and Macon counties. It takes its name from the orientation and depth of the gorge. The sun only illuminates parts of the cliffs at noontime. It is known from the vegetation level with the road up to several hundred feet up the cliff face.

Habitat. This rare snail is found for only about two miles along the north facing cliffs (1100 foot drop) along U.S. 19 in the gorge. The area is forested, shady, and very mesic. There is a lot of exposed rock (some of it calcareous) and an unusually thick layer of humus. The forest has mixed mesophytic elements with rich herbaceous undergrowth.

Life History and Ecology. In April, 1983, snails were found active on the surface vegetation during warm rains (Van Devender 1984). Snails were moving about during daylight and night hours. The snails seem to eat vegetation and probably fungal mycelia. During the early spring, live snails of several size classes were found. The snails probably breed in early summer, overwinter as juveniles, become sexually mature around one year of age and occasionally live another winter. Worn mature adult shells were rare.

Special Significance. The rareness of this snail and other natural features that contribute to the lovely uniqueness of the Nantahala Gorge helped circumvent the widening of U.S. 19 in this area. This is a heavily used recreation site and human impact is a problem. Conserving the snail's habitat helps protect the beauty of the gorge.

Systematics. Clench and Banks described this variant as new species in 1932; but Pilsbry (1940) gave it subspecific rank. More work needs to be done on this complex. Mesodon clarki is rare but widespread in SE Tennessee, western North Carolina, and northern Georgia while M. c. nantahala occurs in the gorge and possibly in the Nantahala Mountains. On

the far side (north) of the Nantahala River, "M. clarki" tends to be smaller than normal while M. c. nantahala tends to be larger than typical. Could three distinct subspecies occur near the gorge separated by habitat differences?

Status. Threatened.

Rationale for Evaluation. This species has a very restricted range which fortunately lies all within National Forest lands. This land use status affords the snail protection from mining and timber cutting. The state revised its long term plans for road building to bypass the gorge altogether, and the mesic conditions and numerous springs control the threat of fire. The only real danger left is heavy human use of the habitat. The site is so accessible to the road that trampling by people climbing the cliffs or getting spring water could hurt the population. Reports circulated that some visitors added bleach to the spring water with unknown results (Steve Morrow, pers. comm.).

Current Protection. Federally listed as a threatened species. A Recovery Plan is being implemented.

Recommendations. Plans are presently being worked out by the U.S. Forest Service and the U.S. Fish and Wildlife Service (Larry Luckett, pers. comm.) to delimit the actual extent of the species' range and to monitor the population size. Some type of public education program to warn visitors away from sensitive areas might be in order. More work on the systematics and ecology should be encouraged.

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Prepared by AMY S. VAN DEVENDER

Mesodon ferrissi (Pilsbry, 1897)
SMOKY MOUNTAIN COVERT

Description. Pilsbry (1940), Burch (1962), and Solem (1955) describe this species as having a thin, glossy imperforate shell with 4 1/2 - 5 1/2 whorls ranging in width from 17.9-24.7 mm and in height from 9.2-13.9 mm. Solem (1955) discusses the variation in the height of the spire that may correlate with ecological variation. The habitat of close packed rock piles may favor a lower spire while overhanging ledges may favor a higher spire. The shell is a distinct yellowish olive with fine, low striae and fine engraved spiral lines. The last whorl is rounded, descends very little in front and is only slightly contracted behind the broadly reflected lip. It resembles Triodopsis dentifera in shape and, like it, has a single parietal tooth but is glossier. It lacks the basal lamina distinctive in Mesodon perigraptus. All three references have illustrations.

Range. Mesodon ferrissi is restricted to the upper elevations (from perhaps 2500' to 6600') of the Smoky Mountains along the North Carolina-Tennessee border (Pilsbry 1940, Solem 1955). Welch Bald in the southwestern edge of the range is under 25 airline miles from Mt. Guyot on the northeast edge of the range. All known sites, with the exception of Plott Balsam in Jackson County, North Carolina (possible type locality of M. ferrissi sericeus) lie within the boundaries of the Great Smoky Mountains National Park.

Habitat. This snail is restricted to the upper elevations within the Park. The whole area (Solem 1955) consists of massive beds of conglomerate rocks dipping sharply to the south and southeast so the north and northwest slopes are very steep. Many rock ledges and boulders have part of the undersurface free of the ground. The exposed area is covered with a luxuriant growth of fungi and a film of seepage water. The ground is covered with sphagnum moss and many rotting logs. In the Chimneys area (2800') the snails are associated with small moss covered rocks on a steep slope with plenty of seepage water (Clench 1937).

List History and Ecology. Solem (1955) summarized the known ecological data. The snail is always associated with rock, from huge boulders and overhanging ledges to tightly packed rock slides. M. ferrissi has very high moisture requirments (or extreme susceptibility to dry conditions). It is probably found only in (or close to) areas within its range with a constant flow of water. Pilsbry (1900) mentions this species as one possessing a thin shell, possibly correlated with extreme conditions of minimal calcium at the higher elevations. Hubricht (1985) stresses that it is active at night.

Special Significance. This is an endemic of the high elevations of the Great Smoky Mountains.

Systematics. Mesodon ferrissi was described as Polygyra ferrissi (Pilsbry, 1897). Though its shell superficially resembles Triodopsis dentifera, it is isolated anatomically, forming its own species subgroup.

Status. Vulnerable, Category 1.

Rationale for Evaluation. This species is known only from a restricted area within the Great Smoky Mountains National Park. It seems to have a viable population size at this time (found in all sites sampled - A.S.V.). Being a larger snail, it may be eaten by wild boar and in some danger from overcollecting in more exposed sites. However, the species may be particularly vulnerable to environmental pressures in the changing conditions of the upper elevations spruce-fir forest. In an area of little calcium and increasingly acidic conditions, a moisture loving snail with a thin shell may soon reach its tolerance. The high elevation forest itself is declining from the onslaught of the introduced balsam woolly aphid and increased atmospheric deposition of pollutants (White 1984).

Current Protection. Occurs in Great Smoky Mountains National Park.

Recommendations. There should be consistent monitoring of population status with estimates of such variables as shell thickness and shell size. Efforts to study and eliminate the stressors of forest destruction and "acid rain" should be strongly encouraged. The systematic variation in the Plott Balsams should be investigated.

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Prepared by AMY S. VAN DEVENDER

Mesodon jonesianus (Archer, 1938)
BIG-TOOTH COVERT

Description. This is a small, subglobose Mesodon, with shell height of 7.5 to 8.5 mm and a diameter ranging from 12.8 to 13.5 mm. It has 5 1/4 well impressed whorls, which gradually increase in size towards the aperature. The umbilicus is imperforate. The shell surface is light chestnut in color, faintly hirsute, covered with axial ribs and very fine and closely arranged granules. The aperature is ovate-lunate in shape with the lip reflected, and there is a pronounced, slightly curved parietal tooth. Additional conchological descriptions and figures can be found in Archer (1938), Pilsbry (1940), Burch (1962), and Bogan and Parmalee (1983). Pilsbry (1940) also figures the genitalia. Caution should be used in referring to Pilsbry's (1940) figures of the shell of M. jonesianus. Close inspection shows that the small specimen labeled M. jonesianus in figure 455c is actually Mesodon wetherbyi, and that the small specimen in Figure 455a, labeled M. wetherbyi, is actually M. jonesianus. This snail is similar in appearance to both M. wetherbyi and Mesodon subpalliatus but can be distinguished from them by its smaller size and a narrower last whorl (Pilsbry 1940). It is also very similar to toothed forms of Mesodon wheatleyi, from which its separation is more difficult (see Systematics, below).

Range. This species is known only from elevations between 3400 and 5200 feet on three ridges in the Newfound Gap region of the Great Smoky Mountains National Park in Swain County, North Carolina, and Sevier County, Tennessee. Hubricht (1970) included Haywood County, North Carolina, within its range but later (1985) withdrew the record. Based on Hubricht's 1970 record, other authors included Haywood County in the range of the species during the intervening years. However, as a recent search of museum records at ANSP did not locate any Haywood County specimens, it appears that the species should be considered restricted to the vicinity of Newfound Gap.

Habitat. Archer (1938) stated "It inhabits the birch-beech-maple-hemlock forest of the higher elevations....Its habitat is under the top layer of leaves and hemlock spills, or under bark and logs in a cover of fallen limbs and twigs". Thompson (1978) noted the scattered occurrence of this species within its habitat and attributed it to the calcium deficiencies normally found in acid soils such as those underlying the area. The most abundant population encountered by Thompson (1978) was at elevation 3400 feet in a "wet, mixed stand of Maple-Buckeye-Tulip Poplar." He found the species under fallen bark, limbs, logs, and leaves but did not encounter it under rocks.

Life History and Ecology. Nothing is known of the life history or ecology of this species.

Special Significance. None known.

Type Locality. Near Newfound Gap, 2 1/2 miles south of Mount LeConte, Swain County, North Carolina.

Systematics. This species was described and placed in the subgenus Mesodon within the genus Polygyra by Archer (1938). Pilsbry (1940) elevated Mesodon to genus level and placed jonesianus within it in the subgenus Patera. Thompson (1978) raised questions regarding the relationship of this species to Mesodon wheatleyi, noting areas where possible intergrades occur. A forthcoming monograph on the genus Mesodon from Ken Emberton (ANSP) may help to clarify this situation.

Status. Vulnerable, Category 1.

Rationale for Evaluation. Although Thompson (1978) found the species to be widely distributed within its range, its known range is exceedingly small. Direct destruction of individuals undoubtedly occurs through trampling by hikers and rooting activities of wild hogs (Sus scrofa); however, these activities are not known to be a serious threat at this time. Alteration of soil chemistry and microflora by acid precipitation may be seriously impacting the habitat of this species and is, at present, considered the greatest threat to its survival.

Current Protection. This species currently has no legislative protection. As all known populations occur entirely within the Great Smoky Mountains National Park, the habitat of the species receives some protection.

Recommendations. The effects of acid precipitation on this species and its congeners should be investigated. In addition, its systematic relationship with Mesodon wheatleyi should be evaluated through the use of allozyme analysis.

Remarks. The common name used here is that established by Turgeon et al. (1988). Other common names which have been used for this species are Jones' Middle-toothed Land Snail and the Newfound Gap Helix.

LITERATURE CITED

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Prepared by WILLIAM F. ADAMS and RICHARD G. BIGGINS

Mesdon orestes Hubricht, 1975
ENGRAVED COVERT

Description. Hubricht (1975) describes the shells of Mesodon orestes as semi-globose, depressed, and imperforate. Shells are pale olive brown, dull, and thin. There are 5 to 5 1/4 whorls measuring up to 18.3 by 11.4 mm. The aperature is oblique and lunate with a broadly reflected, white lip that is appressed over the umbilicus. Some specimens have a small parietal tooth. The body whorl has numerous engraved spiral lines and distinct low rib striae. Hubricht compares it to Mesodon wheatleyi, but notes that it has spiral engraved lines rather than short hairs. Its shape is also similar to Mesodon ferrissi, but it is smaller and has a pitted surface rather than papillae on internal whorls.

Range. This species is known from high elevations in the Plott Balsam Mountains of Haywood and Jackson counties, NC.

Habitat. Hubricht (1985) mentions finding this species in crevices of rock ledges. It crawls about in the open in wet weather.

Life History and Ecology. Nothing is known.

Special Significance. This species has a very small range near a popular tourist area. It is known from along the Blue Ridge Parkway at the edge of the Cherokee Indian Reservation, south of the Great Smoky Mountains National Park. The type locality is at 6200 feet in an area whose high elevation forests are being damaged by air pollution.

Type Locality. The type locality is Waterrock Knob at 6200 feet in Haywood County, NC. This is in the Plott Balsam Mountains.

Systematics. This species was discovered and described in 1975.

Status. Vulnerable, Category 1.

Rationale for Evaluation. This nearly unknown species lives in a small area at high elevations in a region whose plant life and soil are currently being adversely affected by air pollution.

Current Protection. Its range is partially on protected land along the Blue Ridge Parkway.

Recommendations. More study of the range and ecology of this species is essential to understanding its protection needs.

LITERATURE CITED

Hubricht, Leslie. 1975. Four new species of land snails on the eastern United States. Nautilus 89(1):1-4.

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Prepared by AMY S. VAN DEVENDER

Mesdon clingmanicus (Pilsbry, 1904)
CLINGMAN COVERT

Description. This is a variant of the more widespred Mesodon wheatleyi known from most of the southern Appalachians. The shell is small, thin, and fragile and is nearly a transparent, glossy green. It is covered with short, delicate hairs. It has a narrow lip and lacks a parietal tooth (unlike M. wheatleyi). It measures 13 mm in diameter and 9 mm high. The rib striae found in M. wheatleyi are nearly effaced in this snail.

Range. Pilsbry (1940) gives the range as the summit of Clingman's Dome on the TN - NC border. Hubricht (1985) defines this range as Cherokee and Graham counties, NC and Monroe County, TN.

Life History and Ecology. This snail prefers coniferous forest at high elevations from 5500' to the summit of Clingman's Dome. Its shell is very thin like many high elevation species. In life it is covered with dirt. Hubricht (1985) found it as low as 2000' elevation under rocks, logs, and leaf litter.

Special Significance. This is another species of the high elevation snail assemblage whose habitat is being threatened by air pollution. Calcium, an already scarce nutrient as evidenced by the snail's thin shells, is rapidly leached from these soils. The coniferous forest that provides the cool, moist shade needed by this species is succumbing to disease (Van Devender 1985).

Type Locality. The species was described from specimens taken near the summit of Clingman's Dome in the Great Smoky Mountains.

Systematics. Pilsbry (1940) gave the following synonymy. He described it as Polygyra wheatleyi clingmanica in 1904, but later divided Mesodon out with clingmanicus still a subspecies of wheatleyi in 1940. Hubricht (1985) presents a problem. With no discussion of his rationale, he elevates clingmanicus to a full species and then gives it the anatomy and distribution of Mesodon wheatleyi. This may all just be a publishing error but it needs clarification.

Status. Vulnerable, Category 1.

Rationale for Evaluation. This snail has a restricted range in an area with a deteriorating environment.

Current Protection. Its range is within national park lands.

Recommendations. This snail probably should be investigated for threatened status and any protection that can be provided will depend on the stability of its environment. Clarification of its taxonomic status will be included in Emberton's monograph on Mesodon.

Remarks. The common name assigned here is derived from the type locality.

LITERATURE CITED

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Prepared by AMY S. VAN DEVENDER

Triodopsis soelneri (J.B. Henderson, 1907)
CAPE FEAR THREE TOOTH

Description. Pilsbry (1940) and Burch (1962) give the following details from Henderson's description. Depressed globose with rounded periphery. Perforate, the opening half covered by columellar lip. Surface very glossy with close, deep, even rib straie, 5 1/2 whorls, diameter 10-11 mm. Lip reflexed with internal thickening widest basally but that does not extend to the columellar end of the lip. Long curved parietal tooth. Color mahogany with a glossy satin-like sheen. Shell contracted behind purple lip.

Range. This snail is a North Carolina endemic restricted to sites in four counties in extreme southeastern North Carolina (Hubricht 1985). Searches in the type locality have turned up fewer and fewer live snails in the last three years (Emberton, pers. comm.). The snails favor swampy regions and this area's swamps have been severely affected by drought since 1987. Hubricht (1985) claims the snails may also be found under trash in pine woods. He speculates that since most of the pine woods T. soelneri have a small tooth in the outer lip, it may be hybridizing with Triodopsis messana. The two may hybridize in the laboratory.

Life History and Ecology. Little is known of the snail's life history. Pilsbry (1940) says the snail shows a distinct preference for fallen logs (particularly cypress) and wet conditions. Hubricht (1985) adds it may be found under trash in pinewoods.

Special Significance. Emberton (1988) discusses Grimm's interesting theories on this species as a member of the Triodopsis fallax group. Apparently three separate species have radiated from the ancestral T. fallax stock as recently as Plio-Pleistocene regressions of the ocean waters. This radiation is mirrored by another radiation from Triodopsis alabamensis further south. Here is an ongoing evolutionary experiment awaiting further study.

Type Locality. North shore of Lake Waccamaw, Columbus County, N.C.

Systematics. T. soelneri was described as Polygyra soelneri by J.B. Henderson in 1907. Polygyra was the blanket genus name at that time (Emberton 1988). In Pilsbry (1940) it was placed in the genus Triodopsis s. str. because of its penial anatomy. Emberton (1988) discusses its relationship to T. fallax.

Status. Vulnerable, Category 1.

Rationale for Evaluation. T. soelneri is a North Carolina endemic. It was always rare and there has been a drastic population drop. In fact, though Emberton spent three days looking for it at the type locality in 1987, no live animals were found. Drought has adversely affected these swampy areas in recent years and this species may be a victim. The most recent records are from New Hanover County, where W. F. Adams collected 2 specimens in 1989.

Current Protection. None.

Recommendations. Immediate efforts to locate remaining populations of this species should be undertaken. Study of its ecology (especially its possible preference for two types of habitats) should have high priority. Drought conditions have ended so rechecks of the Lake Waccamaw site are in order.

LITERATURE CITED

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Prepared by AMY S. VAN DEVENDER

Pallifera hemphilli (W. G. Binney, 1885)
BLACK MANTLESLUG

Description. The black mantleslug is a member of the family Philomycidae, and as such, lacks the familiar shield shaped mantle common to introduced slugs of the families Arionidae and Limacidae. In the Philomycidae, the mantle covers the entire back of the animal. The black mantleslug is "long, narrow, cylindrical, with pointed tail (Binney 1885)." The mantle of Pallifera hemphilli is uniformly black, fading to gray at its edges. The species normally ranges from 25 to 30 mm in length.

Range. Hubricht (1985) reports this restricted species only from high elevation forests in the mountains of Virginia, Tennessee, and North Carolina. Pilsbry (1948) also lists Georgia (Hall County) and Michigan (Ontonagon County and Ann Arbor) as places of occurrence. Those locales may represent established populations, however, Hubricht (1985) reviewed Pilsbry's text and selected not to include them, presumably due to taxonomic uncertainties. North Carolina is apparently the stronghold for the black mantleslug as it is known from 5 counties in the state; Avery, Jackson, Mitchell, Swain, and Yancey. It is known from only 2 counties each in Virginia and Tennessee. Walker and Pilsbry (1902), in an account which includes a delightful description of traveling in the mountains of North Carolina at the turn of the century, stated that the black mantleslug was common on Mt. Mitchell (Yancey County).

Habitat. Hubricht (1985) believes this species to be restricted to spruce-fir forests above 5000 feet and reports it most frequently found during wet weather. However, Pilsbry (1948) indicates a less restrictive habitat, reporting occurrences as low as 2000 feet.

Life History and Ecology. Nothing is known of the life history or ecology of this species.

Special Significance. This taxon may be an extremely good indicator species for habitat perturbations in high elevation forests.

Type Locality. Mount Mitchell, Yancey County, North Carolina.

Systematics. Binney (1885) described the species and placed in the genus Tebennophorus Binney, 1842. The generic name Philomycus Rafinesque, 1820 had priority over it, and was subsequently used until Walker (1906) transferred it to Pallifera Morse, 1864.

The differing species concepts used by Pilsbry (1948) and Hubricht (1985) restrict the certainty with which any status assessment of Pallifera hemphilli can be made. Taxa in the Family Philomycidae are poorly known and there may be some which are as yet undescribed. Many forms of established species are known and these may be separable as distinct species once detailed anatomical and allozymic investigations are made.

Status. Vulnerable, Category 2.

Rationale for Evaluation. Ecological perturbations occurring in high elevation spruce-fir forests may have severely impacted this species. Lacking a shell, the species has little protection from adverse edaphic or climatic conditions. Its food sources may also have been adversely impacted by these events. Given this species' apparently restricted range and the changes occurring within it, its populations should be considered imperiled until investigations can be undertaken which show that its populations are stable.

Current Protection. None.

Recommendations. Differing species concepts, evidenced by Pilsbry (1948) and Hubricht (1985), add an element of uncertainty regarding the potential range of this species in the state. Resolution of this taxonomic issue should be given high priority. Should the broader species concept used by Pilsbry be correct, spot surveys should be performed to determine the need for more extensive surveys. If Hubricht's restricted species concept proves correct, monitoring of populations in the state's high elevation forests should be undertaken to assess population trends.

LITERATURE CITED

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_____., and Henry A. Pilsbry. 1902. The mollusca of the Mt. Mitchell region, North Carolina. Proc. Acad. Nat. Sci. Phila. pp.413-442.

Prepared by WILLIAM F. ADAMS

Discus bryanti (Harper 1881)
SAW-TOOTH DISC

Description. The umbilicus of this species is widely open and the spire greatly depressed, making the shape of the shell almost planiform. The whorls are heavily ribbed, usually more heavily above than below. The outer whorl is carinate at its upper and lower margins, with the space between the carinae almost flat. This shape renders the aperature quadrate. Its greatest diameter ranges from 6.5 to 7.5 mm. A complete description with illustrations can be found in Pilsbry (1948). Burch (1962) also figures this species.

Range. This species has a very restricted range which essentially stradles the North Carolina/Tennessee state line. It is known from only eight counties total: Madison, Mitchell, Watauga, and Yancey counties in North Carolina; Carter, Unicoi, and Sullivan counties in Tennessee; and one outlying record from Jackson County in Alabama. For unknown reasons, Hubricht (1985) did not include the Alabama record in his map for the species.

Habitat. Little is known of the habitat of this species. Hubricht (1985) describes its habitat as "leaf litter in rocky upland woods." Pilsbry (1948) gives its habitat as under, and in, rotting logs.

Life History and Ecology. Nothing is known of the life history and ecology of this species.

Special Significance. None known.

Type Locality. Mitchell County, North Carolina.

Systematics. The validity of this species has never been questioned, however, its genus name has changed in concert with the rules of zoological nomenclature. It was originally described and placed in the genus Patula Held. Later workers considered it to be in the genus Gonyodiscus Fitzinger as it had priority for this group. However, Gonyodiscus Fitzinger and Discus Fitzinger are sychronous synonyms, giving priority to Discus, the name used in the first revision of the group.

Status. Vulnerable, Category 2.

Rationale for Evaluation. Over forty years ago, Pilsbry (1948) included remarks indicating that this species is "solitary and very rare." Our knowledge of it today does not indicate that this condition has changed. Populations of this species are especially vulnerable to habitat disturbances due its restricted range. Any habitat disturbance, such as logging, habitat fragmentation, acid precipitation, etc., within its range and preferred habitat could adversely affect it.

Current Protection. This species currently has no legislative protection. However, some populations may occur on state or federal lands.

Recommendations. Studies on the autecology of this species are greatly needed. Status surveys should also be undertaken.

LITERATURE CITED

Burch, John B. 1962. How to know the eastern land snails. W. C. Brown Co.

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Prepared by WILLIAM F. ADAMS

Helicodiscus bonamicus Hubricht 1978
SPIRAL COIL

Description. "Shell small, discoidal, spire depressed, dull, opaque brownish-gray; umbilicus wide and shallow, contained about twice in the diameter of the shell; whorls 5, very slowly increasing in size, the last whorl deflected downward behind the aperature; aperature lunate, and oblique to the axis of the shell, lip slightly thickened, simple; sutures deeply and regularly impressed; whorls with numerous spiral lirae, 3 to 5 of which bear long deciduous hair-like processes; there is usually a pair of small tubercles well within the aperature."

"Height 1.4 mm, diameter 4.2 mm, aperature height 1.1 mm, aperature width 1.1 mm, umbilicus diamter 2.3 mm, 5 whorls. Holotype" (Hubricht 1978).

This species resembles Helicodiscus fimbriatus, but differs most noticeably in having reduced internal aperatural teeth and more pronounced deciduous hairs. The umbilicus is also shallower. The only published illustrations of this taxon are included in Hubricht's description (1978).

Range. Hubricht (1985) reports this species only from Graham and Swain counties, North Carolina. Earlier, Hubricht (1978) gave the distribution for the species as the Macon-Swain County line, near Handpole Creek. Near the type locality, Graham, Swain, and Macon counties meet at the mouth of Handpole Creek. The proximity of this junction may have led to some uncertainties in determining in which county the collections were made. Regardless, available records indicate that the species may be restricted to the immediate vicinity of this tri-county area.

Habitat. Little is known of the habitat requirements of this species. Hubricht (1985) reports it from leaf litter on wooded hillsides.

Life History and Ecology. Nothing is known of the life history or ecology of this species.

Special Significance. None known.

Type Locality. Base of mountain in Nantahala Gorge, near Handpole Creek, 0.4 mile north of Beechertown, Swain County, North Carolina (Holotype 187064 FMNH, Paratypes 171321 and 187065 FMNH).

Systematics. There are no known systematic questions regarding this species.

Status. Vulnerable, Category 2.

Rationale for Evaluation. The known range of this species is so restricted that it must be considered vulnerable. As with our other mountain land snails, potential impacts from logging and acid precipitation are of great concern. Improvements to highways and railroad lines in the area could also impact the habitat of this species.

Current Protection. This species currently has no legislative protection. However, portions of the population may occur on Nantahala National Forest lands.

Recommendations. Like other land snails, studies on the autecology of this species are greatly needed. Status surveys should be conducted with the objectives of assessing the known populations and finding out if additional populations occur. In addition, museum collections of *Helicodiscus fimbriatus* should be reviewed to determine if misidentified specimens of this species from other areas are included.

LITERATURE CITED

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_____. 1985. The distributions of the native land mollusks of the eastern United States. Fieldiana (Zoology) 24:1-191.

Prepared by WILLIAM F. ADAMS

Helicodiscus fimbriatus Wetherby, 1881
FRINGED COIL

Description. The shell of this thin, flat, circular snail is a light green color and consists of about five, gradually increasing whorls. The aperture is crescent-shaped and is slanted relative to the axis of the shell. The whorls have from six to eight ridges. The greater diameter is 5 mm; the lesser diameter is 4.5 mm and the height is 1.5 mm. Additional descriptions may be found in Pilsbry (1948).

Range. Extreme southeast corner of Kentucky, extreme southeastern corner of Tennessee, extreme southwestern corner of North Carolina (Cherokee and Graham counties), extreme northwestern corner of South Carolina, and in about 10 northern counties of Alabama and Georgia.

Habitat. This species is found in leaf litter and under rocks on wooded hillsides (Hubricht 1985). Wetherby (1881) found this species in crevices in slates.

Type Locality. Tellico Gorge, Monroe County, Tennessee.

Status. Vulnerable, Category 2.

Rationale for Evaluation. This species is only found in a small area of the Southeast, and in North Carolina its distribution is very limited.

Current Protection. None.

Recommendations. Additional surveys are needed to determine specific habitats used by the fringed coil and the relative health of the populations.

LITERATURE CITED

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Wetherby. 1881. Jour. Cincin. Soc. N. H. 4:9.

Prepared by JOHN M. ALDERMAN

Glyphyalinia junaluskana (Clench and Banks, 1932)
DARK GLYPH

Description. The dark glyph has a diameter of 6.5 to 7.5 mm, a height of 3.5 to 4.0 mm with about 6 whorls. The shell is a light amber to a yellowish horn. The sculpture consists of radial grooves bordered by beaded riblets. The grooves and riblets are equally developed in the basal area as well. The shell is minutely umbilicated (Pilsbry 1946).

Range. According to Hubricht (1985), G. junaluskana has been found in Union County, Georgia; Monroe County, Tennessee; and Macon, Swain, Graham and Cherokee Counties, North Carolina. This species seems to be restricted to the southern Appalachian Mountains.

Habitat. The dark glyph is "found in moist leaf litter in deciduous woods on mountainsides" (Hubricht, 1985).

Life History and Ecology. Nothing has been recorded about the life history and ecology of the dark glyph.

Special Significance. No special significance can be attributed to the dark glyph.

Type Locality. The type locality of G. junaluskana is a wooded slope of small hill, 2.5 miles east of Andrews, Cherokee County, North Carolina (Pilsbry 1946). The type (86429) is in the Harvard Museum of Comparative Zoology and paratypes (1572115) are in the Academy of Natural Sciences of Philadelphia (Pilsbry 1946).

Systematics. The dark glyph was originally described by Clench and Banks in 1932 as Retinella (Glyphognomon) junaluskana. Pilsbry (1946) made it a subspecies of Retinella sculptilis. Hubricht (1962) made it a distinct species after examining the soft anatomy and placed it in the genus Glyphyalinia. Hubricht (1970) and (1985) lists it as Glyphyalinia junaluskana.

Status. Vulnerable, Category 2.

Rationale for Evaluation. The dark glyph has a limited distribution in an area where development could seriously reduce it's habitat. Much more information is needed concerning this species.

Current Protection. The dark glyph does not currently receive any federal or state protection.

Recommendations. It is recommended that survey work within its known range be conducted in order to determine the habitat, life history, ecology and distribution of this species.

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Prepared by EUGENE P. KEFERL

Glyphyalina pentadelphia (Pilsbry, 1900)
PINK GLYPH

Description. The shell of Glyphyalinia pentadelphia is glossy, pinkish-brown, and with about 4.5 whorls. The diameter is about 5 mm with a height of 2.5 mm. The surface of the shell is sculptured with many irregularly spaced radiating grooves and a few striae in between. The grooves continue on the base, but are weaker (Pilsbry 1946). The aperture is ovate-lunate. The umbilicus is more than one-fourth the diameter (Burch 1962). A more complete description can be found in Pilsbry (1946).

Range. The pink glyph is found in the southern Appalachian Mountains of North Carolina, Tennessee and Georgia. According to Hubricht (1985), the pink glyph is found in Blount, Monroe and Polk Counties of Tennessee; Graham, Cherokee, Clay, Macon and Swain Counties of North Carolina; and Towns and Union Counties of Georgia.

Habitat. The pink glyph is found in pockets of moist leaves in upland woods (Hubricht 1985).

Life History and Ecology. Nothing is known about the life history and ecology of G. pentadelphia.

Special Significance. No special significance is known about the pink glyph.

Type Locality. The type locality is Cade's Cove and the surrounding area, at the western foot of Thunderhead, from about 1800 to 2200 feet elevation, Blount County, Tennessee (Pilsbry 1946). The type is 76856 ANSP.

Systematics. Glyphyalinia pentadelphia was originally described under Vitrea petrophila pentadelphia by Pilsbry in 1900. It was listed as Retinella (Glyphyalops) pentadelphia by Baker (1933) and Pilsbry (1946). Hubricht (1970) lists this species as Glyphyalinia pentadelphia.

Status. Vulnerable, Category 2.

Rationale for Evaluation. The pink glyph appears to be restricted to the southern Appalachians where there has been a lot of recent development. Very little is known about this species.

Current Protection. The pink glyph does not currently receive any state or federal protection.

Recommendations. It is recommended that more survey work be done in the Appalachian Mountains to determine the status of this species and many others which may be threatened or endangered.

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Prepared by EUGENE P. KEFERL

Glyphyalinia vanattai (Pilsbry and Walker, 1902)
HONEY GLYPH

Description. Glyphyalinia vanattai has a depressed, thin, translucent yellow shell about 4.5 mm in diameter, and about 2 mm high. Shell sculpture includes many deeply impressed, irregularly spaced radial grooves with very fine and faint spiral lines (Walker and Pilsbry 1902). There are 5 slowly increasing whorls. The aperture is oblique and broadly lunate. The umbilicus is about one-sixth the diameter of the shell. According to Pilsbry (1946) this species differs from G. clingmani (Dall, 1890) by a smaller shell and different shaped aperture.

Range. According to Hubricht (1985), the honey glyph is found in Carter and Unicoi counties in Tennessee, and Avery, Mitchell and Yancey counties in North Carolina. The honey glyph has been found on Mt. Mitchell (Walker and Pilsbry 1902). Pilsbry (1946) records G. vanattai from Mt. Mitchell (Yancey Co.), Cranberry (Avery Co.), and Magnetic City (Mitchell Co.) in North Carolina. The species has also been found around Roan Mountain (Carter Co.) and Limestone Cove (Unicoi Co.) in Tennessee.

Habitat. The honey glyph is found in moist leaf litter on wooded hillsides and in ravines (Hubricht 1985).

Life History and Ecology. Nothing is known about the life history and ecology of G. vanattai.

Special Significance. The honey glyph does not appear to have any special significance.

Type Locality. The type locality for G. vanattai is Mt. Mitchell, Yancy County, North Carolina (Walker and Pilsbry 1902). The type is 83261 in the Academy of Natural Sciences of Philadelphia.

Systematics. Glyphyalinia vanattai was originally described by Walker and Pilsbry in 1902 as Vitrea vanattai. Baker (1933) and Pilsbry (1946) placed it in the genus Retinella and the subgenus Glyphyalus. Hubricht (1970) placed it in the genus Glyphyalinia. There are no known synonyms for this species.

Status. Vulnerable, Category 2.

Rationale for Evaluation. The honey glyph has a limited distribution in Tennessee and North Carolina. No one knows how common the species is within this small range. In light of the development which has occurred in the Appalachian Mountains, this species should be given special concern.

Current Protection. The honey glyph does not currently receive any federal or state protection.

Recommendations. As is the case with almost all the species which are of special concern, threatened or endangered status, more information is needed to properly protect this species.

LITERATURE CITED

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Prepared by EUGENE P. KEFERL

Paravitrea andrewsae (W. G. Binney, 1879)
HIGH MOUNTAIN SUPERCOIL

Description. The high mountain supercoil is 6.5-8 mm in diameter with a height of 4.2 to 4.5 mm. The snail has 8 to 9 whorls. The umbilicus is about one-sixth to one-seventh the diameter of the shell. The shell is very glossy and corneous. Pilsbry (1946) states that "Teeth are generally present, 3 to 5 being arranged in a radial row, or with several such rows within the basal wall, though the number of teeth may vary down to 0 in the adult stage, or less frequently at any stage of growth." Detailed descriptions, illustrations and comparisons to similar species can be found in Pilsbry (1946).

Range. Perry County, Kentucky (Hubricht 1968). The high mountain supercoil has also been found in Unicoi and Carter counties in Tennessee, and in Watauga, Avery, Mitchell, Yancy, Madison and Buncombe counties in North Carolina (Hubricht 1970, 1985). This snail is restricted to the Appalachian Mountains north of the Great Smoky Mountains National Park, but not extending to Virginia.

Habitat. The only habitat information comes from Hubricht (1985). He states that P. andrewsae is "found in moist leaf litter on wooded mountainsides."

Life History and Ecology. Baker (1931) found that Roan Mountain (Mitchell Co., N. C.) specimens were immature in August, but that Limestone Cove, Unicoi Co., TN., specimens were mature in early April.

Special Significance. The high mountain supercoil has a restricted distribution in the Appalachian Mountains and most of the known localities are found in western North Carolina.

Type Locality. The type locality for P. andrewsae is Roan Mountain, Mitchell County, North Carolina (Pilsbry 1946).

Systematics. Paravitrea andrewsae (W. G. Binney, 1879) was originally described as Zonites andrewsi. Binney, Walker and Pilsbry changed the genus to Gastrodonta in 1902. Then, Pilsbry changed the genus to Vitrea in 1903. H. B. Baker (1931) changed the genus to Paravitrea.

Status. Vulnerable, Category 2.

Rationale for Evaluation. The high mountain supercoil is restricted to a relatively small part of the Appalachian Mountains and could be threatened with further commercial development in the mountains. This species should be considered of special concern until more information is known.

Current Protection. The high mountain supercoil currently has no special protection. Some of the localities are in the Cherokee National Forest and in Roan Mountain State Park which may afford some protection from habitat destruction.

Recommendations. It is recommended that further survey work be done to clearly define those areas which currently have viable populations of the high mountain supercoil and then to protect those areas from any habitat alterations.

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Prepared by EUGENE P. KEFERL

Paravitrea clappi (Pilsbry, 1898)
MIREY RIDGE SUPERCOIL

Description. Pilsbry (1946) described P. clappi as having a depressed shell with nearly flat spire. The base of the shell is deeply indented around a minute umbilicus. It has 6 1/2 narrow, closely coiled whorls sculptured with regular, impressed radiating grooves. The shell is thin, a little transparent, deeply chestnut-amber colored and brilliantly glossy (in life, it appears pink - A.S.V.). This small shell only attains a diameter of 6 to 6.5 mm. It is an unusual Paravitrea in that it has no internal teeth. Pilsbry (1946) has good illustrations and a key to species and a key to subdivisions based on genitalia.

Range. This snail only occurs near or above the 5000 foot contour within the boundaries of the Great Smoky Mountain National Park.

Life History and Ecology. Hubricht (1985) lists it as living in moist leaf litter. Pilsbry (1946) describes its substrate as conglomerate rock. Van Devender (1985) confirmed Pilsbry's (1900) observation that the snails prefer small wet stones "some distance below the surface". Adult size snails were found with immatures in July so the animal lives longer than a year, perhaps overwintering as a juvenile.

Habitat. Pilsbry never mentions a specific habitat but much of the area in the Smokies above 5000 feet is spruce-fir forest or bare rock. The spruce-fir forest was much more extensive before the logging that preceeded the establishment of the park (Pyle 1984). The habitat is moist. There is approximately 200 cm/yr of rainfall and 150 cm of snow. The high humidity is often in the form of fog (White 1984).

Special Significance. This high elevation endemic is just one of an assemblage of snail species whose small refuge is threatened by habitat destruction due to insect infestation of the areas's trees and atmospheric pollutant deposition. The snails have survived some habitat alteration (Van Devender 1985) that adversely affected salamander populations (Mathews and Echternacht 1984). It is not known if these specialized snails can survive the continuing onslaught. The entire upper elevations are beset by complex problems that are causing rapid change.

Systematics. Pilsbry in 1898 described this species as Gastrodonta clappi. In 1903, it was placed in the genus Vitrea. In 1931, H. B. Baker, on the basis of genital anatomy, placed it in section Paravitreops of the subgenus Paravitrea, genus Paravitrea. Section Paravitreops is equivalent to Pilsbry's Paravitrea multidentata group. It is allied with Paravitrea lamellidens which is more widespread and occurs apparently at lower elevations (Pilsbry 1946).

Status. Vulnerable, Category 2.

Rationale for Evaluation. If the habitat survives ongoing changes, the snail is not in serious danger of extinction. In 1984, the population was extant and reproduction was occurring. However, as the habitat is rapidly changing, this species requires periodic reevaluation.

Current Protection. Occurs only in Great Smoky Mountains National Park.

Recommendations. Monitor population as needed. Clarification of its range should be a priority.

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Prepared by AMY S. VAN DEVENDER

Paravitrea lacteodens (Pilsbry 1903)
RAMP COVE SUPERCOIL

Description. The shell of this taxon is small and, like all the Paravitrea, has many coils. Few specimens of the taxon have been recorded and potential variablity in its size is unknown. The type specimen measures 2.4 mm in height, 4.8 mm in diameter, and has 6 3/4 whorls. Most specimens have one to three pairs of tubercular teeth within the last whorl. For a complete description, the reader should consult Pilsbry (1946).

Range. Known definitively only from the vicinity of Tuskeegee, Graham County, North Carolina. Other specimens believed to be this species have been taken near Murphey in Cherokee County (see Remarks, below).

Habitat. Unknown, presumably leaf litter in mesic coves.

Life History and Ecology. Nothing is known of the life history or ecology of this species.

Special Significance. This taxon may be a North Carolina endemic; however, resolution of taxonomic problems may show it to be more widespread than currently believed (see Systematics, below).

Type Locality. Original labels on museum labels at the Academy of Natural Sciences of Philadelphia show the type specimen (ANSP 77798) was collected by H. E. Sargent in 1899 between the community of Tuskeegee and Yellow Creek in Graham County, North Carolina. Paratypes (ANSP 77806), also collected by Sargent, came from "Ramp Cove" (location unknown) near Tuskeegee. Pilsbry's (1946) referral to the locality for the type and paratypes as "Ramp Cove, Tuskeegee Mountain" is misleading as there is no mountain known by this name in the area today.

Systematics. Systematic treatment of this taxon to date has been hindered by reliance on variable shell characters. Due to its similarity to immature stages of Paravitrea capsella and Paravitrea placentula, Pilsbry (1946) considered the systematic status of this taxa uncertain and treated it as a subspecies of Paravitrea capsella. Similarly confusing specimens from Wetumpka, Elmore County, Alabama, and Rock Bluff, Liberty County, Florida, were also treated as P. c. lacteodens by Pilsbry (1946). However, Hubricht (1985) elevated P. lacteodens to full species rank and further stated that "What has been called P. capsella by Pilsbry and others is not that species, but a complex of anatomically distinct species with little or no shell differences. It will be necessary to re-collect all the lots that have been labeled P. capsella and dissect them to make a positive identification."

Status. Vulnerable, Category 2.

Rationale for Evaluation. If Hubricht's (1985) assertion that Paravitrea lacteodens is a distinct species is correct, then it is definitively known only from its type locality. With no additional

records, its distribution must be considered extremely restricted and its survival imperiled by acid precipitation, logging, and other types of environmental perterbations.

Current Protection. None known. However, known localities may be on Nantahala National Forest lands.

Recommendations. Surveys should be conducted to determine the status of the species at its type locality and, subsequently, to locate additional populations of this taxon. Anatomical and allozyme analysis of this taxon and its sibling species (*P. capsella* and *P. placentula*) are needed in order to resolve persisting taxonomic questions.

Remarks. Other North Carolina specimens have been collected by J. H. Ferriss in 1899 from Tuskeegee north of Tuskeegee Creek (ANSP 77697), and by A. F. Archer in 1937 from a ravine near the Clay County line, 5 miles ESE of Murphey, Cherokee County (ANSP 171036). Pilsbry's (1946) and Hubricht's (1985) treatment of the Cherokee County specimens of *P. lacteodens* is unclear as neither mentioned Archer's material in their work.

Acknowledgments. Dr. Arthur Bogan provided locality data from the original lots curated in the collections of the Academy of Natural Sciences of Philadelphia.

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Prepared by WILLIAM F. ADAMS

Paravitrea lamellidens (Pilsbry, 1898)
LAMELLATE SUPERCOIL

Description. The lamellate supercoil has a depressed shell with a low spire. This snail is about 3.5 to 4.0 mm in diameter with a height of about 1.6 to 1.9 mm. P. lamellidens has 6.5 to 7.0 closely coiled whorls. The shell has a evenly rounded periphery. The umbilicus is about one ninth to one tenth the diameter of the shell. The shell is a glossy cinnamon-buff. The upper surface of the spire has distinct, close, regularly spaced striae. The aperture is narrowly lunate. On the inside of the last whorl there are one to three white, curved lamellae on the outer and basal walls. This description has been summarized from Pilsbry (1946), Burch (1962) and Clapp (1920).

Range. The lamellate supercoil is found in the southern Appalachian Mountains. It is recorded from Polk, Monroe, Blount, and Sevier counties in Tennessee and Cherokee, Graham, Macon, Swain, Haywood and Yancey counties in North Carolina (Hubricht 1970, 1985).

Habitat. According to Pilsbry (1946) Paravitrea lamellidens was found on a steep slope of a mountain summit which was "deeply covered with a talus of angular stones, small and large, in the interstices of which there is considerable mold which supports a herbaceous growth." Ferriss (1900) found a number of P. lamellidens under slabs of stone laying on the ground at the top of a 5400 foot bald. The snails were found on the wet stones a few inches to a foot or more below the surface of the talus. Pilsbry (1946) also mentions that this species lives mainly in the moist heights. Hubricht (1985) states that P. lamellidens is found "in pockets of deep, moist leaf litter on wooded hillsides and in ravines".

Life History and Ecology. Nothing is known about the life history and ecology of this species.

Special Significance. The lamellate supercoil appears to be endemic to the southern Appalachian Mountains.

Type Locality. The type locality of Paravitrea lamellidens is Thunderhead, Great Smoky Mountains, Blount County, Tennessee, 10 miles north of the North Carolina line.

Systematics. Paravitrea lamellidens was originally described in the genus Gastrodonta by Pilsbry in 1898. Pilsbry then placed it in the genus Vitrea in 1903. H. B. Baker placed it in the genus Paravitrea in 1931 (Pilsbry, 1946).

Status. Vulnerable, Category 2.

Rational for Evaluation. The lamellate supercoil appears to be restricted to the southern Appalachians. This region is currently receiving a lot of pressure for development and lumbering. This snail should be considered of special concern until the precise status of the species is known.

Current Protection. Fortunately, the type locality and several other localities for the lamellate supercoil are in the Smoky Mountains National Park. Most of the other localities are located in either the Cherokee or the Nantahala National Forests of Tennessee and North Carolina. The lamellate supercoil does not now receive any special protection by any state or federal program.

Recommendations. More information on the distribution, abundance and habitat of this species is needed. Only after more information is obtained can the precise status of this species be determined.

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Pilsbry, Henry A. 1946. Land Mollusca of North America (North of Mexico). Acad. Nat. Sci. Phila., Monogr. No. 3, Volume II (Part 1), 520 pp.

Prepared by EUGENE P. KEFERL

Paravitrea placentula (Shuttleworth, 1852)
GLOSSY SUPERCOIL

Description. The glossy supercoil has a diameter range of 7.2 to 7.8 mm and a height range of 3 to 3.6 mm. The shell has 7 to 7.5 slowly increasing whorls. The size of the umbilicus is about one sixth of the diameter. The glossy supercoil shell is a glossy translucent corneus color with widely spaced, irregular, impressed striae. The aperture is oblique, lunar with a simple peristome. Teeth, if present, are usually small, in two or three pairs and usually in immature specimens. Check Pilsbry (1946) for a more complete description and illustrations.

Range. Paravitrea placentula is found in Letcher, Harlan and Bell counties in eastern Kentucky (Hubricht 1968); Dickenson County in western Virginia; Sullivan, Cocke, Sevier, Blount, Knox, Loudon, Monroe, Polk and Hamilton Counties in eastern Tennessee; Mitchell and Swain Counties in Western North Carolina; and Bartow County in Northern Georgia (Pilsbry 1946, Hubricht 1970, 1985).

Habitat. Very little is known of the habitats for the glossy supercoil. Hubricht (1985) found it "under leaf litter on wooded hillsides and ravines."

Life History and Ecology. Baker (1931) found that specimens collected in early April were mature.

Special Significance. The glossy supercoil has been found in only two counties in western North Carolina. Even though the glossy supercoil has a fairly wide distribution from Georgia to Virginia, virtually all the localities are on the western side of the Appalachian Mountains. The North Carolina populations are on the eastern slopes.

Type Locality. Pilsbry (1946) selected the type locality of P. placentula as Cherokee Bluffs, Knox County, Tennessee (ANSP 150393).

Systematics. Paravitrea placentula (Shuttleworth, 1852) was first described in the genus Zonites. Pilsbry (1903) placed it in the genus Vitrea and H. B. Baker (1931) finally placed it in the genus Paravitrea. According to Pilsbry (1946), Helix Monroensis Lewis, 1871 is a synonym. Hubricht (1985) places P. placentula lithdora Pilsbry, 1946 in synonomy with P. placentula.

Status. Vulnerable, Category 2.

Rationale for Evaluation. The glossy supercoil is currently found in only two counties in North Carolina. This species should be listed as special concern until more information is known.

Current Protection. None.

Recommendations. The best thing that can be done at this time is to do a lot more survey work in the mountains of North Carolina to determine the distribution and habitats for this species in North Carolina.

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Pilsbry, Henry A. 1946. Land Mollusca of North America (North of Mexico). Acad. Nat. Sci. Phila., Monogr. No. 3, Volume II (Part 1), 520 pp.

Prepared by EUGENE P. KEFERL

Paravitrea umbilicaris (Ancey, 1887)
OPEN SUPERCOIL

Description. The open supercoil has a depressed or discoidal shell. The shell varies from 2.9 to 3.6 mm in diameter and 1.5 to 1.7 mm in height. There are 5.5 to 6.5 whorls. The umbilicus is about 1/6 or less of the diameter of the shell. The surface of the corneous shell is dull to the naked eye. Under magnification the surface is marked by "striae cut into minute beads by close decussating, impressed, encircling lines" (Pilsbry 1946:362). The last whorl may be toothless or it may contain radial barriers or lamellae. According to Hubricht (1985) this species has spiral lamella which are about 1/2 whorl long. The size of the shell, the size of the umbilicus and surface sculpture distinguish this species from other Paravitrea. A much more complete description can be found in Pilsbry (1946).

Range. The open supercoil has been found in Blount, Monroe and Polk counties in eastern Tennessee; Cherokee, Graham and Macon counties in Western North Carolina; and in Stephens County, Georgia (Hubricht 1985). Pilsbry (1946) gives the following localities for Paravitrea walkeri (Pilsbry 1900), a synonym; along the Cheoah River near the junction of Yellow Creek, Graham County, North Carolina; and Tuskegee Mountain between heads of Tuskegee and Yellow Creeks.

Habitat. According to Pilsbry (1946), Paravitrea walkeri form dentata H. B. Baker, 1929 (also a synonymn of P. umbilicaris form walkeri) was found in leaf humus at the base of slate ledges in a gorge. Hubricht (1985) records the open supercoil from pockets of deep, moist leaf litter on wooded hillsides and in ravines.

Life History and Ecology. Nothing is known about the life history and ecology of this species.

Special Significance. This species appears to be restricted to mountainous regions in several counties in Tennessee, North Carolina and Georgia south of Great Smoky Mountain National Park.

Type Locality. The type locality of Paravitrea umbilicaris is Alleghany Springs, Blount County, Tennessee on the side of Chilhowee Mountain, about 14 miles southwest of Maryville (Hubricht 1976).

Systematics. According to Hubricht (1976) Paravitrea umbilicaris (Ancey, 1887) is not related to P. multidentata (Binney, 1840) as stated in Pilsbry (1946), but is the same as P. walkeri form dentata H. B. Baker, 1929. Hubricht (1976) recognizes P. walkeri (Pilsbry, 1900) as P. umbilicaris form walkeri (Pilsbry, 1900).

Status. Vulnerable, Category 2.

Rationale for Evaluation. This species has a very restricted range. It is found in a region of the Appalachian Mountains which is under a lot of pressure for lumbering and tourist development. The open supercoil should be considered of special concern until more information is known.

Current Protection. Part of Blount County Tennessee is the Great Smoky Mountains National Park and parts of Monroe and Polk counties, Tennessee are included in the Cherokee National Forest. In North Carolina, parts of Cherokee, Graham and Macon Counties are in the Nantahala National Forest.

Recommendations. A lot more survey work is needed to define the specific locations where this species is located in Tennessee, North Carolina, Georgia and possibly South Carolina. Only after specific data on its distribution, and habitat has been gathered can the precise status of this species be determined.

LITERATURE CITED

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Pilsbry, Henry A. 1946. Land Mollusca of North America (North of Mexico). Acad. Nat. Sci. Phila., Monogr. No. 3, Volume II (Part 1), 520 pp.

Prepared by EUGENE P. KEFERL

Ventridens coelaxis (Pilsbry 1899)
SAW-TOOTH DISC

Description. Pilsbry (1946) provides the following description. "Shell rather widely umbilicate, the width of the umbilicus contained 6 to 6 1/2 times in the greatest diameter of the shell; thin, somewhat fragile, yellow-corneous, sub-transparent, the last suture readily visible through the base; much depressed, the periphery subangular, upper surface convex; surface glossy, sculptured with irregular wrinkles in the direction of growth lines above, almost smooth beneath, and in favorable lights showing subobsolete spiral striae. Whorls 6 1/2, slowly widening, a little convex, the last moderately convex below. Aperature oblique, irregularly lunar, deeply excised by the preceding whorl, not calloused inside, two-toothed a short distance within; one thin and rather short lamella projecting from the lower part of the outer wall, and another smaller one from the middle of the baso-columellar wall; both sometimes wanting; peristome thin and sharp, the outer margin well rounded, baso-columellar margin straightened. Umbilicus well-like, but widening at the opening and showing the penultimate whorl."

"Height 3 mm, diameter 6.6 mm, 6 3/4 whorls; umbilicus contained 6.13 times in diameter."

This species was figured by Pilsbry (1946) and Burch (1962).

Range. This species ranges over nine counties in three states. In North Carolina, it has been recorded from Alleghany, Avery, and Watauga counties. Outside of our state, it has been recorded from Carter, Johnson, and Sullivan counties in Tennessee and Grayson, Smyth, and Washington counties in Virginia.

Habitat. Little information is available on the habitat of this species. Hubricht (1985) states that it occurs "in leaf litter on mountain sides, usually at higher elevations."

Life History and Ecology. Nothing is known of the life history or ecology of this species.

Special Significance. None known.

Type Locality. Cranberry, Avery County, North Carolina (Type 75730 ANSP).

Systematics. The systematic treatment of this species since its description has been stable.

Status. Vulnerable, Category 2.

Rationale for Evaluation. Pilsbry (1946) noted that this species was rare and, while other populations have been encountered since his writing, it is unlikely that its numbers have increased over the intervening years. Populations of this species are especially vulnerable to habitat disturbances due its restricted range. Common habitat modifications such as land clearing, logging, and residential development could be affecting

individual populations and acid precipitation could be adversely affecting the species range-wide.

Current Protection. This species currently has no legislative protection. However, some populations may occur on public lands.

Recommendations. Studies on the habitat requirements and life history of this species are needed. Status surveys of known populations should be undertaken and, once its habitat is understood, searchs for new populations should take place.

LITERATURE CITED

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Pilsbry, Henry A. 1946. Land Mollusca of North America (North of Mexico). Acad. Nat. Sci. Phila. Monogr. 3. Vol. II, Part 1, pp. 1-520.

Prepared by WILLIAM F. ADAMS

Zonitoides patuloides (Pilsbry 1895)
APPALACHIAN GLOSS

Description. The adult shell is between 5 and 6 mm in diameter, light green and not transparent. It is rib-striate throughout except for the first 1 1/2 whorls. It has 4 1/2 to 5 whorls, which are well impressed and slowly increase in size. The aperature has a simple lip with the upper margin flattened and arched downward. The umbilicus is large, contained 3.2 times in the diameter, and clearly shows all the whorls. The species was figured by Burch (1962) and Pilsbry (1946).

Range. This species is known from 5 counties in 4 states, in or near the Great Smoky Mountains. It has been recorded from the following counties; Macon and Swain counties in North Carolina, Blount County in Tennessee, Greenville County in South Carolina, and Rabun County in Georgia.

Habitat. Very little is known about the specific habitat requirements of this species. Hubricht (1985) reports that it should be sought in deep, moist leaf litter on mountain sides or in ravines. Pilsbry (1946) reports one specimen taken from beneath the bark of a rotten log.

Life History and Ecology. Nothing is known of the life history or ecology of this species.

Special Significance. None known.

Type Locality. Thunderhead, Great Smoky Mountains, Blount County, Tennessee (ANSP 12122, Type).

Systematics. This species was originally placed in the genus Gastrodonta but was reassigned to Zonitoides a short time later. Its systematic placement has remained stable since that time.

Status. Vulnerable, Category 2.

Rationale for Evaluation. Like so many other mountain land snails, this species is considered vulnerable due to its restricted range. With such a small range, seemingly minor land disturbing actions could have significant effects on the state's populations of this species. Impacts may be occurring from logging, rooting by wild boars (Sus scrofa), and acid precipitation.

Current Protection. This species currently has no legislative protection. However, some populations occur on public lands.

Recommendations. Studies on the habitat requirements and life history of this species are needed. Status surveys should be undertaken in all known locales for the species and searches for new occurrences should be undertaken once its habitat has been defined.

LITERATURE CITED

Burch, John B. 1962. How to know the eastern land snails. W. C. Brown Co.

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Pilsbry, Henry A. 1946. Land Mollusca of North America (North of Mexico). Acad. Nat. Sci. Phila. Monogr. 3. Vol. II, Part 1, pp. 1-520.

Prepared by WILLIAM F. ADAMS

Haplotrema kendeighi (Webb 1951)
BLUE-FOOT LANCETOOTH

Description. Using shell characters, this species is virtually indistinguishable from Haplotrema concavum, differing only in being slightly smaller when mature. Diameters of mature H. concavum typically range between 19.5 and 22.5 mm while that of mature Haplotrema kendeighi ranges from 15.4 to 16.4 mm. Both taxa have depressed shells, with spires that are weakly convex to almost flat. They have 5 1/4 to 5 1/2 whorls and a deep, wide umbilicus that exhibits all the whorls. The periostracum of both species is greenish-yellow. H. kendeighi is most readily separated from H. concavum by the color of the foot; being yellow-gray in H. concavum and bright blue in H. kendeighi (Hubricht 1956). Anatomical differences also exist (Hubricht 1956). Since conchological separation of this species from H. concavum is not possible, figures of that taxon from Burch (1962) and Pilsbry (1946) should aid in discerning this species.

Range. This species is endemic to the Great Smoky Mountain region of North Carolina and Tennessee. It has been recorded from 2 counties in North Carolina (Macon and Swain) and 3 counties in Tennessee (Blount, Monroe, and Sevier) (Hubricht 1985).

Habitat. According to Hubricht (1985), H. kendeighi is "found on mountainsides in leaf litter or crawling on the ground in wet weather. Usually found at higher elevations (above 2,000 ft), frequently in company with H[aplotrema] concavum." Webb (1951) found H. kendeighi most frequently in mixed or cove hardwood forests.

Life History and Ecology. Virtually nothing is known of the life history or ecology of this species. Hubricht (1956) noted immature individuals in early June and mature individuals in late August. Like H. concavum, it is probably molluscivorous, feeding on other land snails within its range.

Special Significance. None known.

Type Locality. "Slopes of the Chimneys above the camp area on the west prong of Little Pigeon River near Tennessee highway 71, Sevier Co., Tennessee" (Webb 1951).

Systematics. Webb (1951) established this taxon as a subspecies of Haplotrema concavum based on shell characters. However, Hubricht (1956) determined that these characters were not reliable sources of separation, noting examples of intergrades between shells of the two taxa. Based on his examination of soft-tissue anatomy, Hubricht (1956) determined it was a distinct species. Its systematic treatment has been stable since that time.

Status. Vulnerable, Category 2.

Rationale for Evaluation. This species is considered vulnerable primarily due to its restricted range. With such a small range, seemingly minor land disturbing actions could have significant effects on the

state's populations of this species. Impacts to the species may be occurring from logging, rooting by wild boars (Sus scrofa), and acid precipitation.

Current Protection. This species currently has no legislative protection. However, some populations occur on public lands.

Recommendations. Studies to define the habitat requirements and life history of this species are needed. Once its habitat requirements are understood, status surveys should be undertaken.

LITERATURE CITED

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Webb, Glenn R. 1951. A new landsnail, Haplotrema concavum kendeighi (Mollusca, Pulmonata). Trans. Kansas Acad. Sci. 54:78-82.

Prepared by WILLIAM F. ADAMS

Stenotrema depilatum (Pilsbry, 1895)
GREAT SMOKY SLITMOUTH

Description. The shell of this species is imperforate, thin, globose-conic, with a rounded perifery. It has a large parietal tooth that nearly closes the aperature, and newest parts of the shell possess a silky sheen. The sizes of known specimens are as follows: height, 8-9 mm; width, 9.3-11.0 mm. Pilsbry (1940) and Burch (1962) provide descriptions and illustrations. Unlike Stenotrema altispira, which it closely resembles, S. depilatum totally lacks any hairs or hair scars.

Range. This species is known only from the Great Smoky Mountains of North Carolina (Graham and Swain Counties) and Tennessee (Blount, Monroe, and Sevier counties).

Habitat. Little is known of the habitat of this species. It is a species of the higher elevations, the lowest station being recorded at 3000 feet. It occurs in moist to wet situations and has been found in moss on trees (Pilsbry, 1940) and "on rocks (Pilsbry, 1900). Hubricht (1985) reports it from "about logs and in leaf litter at higher elevations in the mountains".

Life History and Ecology. Nothing is known of the life history or ecology of this species.

Special Significance. None known.

Type Locality. Thunderhead Mountain from the summit to Cades Cove, Blount County, Tennessee (ANSP 65729).

Systematics. This species was originally described as a subspecies of Stenotrema stenotrema (Pfeiffer, 1819). It bears some resemblance to Stenotrema altispira (Pilsbry, 1894) but Pilsbry (1940) remarks that integrades have not been found.

Status. Vulnerable, Category 2.

Rationale for Evaluation. The known range of this species is very small and it occurs within that range only at high elevations. Due to the changes in vegetation and soil chemistry which are occurring in such areas, populations of this species are being subjected to unnatural stresses. Additionally, its habitat is subject to damage by rooting wild boars (Sus scrofa.

Current Protection. The species has no legal protection at this time. Known localities are within the Great Smoky Mountains National Park.

Recommendations. In light of the acid precipitation effects being experienced in our high elevation mountains, status surveys for this species should be conducted to determine if its populations are persisting in reasonable numbers. All avenues available to prevent further deterioration of its habitat should be pursued.

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Prepared by WILLIAM F. ADAMS

Mesdon chilhoweensis (J. Lewis, 1870)
QUEEN CRATER

Description. Pilsbry (1940) gives the following description with some accompanying photographs. Mesodon chilhoweensis has a large (to 42 mm diam.), somewhat depressed shell with up to 6 1/2 whorls, and is narrowly umbilicate and thin. The shell is slightly glossy and cream colored but often has olivaceous streaks (growth rest marks). Whorls are covered with close striae and distinctly engraved spiral lines. The white peristome is rather broadly reflected and may have a weak, blunt prominence on its basal margin (on the inner edge). There is a small, oblique parietal tooth in about 20% of the specimens. This snail looks like Mesodon sayanus (from further north) but is much larger, has a more widely reflected lip and always lacks the distinctive basocolumellar tooth.

Range. This species occurs in Haywood, Madison, Graham, and Swain counties in North Carolina, is fairly widespread in eastern Tennessee (with a disjunction in the Cumberland Mountains), and extends into southern Kentucky (Hubricht 1985).

Habitat. Hubricht (1985) mentions finding this snail under leaf litter or in rock piles. It crawls on the surface or is even aboreal in wet weather. Pilsbry (1940) says it favors deciduous forests, living among the leaves and brush on the forest floor.

Life History and Ecology. Hubricht (1985) says this species is rarely found in any numbers. Where it occurs, one often finds broken shells. Even if other large shells are present in greater numbers, one does not find so many of their broken shells. Mesodon chilhoweensis does have a thin shell and is at risk for predation by birds and small mammals (R. W. Van Devender, pers. comm.). This predation pressure may cause the snail's apparent rarity.

Special Significance. This uncommon snail is at the edge of its range in western North Carolina.

Type Locality. The type locality is Chilhowee Mountain in Blount County, TN, just north of the TN - NC state boundary.

Systematics. According to Pilsbry (1940), Lewis described this form as a new Helix in 1870 while Binney classified it as a large form of Mesodon sayii in 1885. Wetherby (1894) followed Lewis and classified it as Mesodon chilhoweensis. In 1900, Pilsbry lumped it into Polygyra; but, by 1940, he had separated out the genus Mesodon with this as a full species.

Status. Vulnerable, Category 2.

Rationale for Evaluation. This species, though fairly widely distributed in Tennessee, is of special concern in North Carolina because of its limited distribution and general rarity. This is a snail of mature

deciduous forests, and nothing is known about how it responds to reductions in plot size.

Current Protection. The snail's range in North Carolina lies mostly within national park or national forest land.

Remarks. This species' large size might make it attractive as an indigenous escargot. It is nearly as large as *Helix pomatia*, and birds obviously find it tasty.

LITERATURE CITED

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Prepared by AMY S. VAN DEVENDER

Mesdon clarki (Lea, 1858)
DWARF PROUD GLOBE

Description. According to Pilsbry (1940), Mesodon clarki has a solid, globose shell with an elevated spire. It has a glossy buff shell that is imperforate and measures up to 11.9 by 17.1 mm with about six, close-coiled whorls. The last whorl becomes angular, descends toward the aperature, and contracts behind the lip. The peristome is white and widely reflected with a blade-like tooth along its inner edge. The parietal wall has a long curved tooth. Its sculpture is variable. This snail looks like a miniature M. elevatus.

Range. This species ranges south and west from the Great Smoky Mountains National Park into SE Tennessee and northern Georgia. This range includes all six of the SW counties in North Carolina.

Life History and Ecology. Hubricht (1985) mentions that this species prefers leaf litter on mountainsides. It is known to crawl about on the surface in wet weather. Pilsbry (1940) implies it has a preference for middle to upper elevations. It is known from up to 6500' in the Great Smoky Mountains.

Special Significance. This is a rather rare snail whose relatively small range is centered on the junction of North Carolina, Georgia, and Tennessee. It is a variable snail that includes one to three subspecies within its small range.

Type Locality. The type specimen was found in Tuskee Cove, Cherokee County, North Carolina.

Systematics. According to Pilsbry (1940), Mesodon clarki was described as Helix clarkii by I. Lea in 1858. Twenty years later W. G. Binney placed it in Mesodon: and in 1900 Pilsbry called it Polygyra clarki. By 1940 Pilsbry had again separated out Mesodon.

Status. Vulnerable, Category 2.

Rationale for Evaluation. This is a relatively rare snail with a small distribution.

Current Protection. Most of its North Carolina habitat falls within national forest or national park land.

Recommendations. The relationships between Mesodon clarki and its subspecies, including the threatened Mesodon clarki nantahala, seem to present interesting problems in terms of anatomy, physiology, and ecology. Understanding these problems would help in planning any necessary protection measures.

LITERATURE CITED

Hubricht, Leslie. 1985. The distributions of the native land mollusks of the eastern United States. Fieldiana, New Series, No. 24. 191pp.

Pilsbry, Henry A. 1940. Land mollusca of North America (North of Mexico). Acad. Nat. Sci. Phila. Monogr. 3. Vol. 1, Part 2. pp. 574-994.

Prepared by AMY S. VAN DEVENDER

Mesdon subpalliatus (Pilsbry, 1893)
VELVET COVERT

Description. Pilsbry (1940) repeats his 1893 description and provides several drawings. The shell is 13.4 - 16.4 mm in diameter and somewhat depressed with 4 1/2 -5 whorls. The shell is buff to yellow and is imperforate. It has a long parietal tooth. The shell has radial striae that in later whorls bear periostracal processes that give the shell a rough appearance and allow it to hold a coat of soil. It is similar to Mesodon jonesianus, but has fewer whorls and is larger. It is related to Mesodon weatherbyi from further west, but is smaller. Hubricht (1985) includes his Mesodon verus in this species.

Range. This species is known from areas around Roan Mountain including Johnson and Carter counties, TN and Watauga, Avery, Mitchell, and Haywood counties, NC.

Habitat. Hubricht (1985) mentions finding this species in leaf litter and around logs and rocks in mountains above 2000 feet. Wetherby (1881) described its habitat as "always in the dirt under and beside rotting logs." Rhoads found it on Roan Mountain between 3500 and 5000 feet (Pilsbry 1940).

Life History and Ecology. Little is known about this species' ecology. Wetherby mentioned that it is "very sluggish and timid, and very rare. ... [it] lives in leaves in damp places during winter and hot, dry weather in summer. During rainy seasons it ascends to a great height, being sometimes found on the upper branches" (quoted in Pilsbry 1940).

Special Significance. Always considered a rare snail, Mesodon subpalliatus is known from only six counties in the southern Appalachians. Its habitat preferences restrict it to mesic conditions at middle elevations.

Type Locality. The type series is from Magnetic City, which is now called Buldeen, in Mitchell County, NC. Magnetic City was named for nearby deposits of iron ore.

Systematics. Mesodon subpalliatus was originally placed in the all-purpose genus Polygyra by Pilsbry in 1893 even though both Bland and Binney considered it to be a variety of Mesodon weatherbyi. By 1940, Pilsbry called this a Mesodon in the subgenus Patera Albers 1850.

Status. Vulnerable, Category 2.

Rationale for Evaluation. This species is known from only six counties along the border between Tennessee and North Carolina. So little is known about the snail's range and ecology that, despite its evident rarity, its status must be clarified before specific recommendations for its management can be made.

Current Protection. The area around Roan Mountain is a state park and some of the forest in this area fall within the Pisgah National Forest.

Recommendations. More study of the ecology and distribution of this species are necessary before any reasonable protection measures could be formulated.

Remarks. This species is being investigated by Dr. Kenneth Emberton (ANSP) in his anatomical and electrophoretic surveys of the larger Polygyrids.

LITERATURE CITED

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Prepared by AMY S. VAN DEVENDER

Triodopsis fulciden (Hubricht, 1952)
DWARF THREETOOTH

Description. This buff colored species ranges from 7.2 to 8.8 mm in size. It has a deep and narrow umbilicus and a depressed spire. It has 5 1/2 slightly convex whorls which range from smooth on the first whorl to costate on the later ones. The opening is strongly constricted behind the peristome. It has three teeth: the outer lip tooth is inflected with a prominent buttress, the basal tooth is blunt and seated transversely on the lip-callus, and the parietal is straight or curved and connected to the outer lip by a low buttress. A detailed description can be found in Hubricht (1952). Emberton's landmark work on the eastern Triodopsinae (1988) provides descriptions and figures of the penial tube and shell of the species. Vagvolgyi (1968) describes and provides photographs of the shell of the species.

Range. As far as is currently known, this species is a North Carolina endemic confined to Burke, Catawba, Cleveland, and Lincoln counties (Hubricht 1985).

Habitat. No detailed habitat data is available for this species. Hubricht (1952) states only that the type specimens were taken from upland oak woods.

Life History and Ecology. Nothing is known of the life history or ecology of this species.

Special Significance. This species possesses one of the most restricted ranges of any of the eastern Triodopsine snails. Like Triodopsis soelneri, its survival rests solely on North Carolina's ability to protect it.

Type Locality. Upland oak woods, 3.4 miles west of Conover, Catawba County, North Carolina.

Systematics. The systematic treatment of this species has remained stable since it was described by Hubricht (1952). Subsequent to this description, Vagvolgyi (1968) and Emberton (1988) have reviewed its systematic position and its full species rank has been supported.

Status. Vulnerable, Category 2.

Rationale for Evaluation. This species has a very restricted range. While the habitat description provided by Hubricht (1952) could be applied to portions of virtually every county in the state, it is obviously subject to microhabitat conditions which are far more restrictive. What these conditions may be is unknown at present. This species is threatened by habitat destruction through logging and development, habitat fragmentation, and the insularity of remaining populations.

Current Protection. None known.

Recommendations. Due to its restricted range, this species may deserve listing as either threatened or endangered. Requisite habitat conditions for this species need to be defined. Known populations should be rechecked to determine their current status. Surveys for additional populations should be undertaken.

LITERATURE CITED

Emberton, K. C. 1988. The genitalic, allozymic, and conchological evolution of the eastern North American Triodopsinae (Gastropoda: Pulmonata: Polygyridae). Malacologia 28: 159-273.

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Vagvolgyi, Joseph. 1968. Systematics and evolution of the genus Triodopsis (Mollusca: Pulmonata: Polygyridae). Bull. Mus. Comp. Zool. 13:145-254.

Prepared by WILLIAM F. ADAMS

SPECIES OF UNDETERMINED STATUS

During its review of North Carolina's molluscan fauna, the committee was unable to assign any status other than undetermined to these species. It is the committee's belief that quite a few of these species probably deserve to be listed as endangered, threatened, or special concern in North Carolina, however, the evidence to support such listings simply is not available. It is a sad, but necessary, fact that only those species we know something about can be listed and receive the attention and protection that all species deserve. The reasons for information voids in this group of animals are legion: lack of researchers, cryptic habits of some species, rapidly changing environmental conditions, and difficulty of identification are but a few. For the present, it will have to suffice to say that many of these undetermined species may be far more rare than those which have been recommended for protection while others may be very common. In order to clarify their statuses, research on these species is most heartily encouraged.

FRESHWATER MOLLUSKS

SNAILS

Valvata bicarinata I. Lea, 1841
TWO-RIDGE VALVATA

Burch (1982) stated that the species has a discontinuous distribution and listed North Carolina as one of the states where it is known to occur. The only published records from North Carolina are those of recently dead specimens found at one station in the Neuse River basin by Walter (1954) and a Bertie County record reported by Dawley (1965). Walter (1954) reported that his attempts to obtain live specimens were unsuccessful. Due to the moderate size of this species and its distinctive characters, it is unlikely that it is being overlooked in field surveys or misidentified. If it still occurs in North Carolina, it is probably local and uncommon. Additional records of occurrence and habitat information are needed before its status in the state can be adequately assessed.

Campeloma crassulum Rafinesque, 1819
PONDEROUS CAMPELOMA

This is a species of the Great Lakes, St. Lawrence and upper Mississippi river drainages. It was collected from 2 locations in the New river basin of North Carolina by Dillon (1977) and these represent our only records of the species from the state. Its continued presence in the state has not been confirmed.

Campeloma geniculum (Conrad, 1834)
OVATE CAMPELOMA
Campeloma limum (Anthony, 1860)
FILE CAMPELOMA

Campeloma geniculum has been reported from the state in Greenfield Lake and Lake Waccamaw. It may be more abundant in the southern parts of North Carolina than available records indicate due to difficulties in separating it from *C. decisum* and *C. limum*. Burch (1982) records *C. limum*

from North Carolina but does not give the location for the record. Keferl and Shelley (1988) report C. limum in the Pee Dee, Catawba, and Saluda River systems.

The status of these species in the state will not be worked out until reliable methods of identification are established. All species within the Campeloma were described by early malacologists based on shell characters, the norm for the time. When specimens were taken which did not fit an established species concept, a new species was described. This disregard for potential ecophenotypic variation led to a profusion of "species". Clench (1962) made an excellent start in reducing the confusion surrounding this genus; however, additional work is still needed. Until that work takes place, available taxonomic keys give the novice little hope of an uncontestable identification.

Somatogyrus virginicus Walker, 1904
PANHANDLE PEBBLESNAIL

The only known records of this species from North Carolina are from the upper Neuse River Basin (Walter 1954). Photographs and descriptions in Walter's (1954) work clearly refer to this species. He further refers to specimens of this species being taken from Maryland. Apparently overlooking these records, Burch (1982) considered this species to be restricted to the Rapidan River River in Virginia, the type locality for the species. Based on available information, meaningful status assessment of this species is impossible. However, the records do indicate that the species is probably restricted to the mid-Atlantic states and, within that range, possesses a spotty distribution. Additional searches for this species are greatly needed and should be given a high priority.

Goniobasis symmetrica (Haldeman, 1841)
SYMMETRICAL ELIMIA

This species is listed for North Carolina by Goodrich (1942) and Burch (1982). It is a poorly known form and may actually be a junior synonym of Goniobasis proxima (R. T. Dillon, pers. comm.). Allozyme analysis is needed to clarify its status.

Goniobasis clavaeformis (I. Lea, 1841)
CLUB ELIMIA
Goniobasis simplex (Say, 1825)
SMOOTH ELIMIA

Goodrich (1940) records both of these species from headwater and tributary areas of the upper Tennessee River in Virginia, Tennessee, and North Carolina. Recent specimens of a pleurocerid which is probably G. simplex have been taken from the Nolichucky River. G. clavaeformis, like G. symmetrica above, may be synonymous with G. proxima (R. T. Dillon, pers. comm.). Until more specimens can be examined and allozyme analyses performed, the statuses of these taxa in the state will remain very much in doubt. Surveys of headwater areas of the Tennessee River system are greatly needed to assess their distribution and abundance. Resolution of systematic problems with these taxa should be given a high priority.

Goniobasis virginica (Say, 1817)
PIEDMONT ELIMIA

Goodrich (1942) lists North Carolina as a questionable locale for this species due to concern over locality data provided with the type description of Goniobasis cingenda (Anthony, 1866), a synonym of G. virginica. J. M. Alderman and I collected G. virginica from the Tar River and 6 tributary streams in 1987, thus confirming its occurrence in the state. The Tar River it probably the southern limit of its distribution although a Neuse River population is certainly a possibility. Its status in the Tar River basin should clearly identified and populations should be sought in both the Roanoke and Neuse River basins.

Leptoxis virgata (I. Lea, 1841)
SMOOTH MUDALIA

Burch (1982) lists the Hiwassee River as part of the range of this species and attributes the record to Goodrich (1940). Review of that and other works by Goodrich reveal that he did not record the species from the Hiwassee. This leaves two possibilities: a record for the Hiwassee exists but the Goodrich citation was incorrect or listing the Hiwassee as a part of the range of this species was a simple textual error in Burch (1982). If this species occurs in the state, it is almost certainly restricted in distribution. Because of these uncertainties, the status, and even the occurrence, of this species in the state must be considered undetermined at this time.

Fossaria humilis (Say, 1822)
MARSH FOSSARIA
Fossaria obrussa (Say, 1825)
GOLDEN FOSSARIA

The marsh fossaria is known along the Atlantic slope from New Jersey to South Carolina but has been noted in North Carolina only in the upper portions of Crabtree Creek in the Neuse River basin (W. F. Adams). The golden fossaria is more widely distributed, occurring essentially throughout the continental United States. It was found in two locations in the Neuse River basin by Walter (1954) and in many parts of the upper New River basin (Dillon 1977, Dillon and Benfield 1982). Both of these species may be more common than these few records indicate.

Gyraulus deflectus (Say, 1824)
FLEXED GYRO
Gyraulus parvus (Say, 1817)
ASH GYRO

The flexed gyro is a northern species, ranging from near the Arctic coast south into the middle United States while the ash gyro spans the whole of North America. Both of the species are very small and are easily overlooked. Our only records of these species from the state are from the Greenfield Lake drainage near Wilmington (Adams, in press). They are probably fairy common but additional records are needed.

Menetus alabamensis (Pilsbry, 1895)
MARSH SPRITE

This taxon looks very much like Menetus dilatatus (Gould, 1841) except that it has an acute peripheral keel. It is known from its type

locality in Woodville, Alabama, and from Lake Waccamaw, North Carolina, where it occurs fairly abundantly. It is classified as undetermined due to current taxonomic uncertainties regarding its relationship to M. dilatatus. That it may be a carinate form of M. dilatatus and not a distinct species is a question which sorely needs investigation, for it appears to be an exceedingly rare animal and, if distinct, may be worthy of designation as an endangered species. Analysis of soft-tissue anatomy and molecular data will be necessary to effectively address this question.

Planorbula armigera (Say, 1821)
THICKLIP RAMS-HORN

This species is wide ranging, occurring throughout much of Canada and the United States. It is known in North Carolina only from specimens collected in the freshwater swamps and creeks on Bogue Banks west of Atlantic Beach. Additional populations almost certainly exist in the state and they should be sought so that an adequate assessment of this species' status can be made.

PEA CLAMS

Sphaerium fabale (Prime, 1852)
RIVER FINGERNAILCLAM
Musculium lacustre (Muller, 1774)
LAKE FINGERNAILCLAM
Musculium partumeium (Say, 1822)
SWAMP FINGERNAILCLAM
Musculium securis (Prime, 1852)
POND FINGERNAILCLAM
Onsidium adamsi (Stimpson, 1851)
ADAM PEACLAM
Pisidium ferrugineum Prime, 1852
RUSTY PEACLAM

Many of the fingernailclams and peaclams are widely distributed throughout North America but are recorded for North Carolina by only a single record. All are listed here due to a lack of records rather than knowledge regarding population trends. A combination of factors render this group of animals one of the least studied of all of the freshwater mollusks: they are small and easily overlooked in the field, specimens can be difficult to identify due to their small size and subtle taxonomic characters and, most are extremely fragile and can be easily broken in the process of identification. However, these difficulties are not insurmountable and can be overcome with practice. Special effort should be made during future aquatic surveys in the state to obtain and identify these animals. The same water quality problems which are affecting a wide variety of other aquatic organisms in the state are undoubtedly affecting these animals as well but, with our limited data base, population trends cannot be measured.

MUSSELS

Fusconaia subrotunda (I. Lea, 1831)
LONG-SOLID

Whether or not this species was ever a part of the state's fauna is questionable. Ortmann (1918) notes unverified records from R. E. Call of this species being in the French Broad River at Asheville but refers to these records as "very doubtful". If it does occur in North Carolina it is certainly very rare. Populations should be sought in the Little Tennessee River basin. Should a population eventually be discovered in the state, it should receive strict protection.

Quadrula pustulosa (I. Lea, 1831)
PIMPLEBACK

Issac Lea described Unio pernodosus from specimens provided by B. W. Budd. Lea did not have precise locality data available to him and, therefore, gave the type locality simply as "North Carolina" while noting that it probably came from tributaries of the Tennessee River. However, Ortmann (1918) synonymized U. pernodosus with Quadrula pustulosa and cast doubt that it ever occurred in the state, noting a lack of any subsequent verification. As with Fusconaia subrotunda, any populations of this species in the state would be quite unusual and, if discovered, should receive protection.

Elliptio cistelliformis (I. Lea, 1863)
BOX SPIKE

This name is currently being applied (Davis, Johnson) to the taxon referred to as the "file spike" of Lake Waccamaw by Fuller (1977). The application of this name is debatable however, as typical Lake Waccamaw specimens of this taxon do not resemble type material (A. G. Gerberich, pers. comm.) and the type locality of E. cistelliformis is the Neuse River. Nothing resembling the Lake Waccamaw specimens of this taxon has been found in the Neuse River basin in recent years. I have recently recovered shells which may represent this species from the Lumber River and E. P. Keferl has recovered similar material from the Pee Dee River basin.

Elliptio fisheriana (I. Lea, 1838)
NORTHERN LANCE
Elliptio producta (Conrad, 1836)
ATLANTIC SPIKE

Both of these species are lanceolate mussels, resembling each other and Elliptio angustata, a common species in southeastern North Carolina. Yet another lanceolate species, Elliptio lanceolata, is currently believed to be confined to the Tar River basin. Due to their similar conchology and soft-part anatomy, the lanceolate elliptios remain in a state of taxonomic confusion. E. fisheriana has been widely reported for North Carolina, however, it is presently recognized as a more northern species and many earlier records from the southern part of the state must be treated as suspect. E. producta has been confirmed only from Lake Waccamaw and the relationship of its range to that of E. angustata in the state is unclear. Due to the difficulty in distinguishing these species on morphological basis, considerable uncertainty regarding the ranges and

statuses of these species in the state will undoubtedly persist well into the future. Allozymic analysis, such as that used by Davis (1984), is the most promising tool for resolving these problems and its application thereto is encouraged.

Elliptio perlatus (I. Lea, 1863)
NO COMMON NAME
Elliptio perstriatus (I. Lea, 1852)
NO COMMON NAME

These taxa were synonymized with Elliptio arctata (I. Lea, 1863) by Johnson (1970), the occurrence of which on the Atlantic slope is now being reexamined. It is quite probable that the species concepts which will emerge from the dissection of the E. arctata complex will bestow these taxa with full species status. The relationship of E. perlatus to E. folliculata has been the subject of considerable debate. Porter (in this report) provides a comprehensive overview of this issue. The type locality of E. perlatus is about 36 miles above Wilmington on the Cape Fear River (Black Rock Landing). The type locality for E. perstriatus is Abbeville District (Savannah River drainage), South Carolina. In recent years, I have collected specimens of these taxa which are identical in conchological characters with their types; E. perlatus from Great Coharie Creek in Sampson County and E. perstriatus from Town Creek in Brunswick County. In both cases, these taxa were only minor components of an otherwise diverse and abundant fauna, indicating they may be quite rare.

Elliptio raveneli (Conrad, 1834)
CAROLINA SPIKE

This taxon is currently known from most of our southern rivers, from the Broad River east and north to the White Oak River. It is placed here primarily because of continuing nomenclatural problems. Johnson (1970) synonymized this taxon with Elliptio icterina (Conrad) and, shortly thereafter, Morrison (1972) synonymized E. icterina with Elliptio congaraea (Lea). Further, Morrison (1972) provided conclusive evidence that E. raveneli and E. congaraea are distinct. Problems with the resulting systematic arrangement are obvious. Should E. icterina and E. raveneli prove to be the same species, the name E. raveneli should be given priority as, though both were described by Conrad in the same publication, E. raveneli is described first in the text.

Elliptio sp. a (Black River system)
NO COMMON NAME

This small taxon is currently known only from Great Coharie Creek in Sampson County. In shape and topography it is similar to Elliptio waccamawensis, bearing an angular posterior ridge, but is distinguishable from it by prominent corrugations on the posterior slope. Its habitat is apparently distinctive. It has been found only on rippled sand bottoms in swift current, a substrate shunned by other mussels in the creek. An analysis of soft-tissue anatomy and molecular data should be performed to determine its relationship to other taxa in the region, particularly E. waccamawensis, E. congaraea, and E. complanata. Should it prove distinct, surveys to locate additional populations should be conducted throughout the lower Cape Fear River drainage.

Elliptio sp. b (Deep River system)
NO COMMON NAME

This large, lanceolate taxon is known only from the Deep River on the Chatham/Lee county line. Only a few specimens have been obtained, the largest of which is about 150 mm long and 50 mm wide. It probably represents an extremely old population of one of the other lanceolate elliptios, but so far exceeds the maximum recorded lengths for any species other than Elliptio shepardiana (I. Lea, 1834) of the Altamaha River drainage that it is not easily referable to any of them (taxonomic problems with the lanceolate elliptios are great, as discussed under E. producta and E. fisheriana, above). No small lanceolate elliptios can be found in the area, indicating that reproductive success of this taxon is being impaired. Efforts should be made to determine the identity of this taxon before the remaining individuals in the population die out.

Pleurobema oviforme (Conrad, 1834)
TENNESSEE CLUBSHELL

Ortmann (1918) did not find this species in North Carolina during his surveys but records observing specimens of this species in Bryant Walker's collections from the French Broad River in Asheville. It is quite possible that the species has been extirpated from the state, however, survey work in western North Carolina has been so limited that a definitive statement regarding its status cannot be made.

Pleurobema sp. (Little Tennessee River drainage)
NO COMMON NAME

This taxon is known only from specimens collected in the Little Tennessee River in North Carolina. Evidence that it is a taxon distinct from Pleurobema oviforme (Conrad) is solely conchological, no soft-tissue analysis has been performed to date. Anatomical analysis and additional surveys for this taxon are greatly needed.

Alasmidonta sp. (Upper Yadkin River system)
NO COMMON NAME

This taxon is known only from one set of valves found on a sandbar in Dutchmans Creek in Davie County. Its placement in the genus Alasmidonta is hypothetical as no soft-part anatomy has been seen. In shell outline, thickness, and shape, this taxon greatly resembles Anodonta cataracta; however, it bears diminutive lateral teeth. Members of the genus Anodonta have neither pseudocardinal or lateral teeth. Additional specimens of this taxon are greatly needed to clarify its taxonomic status.

Epioblasma capsaeformis (I. Lea, 1834)
OYSTER MUSSEL

The only known report of this species from North Carolina is from Ortmann (1918). He notes that this species "is very abundant in the upper Tennessee drainage, all over region", and notes specimens from Bryant Walker's collection taken from the French Broad River at Asheville. Due to the sensitivity of the Epioblasma to pollutants, it is very unlikely that it occurs in the French Broad River today. Survey work should be conducted throughout the region to determine if this species still occurs in the state.

Toxolasma lividus (Rafinesque, 1831)
PURPLE LILLIPUT

Conrad (1838) listed "Warm Springs" (= Hot Springs on the French Broad River) in Madison County as a locale for Toxolasma pullus. Ortmann (1918) assigned Conrad's (1838) Hot Springs specimens to T. lividus; however, he implies that he never examined the specimens. In any case, this assertion was almost certainly correct as Toxolasma pullus is not a species of the Interior Basin. Johnson (1970) notes the possibility that the specimens may have been Villosa vaneuxemensis. Additional survey work will be necessary to resolve the status and confirm the identity of this taxon.

Villosa vibex (Conrad, 1834)
SOUTHERN RAINBOW

This species has been recorded in the state from the Waccamaw and lower Cape Fear River drainages (Johnson 1970). However, Porter (1985) did not find this species in Lake Waccamaw, its previously recorded locale in that basin, and Adams (in press) did not find it in the Greenfield Lake drainage where it had been recorded previously. Of the reported North Carolina locations, only Orton Pond remains as a possible site of occurrence. At best, this species is rare in the state. Surveys to determine its status are needed.

Lampsilis conspicuus (I. Lea, 1872)
NO COMMON NAME

Specimens of this taxon were reported by Walter (1954) from the Neuse River and recent specimens of what may be this taxon are known from the Flat River (J. M. Alderman, pers. comm.) and upper Pee Dee (E. P. Keferl, pers. comm.). Johnson (1970) synonymized this taxon with Lampsilis radiata (Gmelin), however, conchological characters of available specimens appear different enough from the typical L. radiata to call this synonymy into question. Comparison of this taxon with L. radiata should be performed using soft-tissue analysis, including molecular investigations. If it proves to be distinct, it is in even greater jeopardy than L. radiata in the state.

Lampsilis sp. (Deep River system)
NO COMMON NAME

This taxon is known only from very mature (>40 years old) specimens taken from the Deep River and is distinctive for its great size. Mean shell length on 8 males collected by the author was 144.6 mm, with minimum and maximum shell lengths of 122 mm and 165 mm, respectively. Mean shell lengths on 5 females was 130.6 mm, with minimum and maximum shell lengths of 108 mm and 150 mm, respectively. Like all lampsiline species, it is sexually dimorphic. No living females have been collected to date. Except for its great size, this taxon resembles Lampsilis cariosa; however, the maximum size recorded for L. cariosa by Johnson (1970) is 130 mm. According to S. L. H. Fuller (pers. comm.), sectioned mantel flaps of males resemble those of Lampsilis splendida (Lea, 1838), a southern species which has been reported as far north as the Santee-Cooper River basin in South Carolina (Johnson 1970). However, the shell of this species is less inflated than L. splendida and lacks the distinctive angular posterior ridge and elevated umbos of that species. The shell

bears some resemblance to that of Lampsilis ovata (Say, 1817), a species of the Interior Basin and St. Lawrence River which was accidentally introduced to the Potomac River basin (Johnson 1970). This taxon is currently known only from a 20 mile stretch of the Deep River (Cape Fear River basin). Live specimens of this taxon have been found only in mid-channel portions of the river, embedded or lying on a gravel and rubble bottom. No juveniles or small adults of any lampsiline mollusk have been found in the area, indicating that reproduction is being impaired. Comprehensive surveys of the Cape Fear River basin should be undertaken to determine the total distribution of this taxon and to locate evidence of reproduction, if any. Electrophoretic and anatomical relationships to other lampsiline species should be investigated and, if such analysis proves this taxon to be distinct, a formal description prepared. If future work on this taxon shows it to be Lampsilis ovata or Lampsilis splendida, protection would still be in order as it would represent the only population of either species in the state.

Medionidus conradicus (I. Lea, 1834)
CUMBERLAND MOCCASINSHELL

The only published record of this species from the state is from Ortmann (1918). He discussed the species under the synonym Medionidus plateolus and stated that the species was "very abundant" throughout the upper Tennessee River drainage and occurred in the French Broad River up to Asheville. This species may well be extirpated from the state but, until additional survey work is conducted to confirm its status, caution dictates that it be classified as undetermined.

Ptychobranchus fasciolaris (Rafinesque, 1820)
KIDNEYSHELL

Ortmann (1918) provides the only North Carolina record for this species. He discussed the species under the synonym Ellipsaria fasciolaris and stated that it was "widely and uniformly distributed" in the upper Tennessee river basin but "nowhere in great numbers". As with the previous species, Ptychobranchus fasciolaris may be extirpated from the state additional survey work will be necessary to establish its status.

TERRESTRIAL MOLLUSKS

Distribution and habitat data for the following taxa have been extracted principally from Hubricht (1985) and Pilsbry (1938-1947). Indeed, no evaluation of North Carolina's terrestrial mollusks would have been possible without the mammoth contributions of these researchers. Habitat data is generally lacking or, if available, so generally stated as to be almost meaningless. Life history information is similarly depauperate and, for the most part, has been omitted from the accounts for the sake of brevity. Interested readers should consult the texts mentioned above as a starting point for acquiring such information.

Most of these species have been classified as undetermined in the state due simply to a lack of records. If no other reason for its placement in the undetermined category is given, this should be the assumed cause. Some of these species are known to be quite localized in

distribution and concern for their welfare is probably warranted. When this is known to be the case it has been so stated.

Many of the species which follow are frequently overlooked in the field due to their small size, thereby skewing the perception of their rarity. As a way of indicating where this might be occurring, approximate sizes of each taxon are provided with its account.

The goal of the following text is to identify which species are in need of directed research. Distribution surveys, habitat delineation, life history information, and assessment of potential threats are needed for all of the species which follow.

Hendersonia occulta (Say, 1831)
CHERRYSTONE DROP WIDTH: 6-8 mm

This species has a split range, occurring in the unglaciated region of Wisconsin and northern Iowa and in the Appalachian Mountains from Pennsylvania to North Carolina. It has been recorded in North Carolina from Caldwell, Madison, Mitchell, Watauga and Yancey counties. It is normally considered to be a calciphilic species and has been recorded from shady, humid sites on mountain-sides, river bluffs, talus slopes, and ravines.

Carychium exiguum (Say, 1822)
OBESE THORN LENGTH: 1.8-2 mm

This species is widely distributed from the mid-Atlantic north into New England and westward to the Great Lakes region. In North Carolina, it is known from Brunswick, Camden, Craven, Duplin, Franklin, Johnston, and New Hanover counties. The implied affinity for the coastal plain may be erroneous as it has been recorded from mountainous areas further north. It has been found in crevices of rotten logs and deep pockets of leaves in moist woods.

Vallonia pulchella (Muller, 1774)
LOVELY VALLONIA WIDTH: 2-2.5 mm

This species has been recorded in North Carolina only from Northampton County but may be more common in the state than records indicate. North Carolina probably represents the southern extent of its range, as it is widespread in New England and the Great Lakes states but absent in the southeast. While this species is also common in much of Europe and Asia, it apparently native to North America, being found here in Pleistocene deposits. This is a species of grassy places such as meadows, lawns, and roadsides.

Gastrocopta pentodon (Say, 1821)
COMB SNAGGLETOOTH LENGTH: 1.5-1.8 mm

This calciphilic species has been recorded from only Johnston, Halifax and Pasquotank counties. It is widely distributed throughout the east, with records from Vermont to Florida, west to about the 100th meridian. It is usually found in dry woods and is most easily found by sifting leaf material and soil. Additional collecting will, without doubt, provide many additional North Carolina records.

Gastrocopta procera (Gould, 1840)
WING SNAGGLETOOTH LENGTH: 2.2-3 mm

While this species has been recorded from every state in the southeastern U.S., it is known from most by only a handful of records. In North Carolina, it has been recorded only from New Hanover County. It is known from dry calcarious soils with sparse vegetation and should be sought in this habitat.

Gastrocopta rupicola (Say, 1821)
TAPERED SNAGGLETOOTH LENGTH: 1.8-2.5 mm

This species is restricted to the coastal plain of the southeastern U.S., ranging from North Carolina to Texas. In North Carolina, it has been recorded from Brunswick, Carteret and Craven counties. Specific habitat requirements are unknown. It has been recorded from disturbed open areas, logs in woods, and on the underside of palmetto leaves in swamps.

Vertigo bollesiana (E. S. Morse, 1865)
DELICATE VERTIGO LENGTH: 1.5 mm

This species occurs principally along the Appalachian Mountains from Maine to North Carolina but is generally rare except in Maine. The single Jackson County record represents the southern limit of its known distribution and is the only record from North Carolina. This species has been recorded from leaf litter and under bark in hardwood forests and from freshwater marshes. Additional surveys should be undertaken to further define its range and abundance in the state.

Vertigo milium (Gould, 1840)
BLADE VERTIGO LENGTH: 1.4-1.8 mm

This species is widely distributed in the east but in North Carolina is known only from Brunswick and Beaufort Counties. It is usually found in wet places but has been found in leaves in upland woods after rain. Like Gastrocopta rupicola, it has also been found underneath palmetto leaves.

Vertigo oralis Sterki, 1898
PALMETTO VERTIGO LENGTH: 1.7-2.0 mm

This is a southern species which runs along the coast as far north as Maryland. In North Carolina, it is known only from Beaufort and Camden counties. It is usually found in low, wet woods. Formerly considered to be a subspecies of V. rugosula Sterki, 1890.

Vertigo parvula Sterki, 1890
SMALLMOUTH VERTIGO LENGTH: 1.4-1.6 mm

Hubricht (1985) does not record this species from North Carolina; however, Pilsbry (1948) refers to a communication with Dr. Victor Sterki in which the latter mentioned collection of the species "in the mountains of North Carolina" by A. G. Wetherby. More precise location information is not available. This is one of the rarest vertigos, being known primarily from Virginia, with single records also available for Tennessee and Ohio. It is found in leaf litter in upland woods.

Vertigo ventricosa (E. S. Morse, 1865)
FIVE-TOOTH VERTIGO LENGTH: 1.7-2 mm

A resident primarily of New England and the Great Lakes area, this species also occurs in the Appalachians south to North Carolina. It is known from the state only from Jackson County. Its habitat appears to be variable, having been recorded from marshes, wet woods, and upland woods in leaf litter.

Columella simplex (Gould, 1841)
HIGH-SPIRE COLUMN LENGTH: 1.8-2.5 mm

This species is widely distributed throughout the east but appears to be absent from the southeastern coastal plain. North Carolina records are limited to sites in McDowell and Rutherford counties. Specimens have come from leaf litter in mesic woods, talus slopes and ravines. Pilsbry (1948) refers to North American specimens of this species as C. edentula (Draparnaud, 1805), a species of Palaearctic distribution. Considering the North American taxa a separate species, Hubricht (1985) refers to them as C. simplex and speculates that the taxon, as presently understood, may actually be two or three species.

Oxyloma effusa (Pfeiffer, 1853)
COASTAL PLAIN AMBERSNAIL LENGTH: 10-19.5 mm

True to its common name, this species is probably limited to the coastal plain in our area. It ranges along the coast from New Jersey south to Florida, where its range broadens to cover essentially the whole peninsula. In North Carolina, it has been recorded only from Chowan and New Hanover counties. Like most ambersnails, it should be sought on vegetation or on the ground in low wet areas such as pond margins, ditches, etc. (Note: Proper identification of ambersnails is very difficult, requiring investigation of both the genitalia and the radula. It should also be noted that, in spite of the rapid advances in ambersnail classification which have been made in this century, systematic rearrangement can still be expected to follow any investigations using electrophoretic evaluation measures.)

Succinea forsheyi I. Lea, 1864
SPOTTED AMBERSNAIL LENGTH: 12-16.8 mm

In the past, this taxon has been separated from, and synonymized with, S. concordialis Gould, 1848 and S. witteri Shimek, 1913 by various authors. It is widely distributed in the central portions of the U.S. but is known from North Carolina only by a single record from Beaufort County. It is normally found on streambanks and exposed portions of gravel bars.

Succinea indiana Pilsbry, 1905
XERIC AMBERSNAIL LENGTH: 10-11 mm

This species is widespread east of the Rocky Mountains but records of occurrence are few. In North Carolina, this species is known from Craven, Cumberland, Robeson, and Scotland counties. Unlike other Succineids, it is usually found in sunny areas on dry ground. Although Pilsbry described this taxon, in later years he considered it synonymous with S. aurea Lea, 1846 (Pilsbry 1948). However, Hubricht (1985) followed Pilsbry's earlier interpretation.

Succinea unicolor Tryon, 1866
SQUATTY AMBERSNAIL LENGTH: 9-12.2 mm

This is a snail of the deep south, extending from east Texas to Florida and up the coast to North Carolina, where it is known only by specimens from Chowan and Perquimans counties. It is probably more common than our records indicate. Its preferred habitat is marsh fringes of lakes or streams.

Novisuccinea ovalis Say, 1817
OVAL AMBERSNAIL LENGTH: 14.2-16.5 mm

The oval ambersnail is a species of New England and the Great Lakes states which extends into North Carolina down the Appalachian Mountains. It is known in the state from Madison, Swain and Yancey counties and one aberrant record from Bald Head Island in Brunswick County. It is normally found near water but has been found associated with Helleborne plants (Veratrum spp.) on mountain-tops. Most texts discuss this species as a member of the genus Succinea Draparnaud, but Hoagland and Davis (1987) relegated it to the genus Novisuccinea Pilsbry on the basis of soft-tissue analysis.

Novisuccinea sp.
STRATTONGAP AMBERSNAIL LENGTH: 19-23 mm

The North Carolina population of this taxon was formerly believed to be N. chittenangoensis Pilsbry, 1908. An electrophoretic survey of known populations of that species disclosed that the single North Carolina population at Stratton Gap in Graham County was probably a new, undescribed taxon (R. Biggins, pers. comm.). However, Hubricht (pers. comm.) doubts these findings and the issue is still unresolved. Determining the proper systematic placement of this taxon should be given high priority. No common name was assigned to this taxon by Turgeon et al. (1988). The common name given here refers to its only known place of occurrence.

Catinella hubrichti Grimm, 1960
SNOWHILL AMBERSNAIL LENGTH: 6.5-9.3 mm

The species is known only from the outer coastal plain of Maryland, Virginia, and the Carolinas. The species is known in the state from a single record in Beaufort County. Grimm (1960) obtained specimens "among wet leaves and cypress needles on mud near [a] small creek".

Catinella pugilator Hubricht, 1961
WEEDPATCH AMBERSNAIL LENGTH: 10.3-13.2 mm

The weedpatch ambersnail is known from only six localities in the U.S.; 2 counties in Alabama, 1 county in Georgia, 2 counties in South Carolina, and a single collection from Currituck County, North Carolina (type locality). Based on these records, the species appears quite rare; however, it may be more widespread than records indicate. It is known from the margins of brackish and freshwater marshes, a habitat which is fairly abundant in the state. Additional survey work for this species should be given high priority.

Philomycus flexuolaris Rafinesque, 1820
WINDING MANTLESLUG LENGTH: 50-100 mm

This species is found in mountainous habitat from New Hampshire to northern Georgia. It has been taken at elevations above 5,000 feet. In North Carolina, it has been recorded from Avery, Graham, Swain, and Yancey counties. Found in woods under loose bark and crawling on leaves or smooth-barked trees during wet weather or at night.

Philomycus virginicus Hubricht, 1953
VIRGINIA MANTLESLUG LENGTH: 50-100 mm

This species has been recorded primarily from Virginia (8 counties) with records of occurrence in West Virginia and Tennessee (1 county each). It is known from North Carolina only by a collection from Siler's Bald Mountain (elevation 5400 feet) in Macon County (Thompson, 1981). It should be sought in forested areas under loose bark or crawling on smooth-barked trees at night or in wet weather.

Pallifera dorsalis (A. Binney, 1842)
PALE MANTLESLUG LENGTH: 6.5-18 mm

This species is widespread in New England and the Great Lakes states but is known in North Carolina only from Caswell County. It is known from leaf litter in woods, under bark, in the soil under decaying logs, and has been found climbing trees.

Anguispira mordax (Shuttleworth, 1852)
APPALACHIAN DISC WIDTH: 17-19 mm

This species is endemic to the southern Appalachians having been recorded from Virginia, West Virginia, Kentucky, Tennessee, North Carolina, and Alabama. In North Carolina, it is known only from Buncombe, Jackson, Swain and Yancey counties. This species is known to hybridize with Anguispira alternata and A. strongylodes. It associates with them in a variety of habitats including areas around logs, stumps and rocks in woods. Walker and Pilsbry (1902) noted an affinity for basswood and tulip tree logs. It may be more common than our few records indicate.

Discus cronkhitei (Newcomb, 1865)
FOREST DISC WIDTH: 5-6.7 mm

This is a northern species, ranging from New England through the Great Lake states into the Dakotas. It comes down the Appalachian chain into western Virginia. It is known in North Carolina only from Guilford County. This is the southernmost record for the species and may represent an introduced or relict population. It is normally a species of wet areas, including meadows and margins of marshes; however, it has frequently been found in urban areas.

Discus nigrimontanus (Pilsbry, 1924)
BLACK MOUNTAIN DISC WIDTH: 7-8 mm

This species has a split range, occurring in the Ozarks and in the southern Appalachians. In North Carolina it is known from Ashe, Watauga and Yancey Counties. It is usually found in rocky upland woods with thin leaf litter.

Punctum blandianum Pilsbry, 1900
BROWN SPOT WIDTH: 1.1-1.3 mm

This species is known infrequently from the southern Appalachians and from North Carolina by a single record from Yancey County. It is found in deep leaf litter. This species and the two following are probably frequently overlooked due to their small size and, therefore, may be more common than our records indicate.

Punctum minutissimum (I. Lea, 1841)
SMALL SPOT WIDTH: 1.1-1.5 mm

This species is widespread east of the 100th meridian with records known from virtually every state from Maine to Florida west to the Dakotas and Texas. However, in North Carolina it has been recorded only in Avery and Mitchell counties. This species can be obtained by sifting damp leaves in hardwood forests and can also be found under the rotten bark of beech tree and in large mushrooms.

Punctum smithi Morrison, 1935
LAMELLATE SPOT WIDTH: 1.1-1.2 mm

This species is easily recognized as it is the only one within the genus Punctum to possess an apertural tooth. This species ranges from tidewater areas of the mid-Atlantic states west to Kentucky, Tennessee and northern Alabama. In North Carolina, it has been recorded only from Caswell County. It should be sought in deep leaf litter.

Glyphyalinia cumberlandiana (G. H. Clapp, 1919)
HILL GLYPH WIDTH: 2.7-3 mm

The hill glyph is found in the Appalachians from Maryland south to Alabama but is known from North Carolina only from Avery, Buncombe, Graham and Macon counties. This species is usually considered a calciphile but Pilsbry (1946) notes that it has been taken on the summits of noncalcareous hills. It is usually found in damp leaf litter and humus in ravines, sinks, or rocky hillsides.

Glyphyalinia luticola Hubricht, 1966
FURROWED GLYPH WIDTH: c. 5.7 mm

This species occurs from New Jersey south and west to Oklahoma. It is known in North Carolina only from a single Scotland County record. It is probably more common than records indicate. This is a species of forested wetlands and it should be sought in floodplain areas during wet weather.

Glyphyalinia umbilicata (Singley, in Cockerell, 1893)
TEXAS GLYPH WIDTH: 4.5-7.5 mm

This species has split range, with strongholds in Texas and Florida. It ranges up the eastern seaboard to North Carolina where it reaches the northern extent of its range. It is known in North Carolina from Brunswick and New Hanover counties. It is usually found near streams under leaf litter and logs.

Mesomphix latior (Pilsbry, 1900)
BROAD BUTTON WIDTH: 22.5-28 mm

The broad button is endemic to the southern Appalachians, occurring in North Carolina, Tennessee, Georgia, and Alabama. In North Carolina it is known only from Macon and Swain counties. It is found under leaf litter on forested hillsides. Confirmation of known locales and searching for additional populations in the state should be given high priority.

Mesomphix pilsbryi (G. H. Clapp, 1904)
STRIATE BUTTON WIDTH: 16.8-27 mm

This is a snail of the south, occurring from North Carolina south and west to Mississippi. In North Carolina, it has been recorded only from Anson and Stanly counties. It has been found under leaf litter of upland woods and flood plains as well as in gardens and waste places in urban areas.

Paravitrea capsella (Gould, 1851)
DIMPLE SUPERCOIL WIDTH: 4.8-6.2 mm

This taxon is the subject of systematic debate and, due to uncertainties surrounding its identification, precise delineation of its range is impossible (see species account for Paravitrea lacteodens). It is currently believed to occur in the southern Appalachians and the midwest. North Carolina records for what is believed to be this taxon exist for Cherokee, Clay, Graham, and Swain counties. Without reevaluation of this taxon using soft-tissue anatomy and electrophoresis, its precise status in the state cannot be determined.

Paravitrea multidentata (A. Binney, 1840)
DENTATE SUPERCOIL WIDTH: 2.5-3 mm

The dentate supercoil ranges from New England and the Great Lakes area south through the Appalachians to Alabama. In North Carolina, it is known from Ashe, Avery, Madison and Yancey counties. It is found in deep leaf litter in woods.

Paravitrea reesi Morrison, 1937
ROUND SUPERCOIL WIDTH: 3.1-4.7 mm

This species has been recorded only from 10 counties; 1 in North Carolina, 5 in West Virginia, 3 in Virginia and 1 in Tennessee. In North Carolina, it is known only from Watauga County. It is known from river bluffs and ravines where it is found under moist leaf litter or rocks. Due to its apparent rarity within its range, additional searches for this species should be given priority.

Ventridens acerra (J. Lewis, 1870)
GLOSSY DOME WIDTH: 12.6-18.4 mm

This taxon is endemic to low elevations (<2000 feet) of the southern Appalachians and has been recorded from 9 North Carolina counties: Avery, Cherokee, Clay, Graham, Haywood, Jackson, Macon, Swain, and Yancey. This taxon is considered status undetermined due to uncertainties regarding its taxonomic relationship with Ventridens demissus Binney. V. acerra is usually taken from rocky wooded areas in leaf litter.

Ventridens collisella (Pilsbry, 1896)
SCULPTURED DOME WIDTH: 8.4-9.6 mm

This species is a southern Appalachian endemic, ranging from West Virginia and Virginia south through the mountains to Alabama. It is included in this report as a part of North Carolina's fauna on the basis of one specimen collected by J. H. Ferriss from Mt. Mitchell, reported by Pilsbry (1946). Pilsbry was hesitant to include it as a part of North Carolina's fauna because it was not mentioned by Bryant Walker (who was one of Ferriss' companions) in a subsequent report of the collecting trip (Walker and Pilsbry 1902). Indeed, his caution seems warranted as the species still has not been recorded from Mt. Mitchell to this date. Regardless, given the range of this species and collections of it from 6 counties which border the state, its ultimate discovery in North Carolina seems assured. The species is calciphilic and usually occurs in leaf litter at low elevations.

Ventridens demissus (A. Binney, 1843)
PERFORATE DOME WIDTH: 7.5-11.4 mm

The perforate dome is a southern species, extending from its stronghold in the middle Gulf states north through the Appalachians to southern Pennsylvania. In North Carolina, it is known only from Buncombe and Graham counties. It is found in leaf litter on forested slopes, ravines, and flood plains and has also been found in urban areas.

Ventridens lawae (W. G. Binney, 1892)
ROUNDED DOME WIDTH: 7.8-9 mm

This species occurs from Virginia and Kentucky south to Alabama through the mountains. In North Carolina, it has been recorded from Avery, Clay, Henderson, Madison, and Transylvania counties. Found in wooded areas in leaf litter and around logs.

Ventridens ligera (Say, 1821)
GLOBOSE DOME WIDTH: 11-15.6 mm

This variable taxon is widespread, ranging from New York southwest through the midwest and Appalachians to Kansas and Mississippi. In North Carolina it is known from three counties in the mountains (Haywood, Jackson, and Macon), two counties in the southeast (Brunswick and New Hanover) and a cluster of counties in the northcentral portion of the state (Caswell, Johnston, Nash, Rockingham, Wake, and Warren). These highly regionalized occurrences in apparently varying habitats are curious and currently unexplainable. Additional information on the distribution of this species in the state is greatly needed. It is a species of open grassy places but it has been taken in low woods.

Ventridens suppressus (Say, 1829)
FLAT DOME WIDTH: 5.4-7.8 mm

There are numerous records of this species from southern New York to southcentral Virginia; however, a single collection from Stokes County constitutes the only record of the species in North Carolina. It should be sought in leaf litter of upland woods in the northern piedmont portions of the state.

Striatura ferrea E. S. Morse, 1864
BLACK STRIATE WIDTH: 2.5-3.4 mm

This species ranges from New England to the Great Lakes states southward through the mountains into North Carolina and Tennessee. In North Carolina, it is known from Graham, Haywood, McDowell, Mitchell, and Watauga counties. It is found in damp leaf litter in upland forests.

Euconulus chersinus (Say, 1821)
WILD HIVE WIDTH: 2.4-3.4 mm

This southern species is known from North Carolina and Tennessee south to Mississippi and Florida. Its occurrence in North Carolina is documented by only 1 Brunswick County record but it has been documented from several Tennessee counties which border the state. It should be sought in moist leaf litter.

Euconulus dentatus (Sterki, 1893)
TOOTHED HIVE WIDTH: c. 2.4 mm

This is a broad ranging but infrequently collected species. Its range extends from Pennsylvania west to Missouri south into the coastal plain of Louisiana. Records are rare for the southeastern states, with 1 record from North Carolina (Caswell County), 1 from South Carolina, and 2 from Georgia. It is probably more common in the southeast than these records indicate. It should be sought in damp leaf litter early in the spring as adults die in April.

Euconulus fulvus (Muller, 1774)
BROWN HIVE WIDTH: 3.1-3.4 mm

This holarctic species occurs in the U.S. from New England west to the Great Lakes states south in the Appalachians to Georgia. In North Carolina, it is known from Avery, Transylvania, and Yancey counties. Its habitat is moist leaf litter on slopes and in ravines and is usually obtained by sifting leaves. It is sometimes found in the drift debris of creeks and rivers.

Guppya sterkii (Dall, 1888)
BRILLIANT GRANULE WIDTH: 1.2-1.3 mm

This taxon is widely distributed, ranging from New York to Iowa south to Louisiana and Florida. In North Carolina, it is known from specimens collected in Avery, Macon, Mitchell, Watauga, and Yancey counties. This species is almost certainly overlooked with great frequency due to its very small size. It should be sought in moist leaf litter. No common name was assigned to this taxon by Turgeon et al. (1988). The one offered here was derived from the description of the type and the common cognomen applied to the genus.

Euglandina rosea (Ferussac, 1818)
ROSEY WOLFSNAIL LENGTH: 50-76 mm

This remarkable snail is an inhabitant of the deep south, ranging through the gulf states from Texas through Florida and up the coast to North Carolina. A population from the Morehead City area in Carteret County constitutes the only North Carolina occurrence for this species. It has earned the name wolfsnail through its molluscivorous habits, apparently using a well-developed sense of smell or vision to locate its

terrestrial molluscan neighbors which it attacks with surprising speed and feeds on voraciously. Its large, elongate, spiral shell and elongated crescentic lips make this snail unmistakable. Like many predators it is variable in its habitats, having been recorded from forested and grassed habitats as well as in gardens and around houses. It should be sought wherever good populations of landsnails occur in the southeastern corner of the state.

Stenotrema barbigerum (Redfield, 1856)
FRINGED SLITMOUTH WIDTH: 8.7-10 mm

This species occurs in the mountains and piedmont between North Carolina and Alabama. In North Carolina, it is known only from Cherokee, Clay, and Graham counties. It is found on logs in forested areas.

Stenotrema fraternum fraternum (Say, 1824)
PHILADELPHIA SLITMOUTH WIDTH: 7.8-11.4 mm

This taxon ranges from New England west to about the 100th meridian, south to northern Alabama. In North Carolina, it is known from Caswell, Cherokee, Columbus, Davidson, and Rockingham counties. It should be sought in leaf litter and around logs in upland forests. No common name was assigned to this taxon by Turgeon et al. (1988). The name given here was derived from the type locality and the common cognomen applied to the genus.

Stenotrema fraternum montanum Archer, 1939
CHEROKEE SLITMOUTH WIDTH: 10.5-11.4 mm

This taxon has a restricted range, being found only in the southern Appalachians. Most of its range occurs in six mountainous North Carolina counties: Cherokee, Clay, Graham, Jackson, Mitchell, and Swain. Due to its restricted range, additional information will necessary before a determination of its status can be made. It has been found in leaf litter, on logs, and under stones in dry oak-hickory forests between 2000' and 3000'. As with the above species, no common name was assigned to this taxon by Turgeon et al. (1988). The name given here honors the Cherokee Indian Nation, which people the land around its type locality (Smokemont, Swain County), and uses the common cognomen applied to the genus.

Stenotrema pilula (Pilsbry, 1900)
PYGMY SLITMOUTH WIDTH: 5.7-6 mm

Like the previous taxon, this species is restricted to the southern Appalachians and will require additional information before a supportable status determination can be made. It is known in North Carolina from collections in Graham, Haywood, Henderson, Macon, Madison, McDowell, Polk, and Swain counties. Its habitat is known to include leaf litter and areas under logs on dry, forested hillsides.

Praticolella lawae (J. Lewis, 1874)
APPALACHIAN SCRUBSNAIL WIDTH: 5.7-6.1 mm

The Appalachian scrubsnail ranges northeast from Mobile, Alabama, into southwestern North Carolina, where it has only been recorded from Clay County. It occurs in open pine woods and clearings, usually on sandy soil.

Mesodon andrewsae W. G. Binney, 1879
BALSAM GLOBE WIDTH: 21.2-38.7 mm

This thin-shelled and variable taxon is restricted to high elevations of the Appalachian Mountains from Pocahontas County, West Virginia, south to western North Carolina. It is known from 11 of our mountain counties: Caldwell, Graham, Haywood, Jackson, Macon, Madison, Mitchell, Swain, Transylvania, Watauga, and Yancey. Due to its restricted range and occurrence at high elevations, it is subject to direct and indirect impacts from habitat fragmentation and acid rain. This taxon is particularly interesting due to its extreme variability and more than one species may actually be involved. Six forms have been noted on Clingmans Dome alone. The haunts of this taxon are also variable. Pilsbry (1900) reported finding it in a variety of places including densely wooded areas near logs and sticks, in weeds and on trees to several feet off the ground, and under bunches of moss on tree trunks.

Mesodon appressus (Say, 1821)
FLAT BLADETOOTH WIDTH: 13-19.5 mm

This species extends west-southwest from the Delmarva Peninsula to eastern Tennessee and Kentucky. It is known in North Carolina from collections made in Alexander, Caswell, Rowan, Stokes, and Wilkes counties. It probably occurs throughout the western half of the state but, without additional records, no reliable determination of its status can be made. It should be sought in rocky areas, along river bluffs, and along roadsides. It has also been found in urban settings.

Mesodon christyi (Bland, 1860)
GLOSSY COVERT WIDTH: 8.3-10 mm

This species occurs principally in the Carolinas, ranging from southcentral Virginia to Augusta, Georgia, west to eastern Tennessee. Records of occurrence are spotty throughout this range, with the majority being from North Carolina. It has been recorded in over a dozen counties in the state, with most being in the southwestern mountains and foothills. It has been taken in leaf litter of oak forests. While this species is probably secure in the state, more precise habitat and distributional data are needed before this can be verified.

Mesodon wheatleyi (Bland, 1860)
CINNAMON COVERT WIDTH: 13.2-16.4 mm

The Mesodon wheatleyi species complex is restricted to the southern Appalachians, with the bulk of its range occurring in the Smokies. It is known from 12 western North Carolina counties where it occurs above 2,000 feet under logs, rocks, and in leaf litter. This species complex includes Mesodon clingmanicus (see species account for that taxon) and, possibly, several other taxa. Some of these may be distinct species, but additional material is needed for examination before a determination can be made.

Mesodon elevatus (Say, 1821)
PROUD GLOBE WIDTH: 19.8-26.3 mm

This species occurs primarily in the midwest, extending from the Great Lakes west to Oklahoma, south to northern Mississippi and Alabama, and east to western North Carolina and Virginia. In North Carolina, it is

known only from Haywood, Mitchell, and Watauga counties. It has been found on river bluffs.

Mesodon mitchellianus (I. Lea, 1839)
SEALED GLOBELET WIDTH: 15.3-17.2 mm

Scattered records of this species exist from New England west to the Great Lakes states, south to North Carolina where it is known only from specimens collected by W. Van Devender in Hickory Nut Gorge in Rutherford County. This species is known from meadows, flood plains and roadsides during wet weather and under leaf litter during dry periods.

Mesodon sayanus (Pilsbry, 1906)
SPIKE-LIP CRATER WIDTH: 19.4-27 mm

This is a northern species which extends from New England south through the Appalachians to North Carolina where it has been recorded from Ashe, Avery, Madison, Watauga, and Yancey counties. It should be sought in moist leaf litter or around logs in forested areas. North Carolina populations of this species deserve close watching as they are on the periphery of its range.

Triodopsis burchi Hubricht, 1950
PITTSYLVANIA THREETOOTH WIDTH: 8-17 mm

This species is restricted to the upper piedmont in Virginia and North Carolina. It has been recorded from 7 counties in the North Carolina: Caswell, Davidson, Guilford, Mecklenburg, Montgomery, Randolph, and Rockingham. It has been recorded from leaf litter and under logs in oak forests and ravines.

Triodopsis messana Hubricht, 1952
PINHOLE THREETOOTH WIDTH: 8-14 mm

This species is restricted to the coastal plain of the mid-Atlantic states, ranging from Southampton County, Virginia south to Berkeley County, South Carolina. Only a small part of this species' range lies outside of North Carolina. While it has been collected in well over a dozen counties in the state, it is not frequently found. It has been collected in open situations such as along roadsides, railroads, and in yards.

Triodopsis tennesseensis (Walker and Pilsbry, 1902)
BUDDED THREETOOTH WIDTH: 19-24 mm

This species is restricted to the southern Appalachians, with most of its range lying north of the Smoky Mountains in Kentucky and Tennessee. It is known in North Carolina only from Madison County. It is found under logs and leaf litter on forested hillsides and ravines.

Xolotrema caroliniensis (I. Lea, 1834)
BLUNT WEDGE WIDTH: 19.2-23.1 mm

The blunt wedge is a southern species, ranging from North Carolina west to Arkansas and south, excluding Florida. Records within this range are spotty. This species is known in North Carolina from Anson and Union counties. It has been found under bark on old logs and near logs in both flood plains and hillsides.

Xolotrema denotata (Ferussac, 1821)
VELVET WEDGE WIDTH: 19-25.6 mm

This species ranges from New England west to the Great Lakes states and south through the area from the Appalachian Mountains to the Mississippi River. It is known in North Carolina from records from Cherokee, Graham, Madison, Mitchell, and Watauga counties. It is usually found on or near logs on forested hillsides or flood plains.

Neohelix dentifera (A. Binney, 1837)
BIG-TOOTH WHITELIP WIDTH: 20-30.5 mm

This species ranges from New England south through the mountains to North Carolina where it is known from specimens taken in Avery and Watauga counties. It is found under leaf litter, and around logs and rocks in humid, forested areas.

Allogona profunda (Say, 1821)
BROAD-BANDED FORESTSNAIL WIDTH: 19-34 mm

This species occurs throughout the midwest from the Great Lakes south to Tennessee. It is known in North Carolina from Madison and Mitchell counties. It is found in leaf litter in forested areas, especially on bluffs.

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Prepared by WILLIAM F. ADAMS

ACKNOWLEDGMENTS

A faunal group as large as North Carolina's freshwater and terrestrial mollusks cannot be thoroughly reviewed, evaluated and discussed in a meaningful way without a lot of help and sacrifice. Members of the scientific council were richly blessed with assistance from many persons, so many that only a partial listing seems possible at this point. The myriad phone calls that helped solve minor problems along the way have, for the most part, been forgotten, and the hours of separation or neglect suffered by the council member's families too humbling to recall. Several persons however, offered assistance at key points in the process and their efforts here are greatfully acknowledged. Mr. Leslie Hubricht, Dr. Gerry Mackie, Dr. Robert Dillon, and Dr. Kenneth Emberton reviewed the checklist of freshwater and terrestrial mollusks of North Carolina early in the process of its development and provided many helpful comments and suggestions. Mr. Samuel Fuller and Dr. James Parnell provided helpful comments on early drafts of portions of the report. Dr. Arthur Bogan cheerfully sought out data on specimens curated at the Academy of Natural Sciences at Philadelphia whenever called upon. Mr. Randy Wilson provided many helpful words of encouragement when it seemed that the task was too large to ever be completed and an understanding ear when one report submittal date after the other slipped down the road of good intentions.

Finally, many thanks are due to the Wilmington District, Corps of Engineers, for providing the chairman with the support and equipment needed to complete his tasks. Mr. Richard Lewis provided invaluable assistance on software bridging, saving many hours of labor compiling the report. Ms. Betty Sue Westbrook showed unsurpassed skill as a librarian, always managing to obtain the references needed, no matter how obscure. Indeed, preparation of many of the species accounts included in this work would not have been possible without her untiring efforts.

W. F. A.

APPENDIX A

A CHECKLIST OF THE FRESHWATER AND TERRESTRIAL MOLLUSKS OF NORTH CAROLINA WITH NOTATION OF THEIR STATUSES IN THE STATE

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INTRODUCTION

As a prelude to determining which species of freshwater and terrestrial mollusks in North Carolina are in need of protection, the scientific committee determined that it was necessary to develop a list of species which have been documented to occur in the state. Development of a North Carolina list of mollusks has been done only once for freshwater species (Dawley, 1965) and once for terrestrial species (Hubricht, 1970). Due to the multitude of taxonomic revisions which have occurred since these works and the availability of new distributional information, these lists were no longer considered adequate.

This checklist of freshwater and terrestrial mollusks of North Carolina was compiled using literature sources and the personal notes and collections of committee members. The literature sources reviewed are contained in the reference section provided at the end of the checklist. Many specimens of mollusks are housed in museums, universities, and private collections around the country and their review would no doubt expand this list. Time, however, willed that effort to future researchers.

Without doubt, errors have been made in assigning or excluding some species to this checklist. Such errors are unavoidable and exist for several reasons. Because of the spotty nature of literature records, a general lack of recent collecting, and rapidly changing environmental conditions, difficulty was encountered in determining whether or not a species should be considered to be a part of North Carolina's fauna. We tried to rule liberally in this regard. For example, if a species is recorded from both Virginia and South Carolina, we have assumed that it also occurs in North Carolina even if no published record for the state could be located. In such cases, the species is assigned a committee status of "Probable". In other instances, determining which species reported in the literature are valid taxa and which are actually ecophenotypic forms of more common species is impossible. Such taxa were discussed by the committee and its collective judgement used in determining whether or not they should be assigned species rank on the list. Resolution of taxonomic problems is beyond the scope and intent this list; however, the reader should be aware that they exist and that, once resolved, the distribution (and hence the abundance) of some species may be dramatically altered. Because of these inherent uncertainties, this list should be considered to be part of a dynamic continuum, building on the efforts of others and, hopefully, offering research directions to the future.

A diagram (Figure 1) of the current higher classification of North Carolina's freshwater and terrestrial mollusks precedes the checklist. Nomenclature for freshwater mollusks follows multiple authors while for terrestrial mollusks, Hubricht's (1985) work is followed with but a few exceptions. Undescribed species known to the committee have been placed in their presumed genuses and noted as sp. Some of these species may be determined by future research to be ecophenotypic variants of previously described species. Their separation at this point is being made solely on the basis of apparently distinctive concological features.

Every species on the checklist has been assigned to status categories under several different ranking systems. While sometimes confusing, it is a fact of life that different ranking systems evolved out of the different needs of their users and that all persons interested in the conservation of our dwindling resources should be familier with the strengths and weaknesses

of each. Species which were believed to be declining were assigned to a status category under each of these ranking systems. This was done in order to make the list useable to the largest possible audience.

Only native species were evaluated by the committee. Introduced species are included in the checklist for the sake of completeness but it is the opinion of the committee that none of these species should receive protection efforts. The reason for this opinion is twofold. First, few of the introduced species occur in low numbers and their population increases are usually made at the expense of our native fauna. Second, financial and manpower resources available to conservation interests for habitat acquisition and management are presently too limited to be shared with these species. However, research on introduced species should not be discouraged as study of these species may shed light on some of the possible causes of the declines occurring in our native fauna.

The status categories and definitions used in assigning species to the different ranking systems follow. It should be noted that the categories denoting "Extirpated" and "Extinct" status were used sparingly by the committee. This is not a cause for thankfulness; rather, our current state of knowledge regarding the distribution and abundance of many of the species on this list prohibits their use. Some of the "Undetermined" species have not been collected in the state for many years and the use of these categories may, unfortunately, be appropriate.

COMMITTEE CLASSIFICATION

This system was developed by the committee for use during its development of a state list and in deliberating the statuses of the species. It is retained here because of the information it provides on probable, possible and introduced species. It has no legal status.

Endangered (E) - Species which are in danger of extirpation from North Carolina.

Threatened (T) - Species which are likely to become endangered in North Carolina in the near future.

Special Concern (SC) - Species which have significantly declined or have restricted ranges in North Carolina but do not yet warrent a more restrictive status.

Status Undetermined (U) - Species which cannot be adequately assessed due to insufficient information.

Common (C) - Species which have wide ranging habitat in the state and can be easily found in that habitat.

Extinct - Species which can no longer be found in North Carolina or any other locale.

Extirpated - Species which can no longer be found in North Carolina but still occur in other areas.

Probable - Species which have ranges which encompass North Carolina but have not yet been recorded for the state.

Possible - Species which have ranges which approach North Carolina and may extend into it but have not been recorded in the state.

Introduced - Species which have been imported to North Carolina and may or may not be permanently established as a part of the states fauna.

Subcategories - Two subcategories were established by the committee, restricted and peripheral. When appropriate, these subcategories were used in conjunction with major categories to clarify the reason for placement of the taxon in that category. Restricted (R) refers to species that were determined to be of concern solely because they have very restricted ranges, part of which occurs in North Carolina. In instances where additional threats to the species were identified, this subcategory was not used. Peripheral (P) refers to those species which have a large range which occurs primarily outside of North Carolina but having a small portion of their range extending into the state. When this subcategory is used, the major category (e.g. Special Concern) applies only to the North Carolina portion of its range.

NORTH CAROLINA ENDANGERED SPECIES ACT

Definitions of these categories were established in the state endangered species legislation (N.C. Gen. Stat. 113, Article 25). The statuses assigned in this checklist are those which the committee will recommend to the North Carolina Wildlife Resources Commission for adoption. They have no legal status at this time.

Endangered - any native or once-native species of wild animal whose continued existence as a viable component of the State's fauna is determined by the Wildlife Resources Commission to be in jeopardy or any species of wild animal determined to be an "endangered species" pursuant to the Endangered Species Act (Federal).

Threatened - any native or once-native species of wild animal which is likely to become an endangered species within the foreseeable future throughout all or a significant part of its range, or one that is designated as a threatened species pursuant to the Endangered Species Act (Federal).

Special Concern - any species of wild animal native or once-native to North Carolina which is determined by the Wildlife Resources Commission to require monitoring but may be taken under regulations adopted under the provisions of this article.

NORTH CAROLINA STATE MUSEUM OF NATURAL SCIENCES

This classification system was devised by the N.C. State Museum of Natural Sciences to provide a means of identifying declining species without

causing confusion with federal or state designations which indicate legal protection.

Endangered - any species which is in danger of extinction throughout all or a significant part of its range. This category is assigned only to those taxa which have been listed as endangered by the U.S. Fish and Wildlife Service.

Threatened - any species which is likely to become an endangered species within the foreseeable future throughout all or a significant part of its range. This category is assigned only to those taxa which have been listed as threatened by the U.S. Fish and Wildlife Service.

Vulnerable, Category 1 - Comprises taxa for which there is substantial information on hand to support the biological appropriateness of proposing to list the species as endangered or threatened in North Carolina.

Vulnerable, Category 2 - Comprises taxa for which current information indicates that proposing to list the species as endangered or threatened in North Carolina is probably appropriate, but for which substantial data are not currently available to support that proposal. Further research is needed to clarify the status, and some taxa may be found to not warrant listing.

Vulnerable, Category 3 - Comprises taxa that have proven to be more abundant and widespread than was previously believed and/or those that are not subject to any definable threat. Should further research or changes in land use indicate significant decline in any of these taxa, they may be reevaluated for possible inclusion in Categories 1 or 2. Category 3 species are usually those with marginal populations which should be watched for changes.

U.S. FISH AND WILDLIFE SERVICE

The statuses provided on the list are those which are either being applied by the U. S. Fish and Wildlife Service as of the date of this publication or are being recommended by the committee as candidates for federal protection. Status review categories which are being recommended by the committee are enclosed in parentheses. Rankings in this system not in parentheses are already official. U.S. Fish and Wildlife Service ranks are being continually revised so the reader should contact the Service for an updated list if current information is important.

Endangered - any species which is in danger of extinction throughout all or a significant portion of its range.

Threatened - any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Proposed - a species which has been officially proposed for endangered or threatened species status.

Status Review - any species being considered for addition to the list of endangered and threatened species. Species in this group are divided into three categories:

Category 1 - comprises taxa for which the Service currently has substantial information on hand to support the biological appropriateness of proposing to list the species as endangered or threatened.

Category 2 - comprises taxa for which information now in possession of the Service indicates that proposing to list the species as endangered or threatened is possibly appropriate, but for which conclusive data on biological vulnerability and threat(s) are not currently available to support proposal at this time.

Category 3 - comprises taxa which are no longer being considered for listing as endangered or threatened species. Such taxa are included in one of three subcategories depending on the reasons for removal from consideration.

3A. Taxa for which the Service has persuasive evidence of extinction.

3B. Names that, on the basis of current taxonomic understanding do not represent taxa meeting the Endangered Species Act's definition of "species".

3C. Taxa which have proven to be more abundant or widespread than was previously believed and/or those that are not subject to any identifiable threat. Should further research or changes in land use indicate significant decline of these taxa, they may be reevaluated for possible inclusion in category 1 or 2.

NATURE CONSERVANCY

Nature Conservancy categories are two-tiered, with both global and state rankings. The format used provides the global ranking first and the state rank second (e.g., G2/S1). The rankings in the list are recommendations by the committee and may not be ranks which the Nature Conservancy selects to assign.

Global rankings

G1 - Critically imperiled globally because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of factor(s) making it especially vulnerable to extinction.

G2 - Imperiled globally because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it vulnerable to extinction throughout its range.

G3 - Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g., a single western state, a physiographic region in the east) or because of other factors making it vulnerable to extinction throughout its range; in terms of occurrences, in the range of 21-100.

G4 - Apparently secured globally, though it may be quite rare in parts of its range, especially at the periphery.

G5 - Demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery.

GH - Of historical occurrence throughout its range, i.e., formerly part of the established biota, with the expectation that it may be rediscovered.

GU - Possibly in peril range-wide but status uncertain; need more information. NOTE: When uncertainty exists, either the most likely rank and a question mark (e.g., G2?) or a range (e.g., G2G3) are used to delineate the limits (range) of uncertainty.

GX - Believed to be extinct throughout range with virtually no likelihood that it will be rediscovered.

Q - A "Q" in a rank indicates that a taxonomic question concerning the species exists.

State rankings

S1 - Critically imperiled in state because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extirpation from the state.

S2 - Imperiled in state because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extirpation from the state.

S3 - Rare or uncommon in state (on the order of 21 to 100 occurrences).

S4 - Apparently secure in state, with many occurrences.

S5 - Demonstrably secure in state and essentially ineradicable under present conditions.

SH - Of historical occurrence in the state, perhaps having not been verified in the past 20 years, and suspected to be still extant. Upon verification of extant occurrence, SH-ranked elements would typically

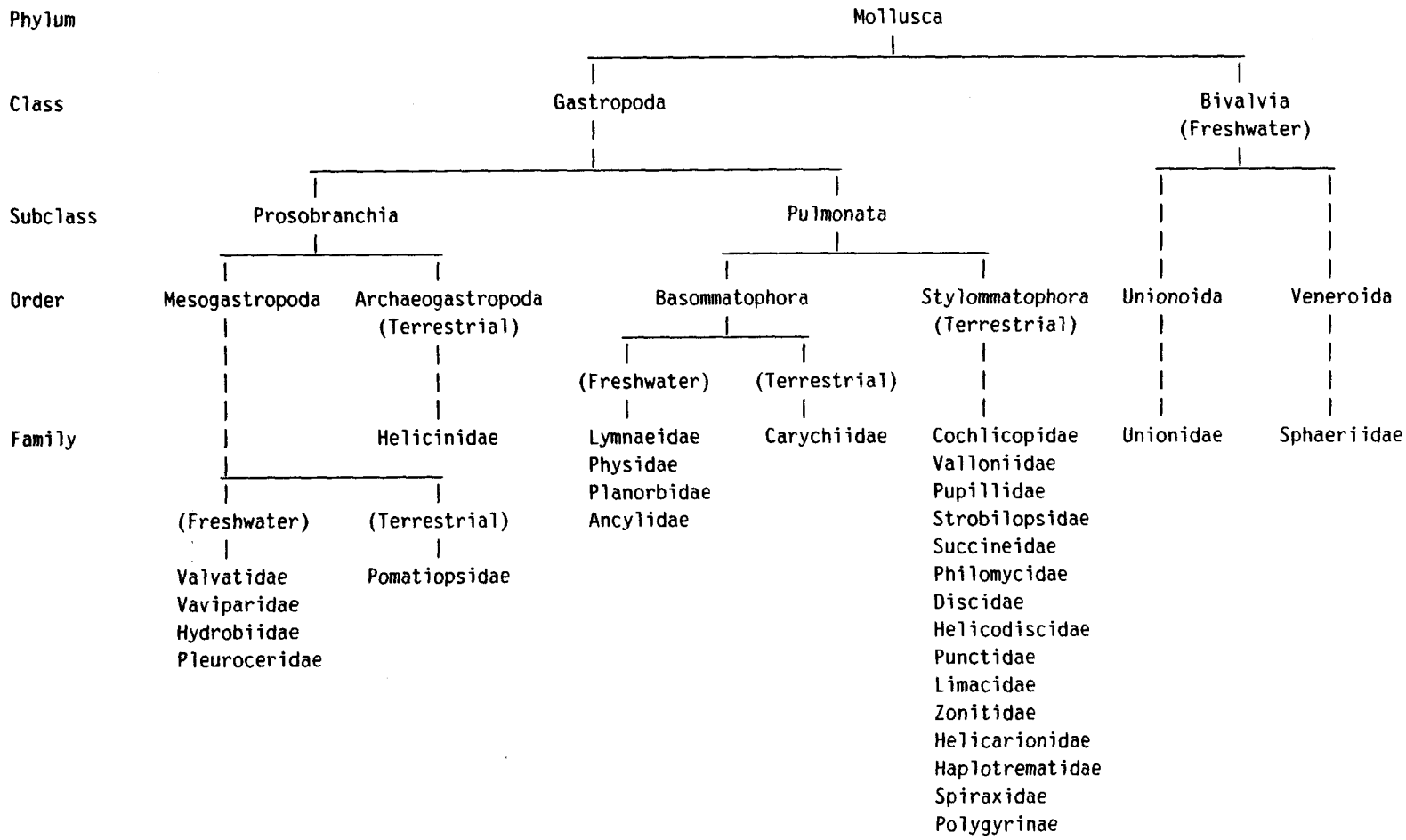
receive an S1 rank. The SH rank is reserved for elements for which some effort has been made to relocate occurrences.

SU - Possibly in peril in state but status uncertain; need more information. NOTE: as in GU above.

SX - Apparently extirpated from state.

Q - A "Q" in a rank indicates that a taxonomic question concerning the species exists.

Figure 1. Higher classification of the native freshwater and terrestrial mollusks of North Carolina



FRESHWATER MOLLUSKS

Taxon	Ranking System				
	Committee	State	NCSM	USFWS	TNC
CLASS GASTROPODA					
SUBCLASS PROSOBRANCHIA					
ORDER MESOGASTROPODA					
Family VALVATIDAE					
Genus Valvata Muller, 1774					
Valvata bicarinata I. Lea, 1841	U	-	-	-	G3/SU
Valvata tricarinata (Say, 1817)	Possible	-	-	-	G3
Family VIVIPARIDAE					
Genus Viviparus Montfort, 1810					
Viviparus georgianus (I. Lea, 1834)	Possible	-	-	-	G4
Genus Cipangopaludina Hannibal, 1912					
Cipangopaludina japonica (von Martens, 1861)	Introduced				
Cipangopaludina malleata (Reeve, 1863)	Introduced				
Genus Campeloma Rafinesque, 1819					
Campeloma crassulum Rafinesque, 1819	U	-	-	-	G5/SU
Campeloma decisum (Say, 1817)	C	-	-	-	G5/S5
Campeloma geniculum (Conrad, 1834)	U	-	-	-	G3/SU
Campeloma limum (Anthony, 1860)	U	-	-	-	G3/SU
Genus Lioplax Troschel, 1857					
Lioplax subcarinata (Say, 1816)	C	-	V3	-	G4/S3
Family HYDROBIIDAE					
Genus Gillia Stimpson, 1865					
Gillia altilis (I. Lea, 1841)	C	-	-	-	G5/S5
Genus Cincinnatia Pilsbry 1891					
Cincinnatia sp.* (Lake Waccamaw)	SC	SC	V2	(C2)	G1Q/S1Q
Genus Somatogyrus Gill, 1863					
Somatogyrus (Walkerilla) virginicus Walker, 1904	U	-	-	-	G2/SU

A dash indicates the taxon was not ranked in the system.

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Taxon	Ranking System				
	Committee	State	NCSM	USFWS	TNC
Family HYDROBIIDAE (cont.)					
Genus Amnicola Gould and Haldeman, 1840					
Amnicola limosa (Say, 1817)	C	-	-	-	G5/S5
Amnicola parva I. Lea, 1841	Probable	-	-	-	G4
Amnicola sp.* (Lake Waccamaw)	SC	SC	V2	(C2)	G1Q/S1Q
Genus Fontigens Pilsbry, 1933					
Fontigens nickliniana (I. Lea, 1838)	Probable	-	-	-	G4
Family PLEUROCERIDAE					
Genus Goniobasis I. Lea, 1862					
Goniobasis catenaria catenaria (Say, 1822)	C	-	-	-	G3/S3
Goniobasis catenaria dislocata (Reeve, 1861)	C	-	-	-	G4/S4
Goniobasis clavaeformis (I. Lea, 1841)	U	-	-	-	G3/SU
Goniobasis interrupta (Haldeman, 1840)	E	E	V1	(C2)	G1/S1
Goniobasis proxima (Say, 1825)	C	-	-	-	G4/S4
Goniobasis simplex (Say, 1825)	U	-	-	-	G3/SU
Goniobasis symmetrica (Haldeman, 1841)	U	-	-	-	G4/SU
Goniobasis virginica (Say, 1817)	U	-	-	-	G4/SU
Goniobasis caelatura georgiana (Lea, 1862)	Possible	-	-	-	G2
Genus Leptoxis Rafinesque, 1819					
Leptoxis (Mudalia) carinata (Bruguiere, 1792)	C	-	-	-	G5/S5
Leptoxis (Mudalia) dilatata (Conrad, 1835)	T (P)	T	V1	-	G3/S1
Leptoxis praerosa (Say, 1821)	Possible	-	-	-	G2
Leptoxis (Mudalia) virgata (I. Lea, 1841)	U	-	-	-	G2/SU
Genus Lithasia					
Lithasia verrucosa (Rafinesque, 1820)	Possible	-	-	-	G2

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Taxon	Ranking System				
	Committee	State	NCSM	USFWS	TNC
SUBCLASS PULMONATA					
ORDER BASOMMATOPHORA					
Family LYMNAEIDAE					
Genus Fossaria Westerlund, 1885					
Fossaria humilis (Say, 1822)	U	-	-	-	G3/SU
Fossaria obrussa (Say, 1825)	U	-	-	-	G5/SU
Genus Pseudosuccinea F.C. Baker, 1908					
Pseudosuccinea columella (Say, 1817)	C	-	-	-	G5/S5
Family PHYSIDAE					
Genus Physella Haldeman, 1843					
Physella gyrina (Say, 1821)	C	-	-	-	G5/S5
Physella (Costatella) hendersoni (Clench, 1925)	C	-	-	-	G5/S5
Physella (Costatella) heterostropha (Say, 1817)	C	-	-	-	G5/S5
Family PLANORBIDAE					
Genus Gyraulus 'Agassiz' Charpentier, 1834					
Gyraulus deflectus (Say, 1824)	U	-	-	-	G5/SU
Gyraulus parvus (Say, 1817)	U	-	-	-	G5/SU
Genus Helisoma Swainson, 1840					
Helisoma anceps (Menke, 1830)	C	-	-	-	G5/S5
Helisoma eucosmium (Bartsch, 1908)	Extirpated	E	-	C2	GH/SX
Genus Menetus H.& A. Adams, 1855					
Menetus (Micromenetus) alabamensis (Pilsbry, 1895)	U	-	-	-	G1/SU
Menetus (Micromenetus) dilatatus (Gould, 1841)	C	-	-	-	G5/S5

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Taxon	Ranking System				
	Committee	State	NCSM	USFWS	TNC
Family PLANORBIDAE (cont.)					
Genus Planorbella Haldeman, 1842					
Planorbella (Pierosoma) magnifica (Pilsbry, 1903)	E	E	V1	C2	G1/S1
Planorbella (Pierosoma) trivolvis (Say, 1817)	C	-	-	-	G5/S5
Genus Planorbula Haldeman, 1840					
Planorbula armigera (Say, 1821)	U	-	-	-	G5/SU
Genus Promenetus F.C. Baker, 1935					
Promenetus exacuous (Say, 1821)	Possible	-	-	-	G5
Family ANCYLIDAE					
Genus Ferrissia Walker, 1903					
Ferrissia fragilis (Tryon, 1863)	C	-	-	-	G5/S5
Ferrissia hendersoni (Walker, 1908)	SC	SC	V2	(C2)	G1/S1
Ferrissia parallelus (Haldeman, 1841)	Probable	-	-	-	G4
Ferrissia rivularis (Say, 1817)	C	-	-	-	G5/S5
Genus Laevapex Walker, 1903					
Laevapex diaphanus (Haldeman, 1841)	C	-	-	-	G4/S4
Laevapex fuscus (C.B. Adams, 1841)	C				G5/S5

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Taxon	Ranking System				
	Committee	State	NCSM	USFWS	TNC
CLASS BIVALVIA					
SUBCLASS LAMELLIBRANCHIA					
ORDER VENEROIDA					
Family CORBICULIDAE					
Genus Corbicula von Muhlfeld, 1811					
Corbicula fluminea (Muller, 1774)	Introduced				
Family SPHAERIIDAE					
Genus Sphaerium Scopoli, 1777					
Sphaerium fabale (Prime, 1852)	U	-	-	-	G5/SU
Sphaerium occidentale (Prime, in: J. Lewis, 1856)	C	-	-	-	G5/S5
Sphaerium striatinum (Lamarck, 1818)	C	-	-	-	G5/S5
Genus Musculium Link, 1807					
Musculium lacustre (Muller, 1774)	U	-	-	-	G5/SU
Musculium partumeium (Say, 1822)	U	-	-	-	G5/SU
Musculium securis (Prime, 1852)	U	-	-	-	G5/SU
Musculium transversum (Say, 1829)	C	-	-	-	G5/S5
Genus Eupera Bourguigant, 1854					
Eupera cubensis (Prime, 1865)	C	-	-	-	G3/S3
Genus Pisidium Pfeiffer, 1821					
Pisidium adamsi (Stimpson, 1851)	U	-	-	-	G3/SU
Pisidium casertanum (Poli, 1791)	C	-	-	-	G5/S5
Pisidium compressum Prime, 1852	C	-	-	-	G5/S5
Pisidium dubium (Say, 1817)	C	-	-	-	G5/S5
Pisidium ferrugineum Prime, 1852	U	-	-	-	G5/SU

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Taxon	Ranking System				
	Committee	State	NCSM	USFWS	TNC
ORDER UNIONOIDA					
Family UNIONIDAE					
Genus Fusconaia Simpson, 1900					
Fusconaia barnesiana (I. Lea, 1838)	E (P)	E	V1	-	G3/S1
Fusconaia masoni (Conrad, 1834)	T	T	V1	(C2)	G2/S1
Fusconaia subrotunda (I. Lea, 1831)	U	-	-	-	G4/SU
Genus Quadrula Rafinesque, 1820					
Quadrula pustulosa (I. Lea, 1831)	U	-	-	-	G4/S1
Genus Tritigonia Agassiz, 1852					
Tritigonia verrucosa (Rafinesque, 1820)	E (P)	E	V1	-	G4/S1
Genus Cyclonaias Pilsbry, 1922					
Cyclonaias tuberculata (Rafinesque, 1820)	Probable	-	-	-	G4
Genus Elliptio Rafinesque, 1819					
Elliptio angustata (I. Lea, 1831)	C	-	-	-	G3Q/S4
Elliptio cistelliformis (I. Lea, 1863)	U	-	-	-	GUQ/SUQ
Elliptio complanata (Lightfoot, 1786)	C	-	-	-	G5/S5
Elliptio congaraea (I. Lea, 1831)	C	-	-	-	G4/S3
Elliptio dilatata (Rafinesque, 1820)	SC	SC	V2	-	G3/S2
Elliptio fisheriana (I. Lea, 1838)	U	-	-	-	G4/SU
Elliptio folliculata (I. Lea, 1838)	SC	SC	V2	C2	G3/S2
Elliptio icterina (Conrad, 1834))	C	-	-	-	G4/S4
Elliptio judithae Clarke, 1986	E	E	V1	(C2)	G1/S1
Elliptio lanceolata (I. Lea, 1828)	T	T	V1	-	G3/S2
Elliptio marsupiobesa Fuller, 1972	T	T	V1	C2	G1/S1
Elliptio perlatus* (I. Lea, 1863)	U	-	-	-	GUQ/SUQ
Elliptio perstriatus* (I. Lea, 1852)	U	-	-	-	GUQ/SUQ
Elliptio producta (Conrad, 1836)	U	-	-	-	G3Q/SU
Elliptio raveneli (Conrad, 1834)	U	-	-	-	G3Q/SU
Elliptio roanokensis (I. Lea, 1838)	T	T	V1	-	G2/S1

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Taxon	Ranking System				
	Committee	State	NCSM	USFWS	TNC
Family UNIONIDAE (cont.)					
Genus Elliptio (Cont.)					
Elliptio steinstansana R. I. Johnson and Clarke, 1983	E	E	E	E	G1/S1
Elliptio waccamawensis (I. Lea, 1863)	T	T	V1	C2	G1/S1
Elliptio sp. a* (Black River system)	U	-	-	(C2)	GUQ/SUQ
Elliptio sp. b* (Deep River system)	U	-	-	(C2)	GUQ/SUQ
Genus Plethobasus Simpson, 1900					
Plethobasus striatus (Rafinesque, 1820)	Possible	-	-	-	G1
Genus Pleurobema Rafinesque, 1820					
Pleurobema oviforme (Conrad, 1834)	U	-	-	C2	G2/SU
Pleurobema plenum (I. Lea, 1840)	Possible	-	-	-	G1
Pleurobema sp.* (Little Tennesse River drainage)	U	-	-	(C2)	GUQ/SUQ
Genus Uniomerus Conrad, 1853					
Uniomerus obesus (I. Lea, 1831)	C	-	-	-	G4/S4
Genus Lasmigona Rafinesque, 1831					
Lasmigona decorata (I. Lea, 1852)	E	E	V1	C2	G1/S1
Lasmigona holstonia (I. Lea, 1838)	E	E	V1	(C2)	G3/S1
Lasmigona subviridus (Conrad, 1835)	E	E	V1		G3/S1
Genus Pegias Simpson, 1900					
Pegias fabula (I. Lea, 1838)	Extirpated	E	-	E	G1/SH
Genus Alasmidonta Say, 1818					
Alasmidonta heterodon (I. Lea, 1829)	E	E	V1	P	G1/S1
Alasmidonta raveneliana (I. Lea, 1834)	E	E	V1	C2	G1/S1
Alasmidonta robusta Clarke, 1981	Extinct	-	-	C3A	GX/SX
Alasmidonta undulata (Say, 1817)	T	T	V1	-	G4/S2
Alasmidonta varicosa (Lamarck, 1819)	T	T	V1	-	G3/S2
Alasmidonta viridis (Rafinesque, 1820)	E (P)	E	V1	-	G4/S1
Alasmidonta sp.* (Upper Yadkin River system)	U	-	-	(C2)	GUQ/SUQ

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Taxon	Ranking System				
	Committee	State	NCSM	USFWS	TNC
Family UNIONIDAE (cont.)					
Genus Anodonta Lamarck, 1799					
Anodonta cataracta Say, 1817					
(= A. teres (Conrad, 1834))	C	-	-	-	G5/S5
Anodonta couperiana Lea, 1842	E	E	V1	-	G3/S1
Anodonta imbecillis Say, 1829	C	-	-	-	G5/S5
Anodonta implicata Say, 1829	SC	SC	V2	-	G4/S2
Genus Strophitus Rafinesque, 1820					
Strophitus undulatus (Say, 1817)	T	T	V1	-	G4/S2
Genus Epioblasma Rafinesque, 1820					
Epioblasma capsaeformis (I. Lea, 1834)	U	-	-	C2	G1/SU
Genus Toxolasma Rafinesque, 1831					
Toxolasma lividus (Rafinesque, 1831)	U	-	-	-	G3/SU
Toxolasma pullus (Conrad, 1838)	T	T	V1	C2	G3/S2
Genus Villosa Frierson, 1927					
Villosa constricta (Conrad, 1838)	C	-	V3	-	G3/S4
Villosa delumbus (Conrad, 1834)	C	-	-	-	G3/S4
Villosa nebulosa (Conrad, 1834)	SC	SC	V2	-	G3/S2
Villosa vanuxemensis (I. Lea, 1838)	T	T	V1	-	G3/S1
Villosa vaughanianus (I. Lea, 1838)	SC	SC	V2	-	G3/S2
Villosa vibex (Conrad, 1834)	U	-	-	-	G4/SU
Genus Ligumia Swainson, 1840					
Ligumia nasuta (Say, 1817)	SC	SC	V2	-	G3/S2
Genus Lampsilis Rafinesque, 1820					
Lampsilis cariosa (Say, 1817)	T	T	V1	-	G4/S1
Lampsilis conspicuus* (I. Lea, 1872)	U	-	-	-	GUQ/SUQ
Lampsilis crocata (I. Lea, 1841)	SC	SC	V2	-	GU/S2
Lampsilis fasciola Rafinesque, 1820	SC (P)	SC	V2	-	G4/S2

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Taxon	Ranking System				
	Committee	State	NCSM	USFWS	TNC
Family UNIONIDAE (cont.)					
Genus Lampsilis (cont.)					
Lampsilis fullerkati R. I. Johnson, 1984	T	T	V1	(C2)	G1/S1
Lampsilis ochracea (Say, 1817)	SC	SC	V2	-	G4/S2
Lampsilis radiata (Gmelin, 1791)	SC	SC	V2	-	G4/S2
Lampsilis sp.* (Deep River system)	U	-	-	(C2)	G1Q/SUQ
Genus Medionidus Simpson, 1900					
Medionidus conradicus (I. Lea, 1834)	U	-	-	-	G4/SU
Genus Ptychobranchus Simpson, 1900					
Ptychobranchus fasciolaris (Rafinesuque, 1820)	U	-	-	-	G4/SU

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TERRESTRIAL MOLLUSKS

Taxon	Ranking System				
	Committee	State	NCSM	USFWS	TNC
CLASS GASTROPODA					
SUBCLASS PROSOBRANCHIA					
ORDER ARCHAEOGASTROPODA					
Family HELICINIDAE					
Genus Helicina Lamarck, 1799					
Helicina orbiculata Say, 1818	Possible	-	-	-	G5
Genus Hendersonia A. J. Wagner, 1905					
Hendersonia occulta (Say, 1831)	U	-	-	-	G4/SU
Family POMATIOPSIDAE					
Genus Pomatiopsis Tryon, 1862					
Pomatiopsis lapidaria (Say, 1817)	C	-	-	-	G5/S4
SUBCLASS PULMONATA					
ORDER BASOMMATOPHORA					
Family CARYCHIIDAE					
Genus Carychium Muller, 1774					
Carychium clappi Hubricht, 1959	C	-	-	-	G4/S4
Carychium exiguum (Say, 1822)	U	-	-	-	G4/SU
Carychium exile exile I. Lea, 1842	C	-	-	-	G5/S5
Carychium mexicanum Pilsbry, 1891	Possible	-	-	-	G5
Carychium nannodes G. H. Clapp, 1905	C	-	-	-	G4/S4

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Taxon	Ranking System				
	Committee	State	NCSM	USFWS	TNC
ORDER STYLOMMATOPHORA					
Family COCHLICOPIDAE					
Genus Cochlicopa Ferussac, 1821					
Cochlicopa morseana (Doherty, 1878)	C	-	-	-	G5/S4
Family VALLONIIDAE					
Genus Vallonia Risso, 1826					
Vallonia costata (Muller, 1774)	Probable	-	-	-	G4
Vallonia excentrica Sterki, 1893	Probable	-	-	-	G4
Vallonia perspectiva Sterki, 1892	Probable	-	-	-	G3
Vallonia pulchella (Muller, 1774)	U	-	-	-	G5/SU
Family PUPILLIDAE					
Genus Pupoides Pfeiffer, 1854					
Pupoides albilabris (C. B. Adams, 1841)	C	-	-	-	G5/S5
Genus Gastrocopta Wollaston, 1878					
Gastrocopta armifera (Say, 1821)	Probable	-	-	-	G5
Gastrocopta contracta (Say, 1822)	C	-	-	-	G5/S5
Gastrocopta corticaria (Say, 1816)	Probable	-	-	-	G4
Gastrocopta holzingeri (Sterki, 1889)	Probable	-	-	-	G4
Gastrocopta pellucida (Pfeiffer, 1841)	Probable	-	-	-	G5
Gastrocopta pentodon (Say, 1821)	U	-	-	-	G5/SU
Gastrocopta procera (Gould, 1840)	U	-	-	-	G5/SU
Gastrocopta rupicola (Say, 1821)	U	-	-	-	G5/SU
Gastrocopta tappaniana (C. B. Adams, 1842)	C	-	-	-	G5/S4

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Taxon	Ranking System				
	Committee	State	NCSM	USFWS	TNC
Family PUPILLIDAE (cont.)					
Genus Vertigo Muller, 1774					
Vertigo bollesiana (E. S. Morse, 1865)	U	-	-	-	G4/SU
Vertigo gouldi (A. Binney, 1843)	Possible	-	-	-	G4
Vertigo milium (Gould, 1840)	U	-	-	-	G5/SU
Vertigo oralis Sterki, 1898	U	-	-	-	G3/SU
Vertigo oscariana Sterki, 1890	Probable	-	-	-	G4
Vertigo ovata Say, 1822	C	-	-	-	G5/S4
Vertigo parvula Sterki, 1890	U	-	-	-	G3/SU
Vertigo teskeyae Hubricht, 1961	C	-	-	-	G4/S3
Vertigo tridentata Wolf, 1870	Possible	-	-	-	G4
Vertigo ventricosa (E. S. Morse, 1865)	U	-	-	-	G4/SU
Genus Columella Westerlund, 1878					
Columella simplex (Gould, 1841)	U	-	-	-	G5/SU
Family STROBILOPSIDAE					
Genus Strobilops Pilsbry, 1893					
Strobilops aenea Pilsbry, 1926	C	-	-	-	G5/S5
Strobilops labyrinthica (Say, 1817)	C	-	-	-	G5/S5
Strobilops texasiana Pilsbry & Ferris, 1906	C	-	-	-	G5/S4
Family SUCCINEIDAE					
Genus Oxyloma Westerlund, 1885					
Oxyloma effusa (Pfeiffer, 1853)	U	-	-	-	G3/SU
Oxyloma subeffusa Pilsbry, 1948	Possible	-	-	-	G3

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Taxon	Ranking System				
	Committee	State	NCSM	USFWS	TNC
Family SUCCINEIDAE (cont.)					
Genus Succinea Draparnaud, 1801					
Succinea campestris Say, 1817	C	-	-	-	G4/S4
Succinea forsheyi I. Lea, 1864 (=S. witteri)	U	-	-	-	G4/SU
Succinea indiana Pilsbry, 1905	U	-	-	-	G4/SU
Succinea unicolor Tryon, 1866	U	-	-	-	G4/SU
Succinea wilsoni I. Lea, 1864	C	-	-	-	G4/S4
Genus Novisuccinea Pilsbry 1948					
Novisuccinea ovalis Say, 1817	U	-	-	-	G5/SU
Novisuccinea sp.* (formerly believed to be N. chittenangoensis Pilsbry, 1908)	U	-	-	(C2)	G1Q/SUQ
Genus Catinella Pease, 1871					
Catinella avara (Say, 1824)	C	-	-	-	G5/S4
Catinella hubrichti Grimm, 1960	U	-	-	-	G3/SU
Catinella oklahomarum (Webb, 1953)	C	-	-	-	G4/S4
Catinella pugilator Hubricht, 1961	U	-	-	-	G3/SU
Catinella waccamawensis* Franzen, 1981	T	T	V1	(C2)	G1Q/S1Q
Family PHILOMYCIDAE					
Genus Philomycus Rafinesque, 1820					
Philomycus carolinianus (Bosc, 1802)	C	-	-	-	G5/S5
Philomycus flexuolaris Rafinesque, 1820	U	-	-	-	G3/SU
Philomycus togatus (Gould, 1841)	C	-	-	-	G4/S4
Philomycus venustus Hubricht, 1953	C	-	-	-	G3/S3
Philomycus virginicus Hubricht, 1953	U	-	-	-	G3/SU
Genus Megapallifera Hubricht, 1976					
Megapallifera mutabilis (Hubricht, 1951)	C	-	-	-	G4/S4

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Taxon	Ranking System				
	Committee	State	NCSM	USFWS	TNC
Family PHILOMYCIDAE (cont.)					
Genus Pallifera Morse, 1864					
Pallifera dorsalis (A. Binney, 1842)	U	-	-	-	G4/SU
Pallifera fosteri F. C. Baker, 1939	C	-	-	-	G5/S5
Pallifera hemphilli (W. G. Binney, 1885)	SC	SC	V2	-	G2/S2
Pallifera secreta (Cockerell, 1900)	C	-	-	-	G4/S4
Family DISCIDAE					
Genus Anguispira Morse, 1864					
Anguispira alternata (Say, 1816)	C	-	-	-	G5/S4
Anguispira fergusoni (Bland, 1861)	C	-	-	-	G4/S4
Anguispira jessica Kutchka, 1938	C	-	-	-	G3/S3
Anguispira knoxensis (Pilsbry, 1899)	Possible	-	-	-	G3
Anguispira mordax (Shuttleworth, 1852)	U	-	-	-	G3/SU
Anguispira strongylodes (Pfeiffer, 1854)	C	-	-	-	G4/S4
Genus Discus Fitzinger, 1833					
Discus bryanti (Harper, 1881)	SC (R)	SC	V2	-	G3/S2
Discus cronkhitei (Newcomb, 1865)	U	-	-	-	G5/SU
Discus nigrimontanus (Pilsbry, 1924)	U	-	-	-	G4/SU
Discus patulus (Deshayes, 1830)	C	-	-	-	G5/S5
Family HELICODISCIDAE					
Genus Helicodiscus Morse, 1864					
Helicodiscus bonamicus Hubricht, 1978	SC (R)	SC	V2	(C2)	G2/S2
Helicodiscus fimbriatus Wetherby, 1881	SC (P)	SC	V2	-	G3/S2
Helicodiscus inermis H. B. Baker, 1929	Probable	-	-	-	G4
Helicodiscus multidens Hubricht, 1962	Possible	-	-	-	G3
Helicodiscus notius notius Hubricht, 1962	C	-	-	-	G5/S4
Helicodiscus parallelus (Say, 1817)	C	-	-	-	G5/S5
Helicodiscus saludensis (Morrison, 1937)	Probable	-	-	-	G3

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	Committee	State	NCSM	USFWS	TNC
Family PUNCTIDAE					
Genus Punctum Morse, 1864					
Punctum blandianum Pilsbry, 1900	U	-	-	-	G3/SU
Punctum minutissimum (I. Lea, 1841)	U	-	-	-	G5/SU
Punctum smithi Morrison, 1935	U	-	-	-	G4/SU
Punctum vitreum H. B. Baker, 1930	Possible	-	-	-	G4
Family LIMACIDAE					
Genus Deroceras Rafinesque, 1820					
Deroceras laeve (Muller, 1774)	C	-	-	-	G5/S5
Family ZONITIDAE					
Genus Glyphyalinia Von Martens, 1892					
Glyphyalinia caroliniensis (Cockerell, 1890)	C	-	-	-	G3/S3
Glyphyalinia clingmani (Dall, 1890)	E	E	V1	(C2)	G1/S1
Glyphyalinia cumberlandiana (G. H. Clapp, 1919)	U	-	-	-	G4/SU
Glyphyalinia indentata (Say, 1823)	C	-	-	-	G5/S5
Glyphyalinia junaluskana (Clench & Banks, 1932)	SC (R)	SC	V2	-	G3/S2
Glyphyalinia lewisiana (Clapp, 1908)	Probable	-	-	-	G4
Glyphyalinia luticola Hubricht, 1966	U	-	-	-	G4/SU
Glyphyalinia ocoae Hubricht, 1978	Possible	-	-	-	G1
Glyphyalinia pentadelphia (Pilsbry, 1900)	SC (R)	SC	V2	-	G3/S2
Glyphyalinia praecox (H. B. Baker, 1930)	C	-	-	-	G4/S3
Glyphyalinia rhoadsi (Pilsbry, 1900)	C	-	-	-	G5/S4

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Taxon	Ranking System				
	Committee	State	NCSM	USFWS	TNC
Family ZONITIDAE (cont.)					
Genus Glyphyalinia (cont.)					
Glyphyalinia sculptilis (Bland, 1858)	C	-	-	-	G4/S4
Glyphyalinia solida (H. B. Baker, 1930)	C	-	-	-	G4/S4
Glyphyalinia umbilicata (Singley, in Cockerell, 1893)	U	-	-	-	G4/SU
Glyphyalinia vanattai (Pilsbry & Walker, 1902)	SC (R)	SC	V2	(C2)	G2/S2
Glyphyalinia wheatleyi (Bland, 1883)	C	-	-	-	G5/S4
Genus Mesomphix Rafinesque, 1819					
Mesomphix andrewsae (Pilsbry,1895)	C	-	-	-	G3/S3
Mesomphix capnodes (W. G. Binney, 1857)	Probable	-	-	-	G4
Mesomphix cupreus (Rafinesque, 1831)	C	-	-	-	G5/S4
Mesomphix inornatus (Say, 1821)	Possible	-	-	-	G5
Mesomphix latior (Pilsbry, 1900)	U	-	-	-	G3/SU
Mesomphix perlaevis (Pilsbry, 1900)	C	-	-	-	G4/S4
Mesomphix pilsbryi (G. H. Clapp, 1904)	U	-	-	-	G4/SU
Mesomphix rugeli (W. G. Binney, 1879)	C	-	-	-	G3/S4
Mesomphix subplanus (A. Binney, 1842)	C	-	-	-	G3/S4
Genus Vitrinizonites W. G. Binney, 1879					
Vitrinizonites latissimus (Lewis, 1875)	C	-	-	-	G3/S4
Genus Paravitrea Pilsbry, 1898					
Paravitrea andrewsae (W. G. Binney, 1879)	SC (R)	SC	V2	-	G3/S2
Paravitrea capsella (Gould, 1851)	U	-	-	-	G4/SU
Paravitrea clappi (Pilsbry, 1898)	SC (R)	SC	V2	C3C	G3/S2
Paravitrea lacteodens (Pilsbry, 1903)	SC (R)	SC	V2	(C2)	G1Q/S1Q
Paravitrea lamellidens (Pilsbry, 1898)	SC (R)	SC	V2	-	G3/S2
Paravitrea multidentata (A. Binney, 1840)	U	-	-	-	G4/SU
Paravitrea placentula (Shuttleworth, 1852)	SC (R)	SC	V2	-	G3/S2

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Taxon	Ranking System				
	Committee	State	NCSM	USFWS	TNC
Family ZONITIDAE (cont.)					
Genus Paravitrea (cont.)					
Paravitrea reesi Morrison, 1937	U	-	-	-	G3/SU
Paravitrea ternaria Hubricht, 1978	T	T	V1	-	G2/S2
Paravitrea umbilicaris (Ancey, 1887)	SC (R)	SC	V2	-	G3/S2
Paravitrea varidens Hubricht, 1978	T	T	V1	-	G2/S2
Genus Hawaiia Gude, 1911					
Hawaiia alachuana (Dall, 1885)	Probable	-	-	-	G4
Hawaiia minuscula (A. Binney, 1840)	C	-	-	-	G5/S5
Genus Gastrodonta Albers, 1850					
Gastrodonta interna interna (Say, 1822)	C	-	-	-	G4/S4
Genus Ventridens W. G. Binney, 1863					
Ventridens acerra (J. Lewis, 1870)	U	-	-	-	G4/SU
Ventridens arcellus Hubricht, 1976	C	-	-	-	G4/S3
Ventridens cerinoideus (Anthony, 1865)	C	-	-	-	G4/S4
Ventridens coelaxis (Pilsbry, 1899)	SC (R)	SC	V2	(C2)	G3/S2
Ventridens collisella (Pilsbry, 1896)	U	-	-	-	G4/SU
Ventridens decussatus (Walker & Pilsbry, 1902)	C	-	-	-	G3/S3
Ventridens demissus (A. Binney, 1843)	U	-	-	-	G4/SU
Ventridens gularis (Say, 1822)	C	-	-	-	G4/S4
Ventridens intertextus (A. Binney, 1841)	C	-	-	-	G5/S5
Ventridens lasmodon (Phillips, 1841)	Possible	-	-	-	G4
Ventridens lawae (W. G. Binney, 1892)	U	-	-	-	G4/SU
Ventridens ligera (Say, 1821)	U	-	-	-	G5/SU
Ventridens pilsbryi Hubricht, 1964	C	-	-	-	G4/S4
Ventridens suppressus (Say, 1829)	U	-	-	-	G4/SU
Ventridens theloides (Walker & Pilsbry, 1902)	C	-	-	-	G4/S3

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Taxon	Ranking System				
	Committee	State	NCSM	USFWS	TNC
Family ZONITIDAE (cont.)					
Genus Zonitoides Lehmann, 1862					
Zonitoides arboreus (Say, 1816)	C	-	-	-	G5/S5
Zonitoides elliotti (Redfield, 1856)	C	-	-	-	G4/S4
Zonitoides patuloides (Pilsbry, 1895)	SC (R)	SC	V2	-	G2/S2
Genus Striatura Morse, 1864					
Striatura ferrea E. S. Morse, 1864	U	-	-	-	G4/SU
Striatura meridionalis (Pilsbry & Ferriss, 1906)	C	-	-	-	G5/S5
Family HELICARIONIDAE					
Genus Euconulus Reinhardt, 1883					
Euconulus chersinus (Say, 1821)	U	-	-	-	G4/SU
Euconulus dentatus (Sterki, 1893)	U	-	-	-	G4/SU
Euconulus fulvus (Muller, 1774)	U	-	-	-	G4/SU
Euconulus trochulus (Reinhardt, 1883)	C	-	-	-	G4/S4
Genus Guppya Morch, 1867					
Guppya sterkii (Dall, 1888)	U	-	-	-	G4/SU
Family HAPLOTREMATIDAE					
Genus Haplotrema Ancey, 1881					
Haplotrema concavum (Say, 1821)	C	-	-	-	G5/S5
Haplotrema kendeighi Webb, 1951	SC (R)	SC	V2	-	G2/S2
Family SPIRAXIDAE					
Genus Euglandina Fischer and Crosse, 1870					
Euglandina rosea (Ferussac, 1818)	U	-	-	-	G4/SU

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Taxon	Ranking System				
	Committee	State	NCSM	USFWS	TNC
Family POLYGYRIDAE					
Genus Polygyra Say, 1818					
Polygyra cereolus (Muhlfeld, 1818)	Probable	-	-	-	G4
Polygyra plicata (Say, 1821)	Possible	-	-	-	G4
Polygyra postelliana (Bland, 1859)	C	-	-	-	G3/S3
Polygyra pustuloides (Bland, 1858)	C	-	-	-	G4/S3
Genus Stenotrema Rafinesque, 1819					
Stenotrema altispira (Pilsbry, 1894)	C	-	-	-	G3/S4
Stenotrema barbatum (G. H. Clapp, 1904)	C	-	-	-	G4/S4
Stenotrema barbigerum (Redfield, 1856)	U	-	-	-	G4/SU
Stenotrema depilatum (Pilsbry, 1895)	SC (R)	SC	V2	-	G2/S2
Stenotrema edvardsi (Bland, 1856)	Probable	-	-	-	G4
Stenotrema fraternum fraternum (Say, 1824)	U	-	-	-	G5/SU
Stenotrema fraternum montanum Archer, 1939	U	-	-	-	G3/SU
Stenotrema hirsutum (Say, 1817)	C	-	-	-	G4/S3
Stenotrema magnifumosum (Pilsbry, 1900)	C	-	-	-	G3/S3
Stenotrema pilula (Pilsbry, 1900)	U	-	-	-	G3/SU
Stenotrema stenotrema (Pfeiffer, 1842)	C	-	-	-	G5/S5
Genus Praticolella Von Martens, 1892					
Praticolella lawae (J. Lewis, 1874)	U	-	-	-	G3/SU

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Taxon	Ranking System				
	Committee	State	NCSM	USFWS	TNC
Family POLYGYRIDAE (cont.)					
Genus Mesodon Rafinesque in Ferussac, 1821					
Mesodon andrewsae W. G. Binney, 1879	U	-	-	-	G3/SU
Mesodon appressus (Say, 1821)	U	-	-	-	G4/SU
Mesodon archeri Pilsbry, 1940	Possible	-	-	-	G1
Mesodon chilhoweensis (J. Lewis, 1870)	SC (R)	SC	V2	-	G2/S2
Mesodon christyi (Bland, 1860)	U	-	-	-	G3/SU
Mesodon clarki (I. Lea, 1858)	SC (R)	SC	V2	-	G2/S2
Mesodon clarki nantahala (Clench and Banks, 1932)	T	T	T	T	G1/S1
Mesodon clausus clausus (Say, 1821)	C	-	-	-	G5/S4
Mesodon clingmanicus (Pilsbry, 1904)	T	T	V1	(C2)	G1/S1
Mesodon downieanus (Bland, 1861)	Possible	-	-	-	G3
Mesodon elevatus (Say, 1821)	U	-	-	-	G5/SU
Mesodon ferrissi (Pilsbry, 1897)	T	T	V1	(C2)	G2/S2
Mesodon inflectus (Say, 1821)	C	-	-	-	G5/S4
Mesodon jonesianus (Archer, 1938)	T	T	V1	C3C	G2/S2
Mesodon mitchellianus (I. Lea, 1839)	U	-	-	-	G4/SU
Mesodon normalis (Pilsbry, 1900)	C	-	-	-	G4/G3
Mesodon orestes Hubricht, 1975	T	T	V1	(C2)	G2/S2
Mesodon perigraptus (Pilsbry, 1894)	C	-	-	-	G4/S3
Mesodon rugeli (Shuttleworth, 1852)	C	-	-	-	G4/S4
Mesodon sayanus (Pilsbry, 1906)	U	-	-	-	G4/SU
Mesodon subpalliatus (Pilsbry, 1893)	SC (R)	SC	V2	-	G2/S2
Mesodon thyroidus (Say, 1816)	C	-	-	-	G5/S5
Mesodon wheatleyi (Bland, 1860)	U	-	-	-	G3/SU
Mesodon zaletus (A. Binney, 1837)	C	-	-	-	G5/S3

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Taxon	Ranking System				
	Committee	State	NCSM	USFWS	TNC
Family POLYGYRIDAE (cont.)					
Genus Triodopsis Rafinesque, 1819					
Triodopsis affinis Hubricht, 1954	C	-	-	-	G4/S4
Triodopsis alabamensis (Pilsbry, 1902)	Possible	-	-	-	G4
Triodopsis anteridon Pilsbry, 1940	Possible	-	-	-	G3
Triodopsis burchi Hubricht, 1950	U	-	-	-	G3/SU
Triodopsis fallax (Say, 1825)	C	-	-	-	G4/S4
Triodopsis fulciden Hubricht, 1952	SC (R)	SC	V2	(C2)	G2/S2
Triodopsis hopetonensis (Shuttleworth, 1852)	C	-	-	-	G4/S4
Triodopsis juxtidens (Pilsbry, 1894)	C	-	-	-	G4/S4
Triodopsis messana Hubricht, 1952	U	-	-	-	G3/SU
Triodopsis obsoleta (Pilsbry, 1894)	C	-	-	-	G3/S3
Triodopsis pendula Hubricht, 1952	C	-	-	-	G4/S4
Triodopsis soelneri (J. B. Henderson, 1907)	T	T	V1	(C2)	G2/S2
Triodopsis tennesseensis (Walker and Pilsbry, 1902)	U	-	-	-	G4/SU
Triodopsis tridentata (Say, 1816)	C	-	-	-	G5/S4
Triodopsis vulgata Pilsbry, 1940	C	-	-	-	G4/S3
Genus Xolotrema Rafinesque, 1819					
Xolotrema caroliniensis (I. Lea, 1834)	U	-	-	-	G4/SU
Xolotrema denotata (Ferussac, 1821)	U	-	-	-	G4/SU
Genus Neohelix von Ihering, 1892					
Neohelix albolabris (Say, 1816)	C	-	-	-	G5/S4
Neohelix dentifera (A. Binney, 1837)	U	-	-	-	G4/SU
Neohelix major (A. Binney, 1837)	C	-	-	-	G4/S4
Neohelix solemi Emberton, 1988	C	-	-	-	G4/S4
Genus Allogona Pilsbry, 1939					
Allogona profunda (Say, 1821)	U	-	-	-	G5/SU

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INTRODUCED SPECIES OF LAND MOLLUSKS

The following species of land mollusks have been documented (Dundee, 1974; Hubricht, pers. comm., 1989) to have been introduced to, or intercepted at ports in, North Carolina. Specimens of many other introduced species have been taken in states adjacent to North Carolina. These species probably occur in North Carolina as well but records are unknown to the committee at this time. No protection status is recommended for any introduced species, regardless of its rarity.

Arion fasciatus (Nilsson)
Arion circumscriptus Johnston
Arion subfuscus (Draparnaud)
Bradybaena despecta (Pfeiffer)
Cochlicella barbara (Linnaeus)
Cochlicella conoidea (Draparnaud)
Cochlicella ventrosa (Ferrussac)
Deroceras reticulatum (Muller)
Helicella apicina (Lamarck)
Helicella caperata (Montagu)
Helicella conspurcata (Draparnaud)
Helicella cretica (Ferussac)
Helicella explanata (Muller)
Helicina cespitum (Draparnaud)
Helix aperta Born
Helix vulgaris Rossmaessler
Hellicella trochoides (Poiret)
Hellicella variabilis (Draparnaud)
Hygromia hispida (Linnaeus)
Lehmannia poirieri (Mabille) (= L. valentiana Ferussac)
Limax maximus Linnaeus
Mesodon laevior (Hubricht)
Monacha carthusiana (Muller)
Monacha olivieri (Ferussac)
Opeas pyrgula (Schmacker and Boettger)
Oxychilus alliarius (Miller)
Rumina decollata (Linne)
Theba pisana (Muller)

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