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STATUS SURVEY OF THE JAMES RIVER SPINY MUSSEL, *CANTHYRIA COLLINA*, IN THE JAMES RIVER, VIRGINIA

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FINAL REPORT

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To

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

OFFICE OF SPONSORED PROGRAMS

BLACKSBURG, VIRGINIA 24061

From

ECOSEARCH, Inc.
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For

Status Survey of the James River Spiny Mussel, *Canthyria collina* (Conrad), in the James River Drainage System

(Contract No. 4107)

Prepared by

Arthur H. Clarke, President

October 30, 1984

ABSTRACT

During 1984 a survey was carried out by ECOSEARCH, Inc. to assess the distribution and endangerment status of the James River Spiny Mussel. The principle results are:

1. Anatomical studies show that this unusual species belongs to the genus *Canthyria* Swainson, along with *C. spinosa* (Lea) and *C. steinstansana* Johnson and Clarke. Its correct name is *Canthyria collina* (Conrad, 1836).

2. About 90% of the specimens of *C. collina* lack spines on their shells. This seems to have been caused by abrasion in some instances, but many specimens never develop spines even when young.

3. Historical records show that *C. collina* was distributed in the recent past throughout the James River above Richmond and in several of its tributaries. More recently it was extipated from about 95% of its former range and now survives only in three small headwater tributaries.

4. Historical data are incomplete but it appears that the disappearance of *C. collina* throughout most of its range was concordant with the invasion and spread of the Asian clam *Corbicula fluminea* in the James River. *Corbicula* is now common to abundant throughout most of this drainage system. It does not occur in the upstream tributaries still inhabited by *Canthyria collina*, however.

5. We recommend that *Canthyria collina* be proposed for inclusion on the U. S. List of Endangered Species. We also urge that life history studies be carried out promptly and that the identity of its fish host be determined. The surviving population should be monitored frequently and if an invasion by *Corbicula* occurs, a substantial number of *Canthyria* should be moved to another site. Other conservation recommendations are also given.

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PREFACE

Substantial progress has been made during the past 16 years in our effort to arrest the decline and extinction of our native molluscan fauna. In 1968 the American Malacological Union convened an Endangered Species Symposium, of leading North American malacologists, and 230 species of land and freshwater mollusks, 1 marine mollusk (a littorinid), and an undetermined number of brackish water species (Hydrobiidae) were identified as potentially endangered (see papers in Clarke (ed.) 1970, and especially the paper by D. H. Stansbery therein). In 1973 the federal Endangered Species Act was promulgated and soon thereafter 25 species of freshwater mussels, all species of _Achatinella_, and 8 other land snails were placed on the federal List of Endangered Species (see Chambers, 1982). Soon several of the states also established similar lists.

During the last four years, and principally sponsored by the U. S. Fish and Wildlife Service, a comprehensive evaluation and rescue program has been underway for species which have been officially listed. Recovery plans have been written for most of them and the activities which have been recommended therein are now being carried out. Other government agencies, particularly the Corps of Engineers and the Tennessee Valley Authority, have also been active in molluscan conservation and research. The AMU also convened another symposium (Clarke (ed.) 1982) and numerous additional species were nominated for possible endangerment status. This year the Fish and Wildlife Service also published a candidate list containing nearly 200 names of molluscan species which are now under initial consideration for investigation and possible eventual listing as Endangered. Although no new species names have actually been added to the official list during the past four years, in 1984 the Tar River Spiny Mussel (_Elliptio (Canthyria) steinstansana_ Johnson & Clarke), was formally proposed for addition to the List, and in 1983 the Wabash Riffle Shell (Epioblasma sampsoni (Lea)) has was removed from the List because it is almost certainly extinct.

In keeping with our commitment to the preservation of molluscan species, ECOSEARCH, Inc. has been involved in many of these activities, including the gathering of much of the information which led to the new official endangerment status of the two species cited above. We are pleased that our efforts have been effective. We hope that this report, which describes the decline and current precarious status of the James River Spiny Mussel (Canthyria collina (Conrad)), will be similarly well-received and that this unique species will receive the protection that it must soon have in order to survive.

Aknowledgments Special thanks are extended to several dedicated friends for valuable assistance in the field, viz. Mr. Andrew Gerberich of the Smithsonian Institution, Dr. Richard J. Neves, Ms. Helen A. Kitchel, Mr. Steven N. Moyer, Ms. Denise Benson, and Ms. Georgia Yamaki of Virginia Tech., Mr. G. Andrew Moser of the Fish and Wildlife Service, Mr. Michael Zeto of the West Virginia Dept. of Natural Resources, and Dr. Mark J. Imlay and Ms. Ann Elsen. We are also grateful to Dr. Joseph Rosewater, Dr. Kenneth J. Boss, and Mr. Richard I. Johnson for generously providing access to collections under their care, and to Virginia Tech. for providing the funds necessary to conduct this fascinating study.

1. INTRODUCTION

1.1 Historical Distribution of *Canthyria collina*

The historical records for *Canthyria collina* have been summarized by Johnson (1970). They are all from the James River System of Virginia and are listed below. Explanatory insertions by me are in square brackets.

Calfpasture River (Conrad, 1846:407); North (=Maury) River, Lexington [type locality]; James River near Natural Bridge (USNM [J. P. E. Morrison!]), all Rockbridge Co.); James River, Buchanan, Botetourt Co. [source?]; Rivanna River, 2 mi W of Columbia, Fluvanna Co.; and James River, opposite Maidens, Goochland Co. [both Clench and Boss, 1967].

Three additional recent finds were also reported to me in 1984 by colleagues. These are Craig Creek (data from Dr. Paul Parmalee), Rivanna River at US Rt. 15 bridge (one *C. collina* out of several hundred mussels examined, ca. 1977, data from Dr. Douglas A. Wolfe) and Potts Creek near Waiteville, W. Va. (1984, data from Mr. Michael Zeto).

1.2 Historical Data on Life History

Nothing is known about the life history of *C. collina*.

1.3 Historial Data on Populations and Habitat Trends

The MCZ contains many specimens of *C. collina* which were collected by W. J. Clench, M. K. Jacobson, and K. J. Boss in 1967 from the Rivanna River at US Rt. 15 and from the James River opposite Maidens. In 1977 D. A. Wolfe found a single specimen at the Rivanna River site after much searching, but other searches at that site in 1983 by Andrew Gerberich failed to locate any. Searches of the James River site by A. H. and J. M. Clarke in 1980, and by A. Gerberich in 1983, also failed to locate specimens there.

No specific data on habitat trends at C. collina sites is available. It is known, however, that a dam was built in the 1970's (?) just above Richmond and that anadramous fishes cannot pass it. It is also known that within the recent past the North River was badly polluted by creosote from a wood treatment plant near Goshen and by outfall from a sewage treatment plant near Buena Vista, and that the Tye River was so polluted by sulfuric acid from a chemical plant near Piney River that the fauna there was extipated. It has also been documented (Diaz, 1974) that invasion of the Asiatic clam (Corbicula fluminea began in the lower James River below Richmond about 1973 and that it has now spread throughout the James River System with the exception of the upper tributaries (this survey). All of these pertubations, and probably other events which are unknown to me, have impacted the system and surely have had a deleterious effect on C. collina.

1.4 Historial Data on Taxonomy

Like nearly all unionids with complete hinge teeth which were discovered before 1900, Canthyria collina (Conrad, 1836) was described as a species of the genus Unio Linnaeus. In 1900 Simpson placed the species in Alasmidonta Rafinesque, in 1967 Boss and Clench transferred it to Pleurobema Rafinesque, and in 1983 Johnson (in Johnson and Clarke, 1983) placed it in Fusconaia Rafinesque. Based on anatomical evidence, discussed below, I now confidently place it in Canthyria Swainson along with the other 2 extant species of spiny mussels, C. spinosa (Lea) and C. steinstansana (Johnson and Clarke). For further details see the discussion on subsequent pages.

2. METHODS

On May 2, 1984 a subcontract was awarded to ECOSEARCH, Inc. by Virginia Polytechnic Institute and State University (Contract No. 4107) to provide specialist services in relation to a status survey of the James River Spiny Mussel in the James River System. These services were to consist of (a) with the assistance of students from Virginia Tech., ECOSEARCH, Inc. would make systematic collections of freshwater mussels from throughout the James River Drainage Area, (b) would identify to species the material collected, and (c) would submit an interim report giving general results and a final report which would present all of the data gathered including ecological observations and other information relevant to the recommended official endangerment classification of the James River Spiny Mussel.

Nineteen eighty-four proved to be a wet year in Virginia and only upper tributaries could be properly searched for most of the summer. Field work began on July 24 and was temporarily suspended on July 5 because of daily rain and high water. Other periods of work, each of which were also terminated by high water, were July 19 to August 9, September 4 and 5, September 30 to October 1, October 6 to 9, and October 13. Water levels in the main river between Glasgow and Lynchburg are controlled by a series of hydroelectric power dams and this causes (a) a pronounced and unpredictable lag effect between lack of rain upstream and expected decline of water levels downstream and (b) a depauperization of the fauna for several miles below Lynchburg.

Field procedure for work in tributaries was generally as follows. Areas to be searched were selected using topographic maps. Field collectors, ordinarily consisting of Arthur H. Clarke, Judith M. Clarke, and any of several colleagues from Virginia Tech., would then drive to the search area and select suitable access points. After local permission was obtained, if necessary, the collectors would then enter the stream and carefully search for freshwater mussels. Equipment for this work consisted of wet suits, chest waders, viewing boxes, water scopes, and masks and snorkels. When we were satisfied that all species present had been found, the collected specimens were sorted by species and tabulated. Except for a few specimens needed for further study, all were then carefully returned to the collection site. Study sites were distributed about 1 mile apart or as access permitted.

Procedures for work in the James River proper involved river runs with a canoe. Municipal access points were used and reaches of about 5 to 8 miles were traversed each day. Stops were made at sandbars and shoal areas which appeared promising and collecting was done using the same equipment and procedures described above. River runs were spaced about 5 to 8 miles apart and thereby covered about 50% of the 90-mile river reach between Wingina and Richmond. Below Richmond the James becomes brackish and unsuitable for unionids so site surveys were not made there.

Specimens which were retained were relaxed by freezing them in river water in a plastic bag in a freezer, thawed, fixed, for about 24 hours in 10% formalin, and preserved in 40% isopropyl alcohol. Subsequent studies of soft parts of many specimens were carried out for taxonomic purposes as described below.

3. RESULTS

3.1 Station List and Map

The 73 study sites which were investigated are listed in geographical sequence in Table 1. Except for a few James River sites which are very close together, each site is also indicated by a separate spot on Map 1. Data sheets, also organized in geographical sequence, are also appended. They describe in some detail locational, ecological and logistical aspects of each study site and include lists of the numbers of living and dead specimens of each species which was observed.

TABLE 1.

1984 Study Stations Arranged in Geographical Sequence. (1)

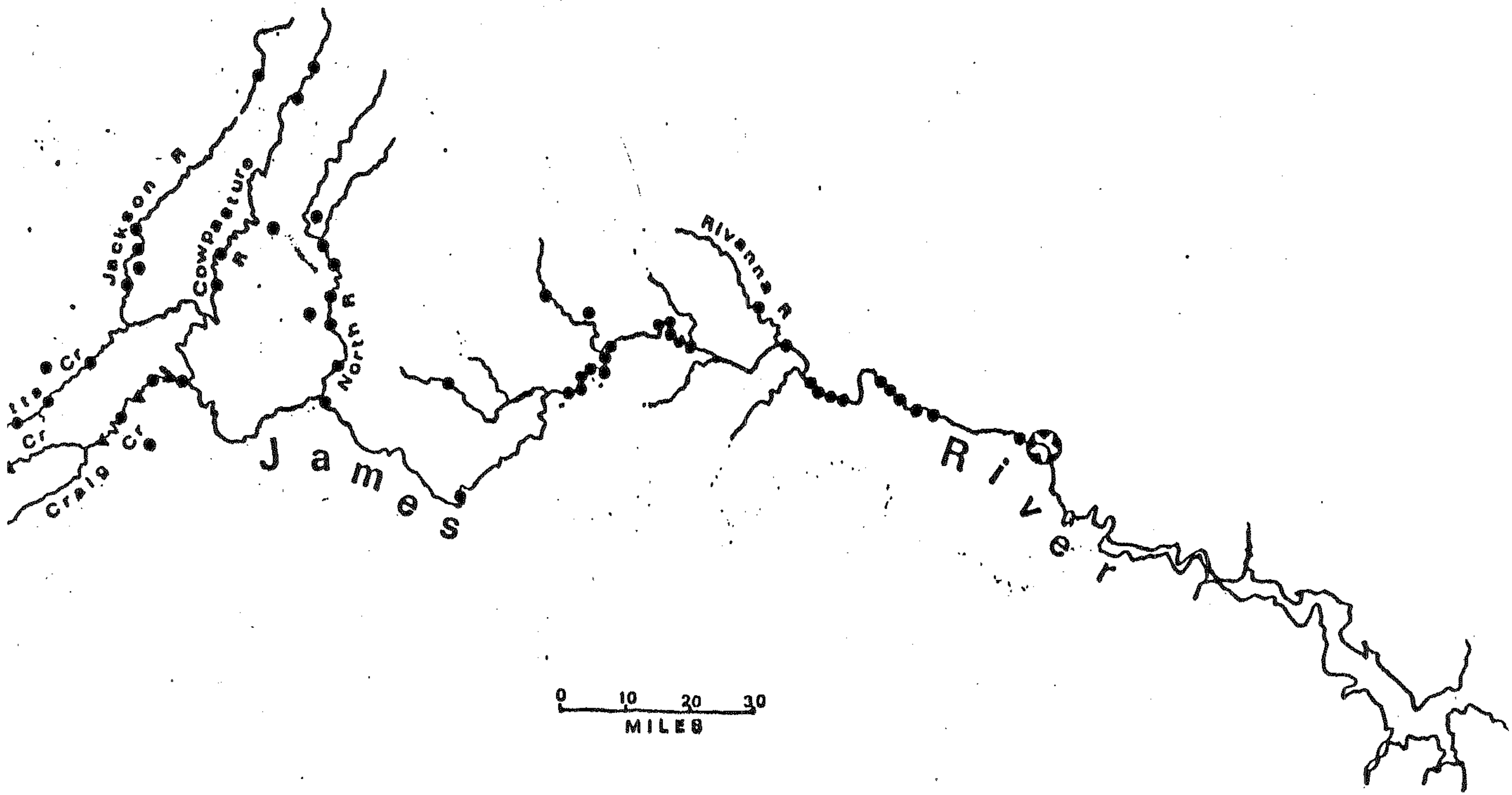
Sequence No.	Station No.	Location (2)
		Potts Creek Drainage
1	2107	Dunlap Cr., ca 2 mi S of Crows.
2	2108	Potts Cr., 0.6 mi WSW of Waiteville.
3	2109	Potts Cr., 3 mi NE of Paint Rock.
4	2110	Potts Cr. 9.5 mi NE of Paint Rock.
5	2111	Potts Cr., just S of Jordan Mines.
		Jackson River Drainage
6	2119	Falling Spring Cr., ca 1 mi NNE of Falling Spring.
7	2101A	Jackson R., 7 mi S of Monterey.
8	2120	Jackson R., 1 mi S of Falling Spring.
9	2121	Jackson R., Morris Hill, in Natural Well.
10	2122	Jackson R., old bridge, SSW of Natural Well.

(1) Sites are listed firstly for tributaries (uppermost to lowermost) and secondly for the main channel of the James River, and arranged within each drainage in a headwaters to mouth sequence.

(2) Sta. 2108 (Site Seg. No. 2) is in W. VA. All other stations are in VA.

Sequence No.	Station No.	Location
		Cow Pasture River Drainage
11	2125	Thompson Cr., N of Millboro.
12	2100	Bull Pasture R., between Flood and Clover Creeks.
13	2101	Bull Pasture R., ca 5 mi S of Sta. 2101.
14	2124	Cow Pasture R., 7 mi SW of Nimrod Hill.
15	2123	Cow Pasture R., 5.5 mi NE of Clifton Forge.
		Craig Creek Drainage
16	2118	Johns Cr., 2 mi SW of Maggie.
17	2117	Johns Cr., 1/2 mi S of Maggie.
18	2116	Johns Cr., ca 15 mi WSW of Newcastle
19	2115,2129	Craig Cr., 2.0 mi NE of Newcastle.
20	2114	Craig Cr., at ford ca 1 mi SW of Oriskany.
21	2113	Craig Cr., 6 mi SW of Strom.
22	2137	Craig Cr., 1 mi W of Strom.
23	2112	Craig Cr., ca 2 mi above mouth, nr. Eagle Rock.
24	2136	Craig Cr., ca 1 mi above mouth nr. Eagle Rock.
25	2135	Craig Cr., 0-0.1 mi above mouth, nr. Eable Rock.
		Catawba Creek Drainage
26	2138	Catawba Cr., ca 5 mi W of Springwood.
		North (or Maury) River Drainage
27	2126	Stewarts Run, nr. Goshen.
28	2095	Big Spring, 4.5 mi NNW of Lexington.
29	2132	North R., ca 4 mi S of Goshen.
30	2131	North R. park, ca 1 mi N of Rockbridge Baths.
31	2130	North R., ca 5 mi S of Rockbridge.
32	2096,2128	North R., 2.0 mi NNW of Lexington.
33	2127	North R., 2 mi WNW of Buena Vista.
34	2098	North R., 3.1 mi SW of Buena Vista.
		Buffalo River Drainage
35	2154	Buffalo R., ca 5 mi WSW of Lowesville.
		Rockfish River Drainage
36	2134	Muddy R., 3 mi NW of Howardsville.
37	2153	Rockfish R., 6 mi NNE of Lovingston.

Sequence No.	Station No.	Location
		Rivanna River Drainage
38	--	Rivanna R., 1 1/2 mi NE of Carysbrook.
		Appomattox River Drainage
39	2184	Appomattox R., ca 3 mi W of Clayville.
		James River (Main Channel)
40	2099	James R., 0.2 mi below mouth of North River.
41	2103	James R., 0.4 mi NE of Kelly.
42	2102	James R., above bridge at Wingina.
43		James R., 1/4 mi below Wingina.
44		James R., 1/2 mi below Wingina.
45		James R., 1 mi below Wingina.
46		James R., 1 1/2 mi below Wingina.
47		James R., 2 mi below Wingina.
48		James R., 3 mi below Wingina.
49		James R., 3 1/4 mi below Wingina.
50		James R., 3 1/2 mi below Wingina.
51		James R., 4 mi below Wingina.
52		James R., 4 1/2 mi below Wingina.
		James River (Main Channel)
53		James R., 5 1/2 mi below Wingina.
54		James R., Howardsville.
55	2182	James R., 0-300 M above landing, Scottsville.
56	2152	James R., 1/2 mi below landing, Scottsville.
57		James R., 1 mi below Scottsville.
58		James R., 1 1/2 mi below Scottsville.
59		James R., 2 1/2 mi below Scottsville.
60		James R., 4 mi below Scottsville.
61		James R., Columbia
62		James R., Cartersville.
63		James R., 1 3/4 mi below Cartersville.
64		James R., 3 mi below Cartersville.
65		James R., 4 mi below Cartersville.
66		James R., 4 1/2 mi below Cartersville.
67		James R., above and below bridge, Maidens.
68		James R., 2 mi below Maidens.
69		James R., 2 1/4 mi below Maidens.
70		James R., ca 4 mi below Maidens.
71		James R., ca 6 mi below Maidens.
72		James R., ca 9 mi below Maidens.
73	2183	James R., just above Huguenot Bridge, Richmond.



Jackson R
Cowpasture R
North R
Rivanna R
Craig Cr
Cr
James River
0 10 20 30
MILES

3.2 Sites Yielding *Canthyria collina*

The James River Spiny Mussel was found at only six sites. These were all located in three upper tributaries, viz, Potts Creek (Site Sequence No. 2), Johns Creek (SS 16 and 18) and Craig Creek (SS 19, 21, and 23). (The report of a Jackson River site as yielding *C. collina*, included in our Interim Report on this contract, was in error). These sites are shown on Map 1 as filled-in triangles. Specimens of *Canthyria collina* bearing spines on their shells were seen only at SS 19 in Craig Creek. The significance of these finds is discussed below.

3.3 Habitat Requirements

3.3.1 Physical and Chemical Aspects.

Physical data associated with the sites yielding *C. collina* (SS 2, 16, 18, 19, 21 and 23) are given in the data sheets. The narrowest stream, Potts Creek at SS 2 is 10-20 ft. wide and 1/2 - 1 ft. deep. The widest stream, Craig Creek (SS 22) is 50-75 ft. wide and about 3 ft. deep. Current was slow or moderate and bottom sediments were of cobbles and sand (with or without boulders, pebbles and silt) at each site. It should also be noted that at one of the recent historical sites, the James River opposite Maidens, the river is about 500 ft. wide with a predominantly sandy bottom containing some gravel.

The upper tributaries of the James River flow through an extensive limestone area in the Appalachian Mountains. Hardness values (ppm $CaCO_3$) measured there were as follows: Dunlap Creek, 280; Potts Creek, 50; Johns Creek, 70; Cow Pasture River, 75; Thompson Creek, 45; and Stewarts Run, 85. Downstream tributaries were much softer, viz. Muddy River, 25; Buffalo River, 16; and Appomattox River, 35. Hardness in the James River at Cartersville, measured from October

1, 1974 to September 30, 1975, varied from 23 to 73 ppm (mean 49.3) (Briggs and Ficke, 1977). All of the historical and recent records for C. collina, except for the Rivanna River site for which no hardness data are available, came from hard water upper tributaries or from the main James River which, because of those upper tributaries also contains hard water.

Briggs and Ficke (1977) also present much additional information on James River water quality measured at Cartersville and, by the use of their maps, comparisons with other river systems are possible. The James River appears to produce much larger standing crops of phytoplankton than is seen in adjacent river systems and to have substantial concentrations of nutrients but no other conspicuous water quality features are evident.

3.3.2 Biological Aspects.

Mollusks which were associated with C. collina at its six locations are as follows (number of co-occurrence sites where found is indicated in parenthesis): Strophitus undulatus (5), Villusa constricta (4), Alasmidonta undulata (3), Elliptio lanceolata (3) Fusconaia masoni (2), and Elliptio complanata (2). At one site (Potts Creek, SS 2) S. undulatus and C. collina were the only mussels present and each was quite abundant (up to ca. 4/ft^2). At another upstream site (Johns Creek, SS 16) C. collina and S. undulatus were joined by Alasmidonta undulata and all were equally abundant. At the other four sites Villosa constricta was dominant or co-dominant, however. Elliptio complanata was common at only one site (Craig Creek, SS 23) and this was the closest site to the James River which yielded C. collina.

Significantly, Corbicula fluminea did not occur at any sites where C. collina was found. It occurs abundantly throughout the main James River and is also found in some of its tributaries on the Piedmont (Muddy River, Rivanna

River and Appomattox River) and it has even reached the mouths of Craig Creek and North River. It has not yet ascended any of the upper tributaries but there appears to be no barrier to its potential movement into those streams. Such immigrations should therefore be expected to occur quickly and their effect on the survival of *C. collina* may be disastrous.

3.4 Threats to Species Existence

3.4.1 Pollution

Pollution is a menace to the survival of freshwater mussels wherever it occurs. The absence of *C. collina* from the North River may well have been brought about by industrial pollution and by sewage. Within the present range of *C. collina* only Newcastle appears to be large enough to pose a significant municipal pollution threat to *C. collina*. That threat is real, however, because a substantial pollution event there might wipe out the entire Craig Creek population of *C. collina*, including the only spine-bearing population which is known to now exist.

3.4.2 Habitat Disruption.

We know of no plans to dam, channelize, or otherwise disrupt habitats where *C. collina* now occurs.

3.4.3 Corbicula fluminea.

It has been calculated (Clarke, 1983) that even a moderately dense population (ca. 250/M^2) *C. fluminea*, living throughout a stream 1 M deep with a current of 1 mile per hour, will filter a volume of water equivalent to 3 times the volume of the whole river within a 24 hour period. This will reduce the phytoplankton standing crop by a factor of approximately 95%. It has been observed that in the Altamaha River *Canthyria spinosa* suffers severe emaciation and high mortality in the presence of dense *Corbicula* populations.

Such an effect may be expected when Corbicula fluminea invades Craig Creek, Johns Creek, and Potts Creek. Corbicula are often used as bait by fishermen and a single Corbicula impaled on a hook may release thousands of swimming veliger larvae. It will be difficult, and perhaps impossible, to keep Corbicula out of the Craig Creek - Johns Creek drainage area. The Potts Creek habitat may remain uninvaded for much longer because of its isolation and because of the pollution barrier in the lower Jackson River.

3.4.4 Over-Collecting

It is recommended that the precise location of C. collina colonies not be made public. Unfortunately many individuals are already aware of some of these locations. If the species is eventually listed as endangered, persons should certainly be discouraged from collecting them.

3.5 Taxonomic Relationships

3.5.1 Spinyness in Canthyria collina.

Station 2115 (SS 19) located in Craig Creek, 2.0 mi NE of Newcastle, Craig County, Virginia yielded 11 specimens of what I am convinced are all Canthyria collina (Conrad). All of these specimens were very similar in shell and soft part characteristics and all obviously belong to the same species. Three small individuals (38.4-45.7 mm long) were prominently spined, one which was 48.5 mm long had only a small stump of a spine visible, and the other six, all within the 42.2-67.6 mm size range, were entirely without spines. Older specimens had shells which were more arcuate and much darker than those of young specimens, had darker pigmentation around the posterior mantle openings, and had more papillae around such openings, but all of these shifts were connected by intergrades and they are all obviously ontogenetic. Analagous morphological changes with growth occur in virtually all species of Unionidae.

Many other unspined specimens, clearly conspecific with the unspined specimens from Site Sequence No. 19 (SS 19) were also found at SS 21 and 23 in Craig Creek, at SS 16 and 18 in Johns Creek and SS 2 in Potts Creek. Some of these were even smaller (down to 33.6 mm) than the smallest spined specimens from SS 19 and all were entirely devoid of any trace of spines. I am therefore convinced that most specimens of Canthyria collina never develop spines. Among those specimens in which spines do occur there is a tendancy for those spines to abrade away during post-juvenile growth. This may correlate with their usual substrate which is sand and gravel in many instances.

3.5.2 Morphology of Canthyria collina.

The shell of Canthyria collina is subrhomboid in juveniles (i.e. in those less than 40 mm long) with an obliquely subtruncated posterior (resembling Elliptio complanata in this feature), with widely-spaced concentric striations, with a shiny, straw-colored periostracum, and with or without 1 to 3 short but prominent spines on each valve. With growth the shell becomes more ovate or even arcuate, develops a rounded posterior and a brownish-black, subshining periostracum, and in most cases loses any spines it may have had. In the adult the posterior ridge is also broad and rounded, the hinge teeth are medium sized but strong and completely developed, and the nacre is whitish and with or without pink or bluish suffusions.

Features of topographic anatomy include the following. The foot and mantle are conspicuously orange (but not as intensely orange as in Alasmidonta undulata, for example) and the mantle is darkly pigmented in a narrow band around and within the edges of the branchial and anal openings. In a (presumably) female specimen 70.6 mm long the outer demibranch (OD) has septa which are about 0.7 mm apart and the inner demibranch (ID) has septa which are about 1.2 mm apart.

(In two other specimens, also presumably females, the septa in specimen A are (OD) 0.5 and (ID) 1.0 mm apart and in specimen B they are (OD) 0.5 and (ID) 1.3 mm apart). The branchial opening is 10 mm long and is surrounded at the edge and within the edge by about 60 simple, large (up to 1.5 mm long) and small papillae, arranged principally in a double row.

The anal opening, which is apparently separated from the branchial opening by apposition of the narrow non-papillate areas of opposite sides of the mantle and by the diaphragm, is 12 mm long and surrounded by a single row of about 50 very short (< 0.5 mm), triangular papillae which are little more than crenulations. The distance between the anal and supra-anal openings is about 2.5 mm and the supra-anal opening is about 12 mm long. The inner demibranchs are not attached to the visceral mass. The labial palps are rounded below, straight above, and slightly overlap the inner demibranchs.

3.5.3 Taxonomy of *Canthyria collina*.

Canthyria collina is obviously more closely related to *Canthyria steinstansana* from the Tar River in North Carolina than to any other species, but it is clearly a distinct species. Both have spiny shells in some individuals and both share many other morphological attributes. In *collina* the juveniles are much more rhomboid than in *steinstansana*, however, and spined individuals are proportionately much less common. Further, in *collina* the branchial papillae are medium-sized and arranged in a double row and anal papillae are very small whereas in *steinstansana* the branchial papillae are large and in a single row and the anal papillae are also large. Also, in *collina* the anal opening is slightly longer than the branchial opening but in *steinstansana* the anal opening is distinctly shorter than the branchial.

The generic placement of *Canthyria collina* also requires comment. Boss and

Clench (1967) placed the species originally described as Unio collinus and Unio masoni by Conrad (in 1836) in the genus Pleurobema Rafinesque. Fuller (1971) observed that masoni is tetragenous and therefore transferred it from Pleurobema, in which all species are digenous (ectobranchous), to Fusconaia Rafinesque in which all species are tetragenous. I concur in that observation and that decision. Johnson (in Johnson and Clarke, 1983) also followed that transfer for masoni (and also placed masoni in the subgenus Lexingtonia Ortmann, without explanation) and maintained a close nomenclature association between masoni and collina by including the latter in Fusconaia (Lexingtonia) also.

I have shown that collina is digenous (extobranchous). It therefore does not belong with masoni in the genus Fusconaia. Further, since it has simple, and not branched branchial papillae and a non-pleurobemoid shell, it does not belong in Pleurobema. It does agree with species of the Elliptio-Canthyria complex, however, as do the two other spined species which are obviously closely-related to it, viz. Unio spinosa Lea and Elliptio (Canthyria) steinstansana Johnson and Clarke. A case could be made for following Johnson and Clarke and considering Canthyria Swainson as a subgenus of Elliptio Rafinesque, but since Canthyria is clearly monophyletic and is distinguishable from Elliptio both by the possession of spines and by having orange bodies, I now believe that Canthyria should be regarded as a distint genus and one which contains 3 species, viz. spinosa, steinstansana, and collina.

A comment about Unio subplanus Conrad, 1837 (now Lexingtonia subplana) is also appropriate here. Further experience with James River System mussels has convinced me that contrary to my previous belief, this name is probably not applicable to the unspined morph of Canthyria collina but is more likely applicable for the James River Drainage population of what is known as Fusconaia masoni. Our survey of James River mussels has revealed no other species which closely resembles Conrad's figure of subplana. Before a decision can be made gravid specimens of James River masoni must be examined to determine if red marsupia are present, as stated by Ortmann for Lexingtonia subplana. Because of high water few mollusks were collected early in the summer and no gravid specimens of "masoni" were found during the present survey.

3.6 Population Data

No consistent attempt was made during this survey to measure the sizes of living C. collina populations, and that should certainly be done. C. collina populations were seen in Potts Creek in densities up to about $4/ft^2$ but in Johns Creek and Craig Creek populations are much sparser.

An order of magnitude estimate of population size is perhaps useful. The Potts Creek reach inhabited by C. collina is short and probably does not exceed 500M. The average width of that reach is about 5M. If the mean density of C. collina in that reach is about $1/M^2$, which I believe is correct, then the Potts Creek population totals about 2,500 individuals.

The Johns Creek - Craig Creek reach is about 40 miles (ca. 64 km) long and its average width is about 14M. C. collina was found at only about half the sites investigated at those sites and in rather low average densities, believed to be about $1/20M^2$. This produces an estimate of about 22,500 individuals for the Johns Creek - Craig Creek reach and a total population estimate of about 25,000 individuals.

It must be stressed that this is only a grossly approximate estimate. I believe that it does indicate the order of magnitude of the population, however, which probably numbers in the low tens of thousands of individuals and is predominantly distributed in the Johns Creek - Craig Creek waterway.

3.7 Indications of Population and Habitat Decline

Although no comprehensive baseline studies have been done, and surprisingly, not very much field work had been carried out in the James River System prior to about 1980, the historical records of *C. collina* show that the species probably lived throughout the James River above Richmond, in the Rivanna River, and in ecologically suitable areas in all of the major upstream tributaries, i.e. in the Calf Pasture River - North River System, the Johns Creek - Craig Creek System, the Bull Pasture River - Cow Pasture River System, Jackson River, and Potts Creek. This totals about 400 river miles. The results of the present survey show that *C. collina* now occurs in only about 40 river miles and that, in terms of river miles occupied, it has suffered a loss of about 90% of its former range. The actual loss of suitable habitat is probably even more than this, however, because most of the presently unoccupied portion of its previous range is comprised of the James River itself and its larger tributaries. Areas ecologically suitable for *C. collina* are conservatively estimated as at least twice as wide in these vacated reaches as in presently occupied ones and this means that *C. collina* has probably lost about 95% of its previously occupied range, in terms of benthic area.

It has already been pointed out that the 1967 collections of *C. collina* in the James and Rivanna Rivers yielded numerous specimens. It therefore seems reasonable to conclude that previous populations of *C. collina* throughout its historical range may have been of a density similar to that which one now sees in Craig Creek. If this is true then the total population has declined from of the order of about 500,000 individuals to about 25,000.

3.8 Life History Information

Nothing is known about the life history of *C. collina* except that young individuals can still be found and that successful reproduction is therefore apparently still occurring. The life history of C. collina is in urgent need of investigation.

4. CONCLUSIONS

4.1 Status of the James River Spiny Mussel

In my opinion Canthyria collina should be placed on the U. S. List of Endangered Species because of the recent probable loss of about 95% of its range and about 95% of its total population, and because the principle menace to its survival is expected to continue to spread and soon to affect C. collina even in the remaining 5% of its range.

The applicability of the 5 factors which are recognized determinants of endangered species status is discussed below.

4.1.1 The Present or Threatened Destruction, Modification, or Curtailment of the Species Habitat on Range.

We may never know with certainty what caused the dramatic population decline of C. collina. It seems reasonable to assume that it began with the municipal growth and industrialization of cities and towns in the watershed and that it has been exacerbated by dam construction and by run-off of agricultural pesticides and other chemicals. Such threats are likely to continue and to prevent recolonization by C. collina in previously vacated areas.

The temporal correlation between the disappearance of downstream populations of C. collina, and the appearance and proliferation of Corbicula fluminea in the James River System is persuasive evidence of a cause and effect relationship, as is the mutually exclusive present distribution of the two species. The possible deleterious effects of the development of dense colonies of Corbicula in fresh-water mussel habitats, whose mussel populations are already food limited, are surely obvious (see previous discussion). Clearly, at least in my opinion, Corbicula fluminea presents a fatal menace to the continued survival of Canthyria collina.

4.1.2 Overharvesting for Commercial, Sporting, Scientific, or Educational Purposes

This danger is real and the precise location of Canthyria collina populations should be kept confidential. Shell collecting is a popular hobby and spine-bearing specimens of C. collina may soon become much sought after. If allowed to remain unchecked, shell collecting could very well cause the genes responsible for spinyness to virtually disappear from the population. Such a phenomenon has recently been observed by us in Key Largo, Florida where shell collectors have removed colorful specimens to such an extent that gene frequencies have shifted dramatically and the previously rare white and pale phenotypes now comprise almost the entire the populations.

4.1.3 Disease or Predation.

We do not know what effect disease may have had in C. collina. In view of the fact that several other species of unionids now occur in the same habitat with Corbicula, it could be argued that Corbicula probably did not drive out Canthyria in the James River, but that disease may have been the principle factor. This is certainly possible. Further research is desirable here.

Predation is not thought to be a major cause for the decline of C. collina. In the sense that shell collectors are predators, however, this may become an important factor for its future survival.

4.1.4 The Absence of Regulatory Mechanisms Adequate to Prevent the Decline of the Species or Degradation of the Habitat.

There appear to be no regulations which would restrict the damming or channelization of Potts Creek, Johns Creek, or Craig Creek, or which would prevent gravel dredging. There are also no regulations restricting the use of Corbicula as bait in streams where it does not now occur, nor are there any regulations

4.1.5 Other Natural or Manmade Factors Affecting the Species' Continued Existence.

The principle menace here is thought to be Corbicula fluminea, as discussed above. In 1974 Diaz reported populations of C. fluminea exceeding $1000/M^2$ below Richmond. Similar densities now occur at many sites above Richmond as well.

4.2 Critical Habitat

4.2.1. Area Recommended for Critical Habitat.

The area recommended for critical habitat of C. collina is the region in which it now occurs, i.e. (1) Potts Creek in the short low-gradient reach centered about 0.6 mi WSW of Waiteville, Monroe Co., W. Va. (37^o 28' 21" N, 80^o 25' 54" W); and (2) the Johns Creek - Craig Creek waterway from a point in Johns Creek 2 mi SW of Maggie (at Va. Rt. 632), Craig Co., Va. to the mouth of Craig Creek at its junction with the James River, near Eagle Rock, Botetourt Co., Va. The precise limits of the Potts Creek reach should be investigated, as should the upstream limit of C. collina in Johns Creek, before exact limits of the critical habitat can be defined. Searches of Craig Creek upstream from its confluence with Johns Creek, by students from Virginia Tech., have failed to find C. collina, but that area should be searched again to ensure that none of it should be included in the critical habitat for C. collina.

4.2.2 Essential Biological and Physical Elements.

The data sheets for Site Sequence numbers 2, 16, 18, 19, 21 and 23 contain details of the biological and physical elements which were found to be associated with C. collina. These have also been discussed above. In general a natural, unpolluted, relatively hard-water (> 50 ppm $CaCO_3$), free-flowing stream habitat, with slow to moderate current, between about 5 to about 20 M in width, up to about 1 M in depth, in a region of mild temperature regime, with a substrate containing sand and gravel and/or cobbles, and without any Corbicula fluminea, is needed. Historical records also show that larger streams in that region are also suitable.

Of course a good population of the natural fish host of this species is also needed, but the identity of this fish species is still unknown.

4.2.3 Planned Activities and Their Effects.

We know of no planned activities such as channelization or damming which are scheduled for the area where C. collina still occurs. We may expect that disposal of sewage and other wastes at Newcastle and at other towns in Craig Creek, gravel dredging, and the transport of Corbicula (as bait) into presently unoccupied areas, will probably occur, however, unless such acts are prohibited by law.

4.3 Management and Recovery

First and foremost, we recommend that Canthyria collina be formally proposed for inclusion on the U. S. List of Endangered Species. Several powerful protective regulations of benefit to the species would then automatically come into force.

A proper recovery plan for C. collina would contain many of the stipulations which are already included in recovery plans for other listed species, i.e. encouraging cooperation from various levels of state and local government; prohibiting channelization, damming, or other habitat disruption; and educating the public in affected areas; among many others.

Some special considerations also apply. In our opinion regulations should be promulgated which would prohibit the use of Corbicula fluminea as bait except in areas where it now occurs. Further, life history studies should be carried out to determine the fish host of C. collina and other necessary attributes of a suitable habitat. And finally, the present habitats and populations of C. collina should be frequently monitored and, if Corbicula fluminea becomes a menace in the critical habitat, some appropriate actions should be taken. Such actions might include the transfer of specimens to another stream which appears to possess the proper biological and physical features and which does not contain Corbicula, or perhaps the transfer of numerous C. collina individuals to some highly productive streams with or without Corbicula, in which mussel populations are not food limited.

Fortunately the reaches recommended for critical habitat are close to Blacksburg, VA and could be studied and monitored by students from Virginia Tech. A substantial resource of expertise in mussel life history investigations already exists at that institution.

4.4 Taxonomy

The taxonomy of this species has already been discussed. I believe that it should bear the name Canthyria collina (Conrad, 1836).

4.5 Research Needs

Most of the research needs relative to Canthyria collina have already been discussed. Chief among these, I believe, is the need to work out the life history of C. collina and the identity of its fish host, and to measure more accurately the population size of that species. This should be done quickly because there may not be more than one or two years left before Corbicula fluminea overruns the Johns Creek - Craig Creek waterway. Urgent research should also be carried out to locate suitable areas into which C. collina might be moved if the critical habitat becomes unsuitable.

We encourage the Fish and Wildlife Service, through its facility at Virginia Tech., to take a leading role in these investigations and to monitor the C. collina populations on a frequent basis. ECOSEARCH, Inc. is also ready to assist in these efforts and in the development of a recovery plan for this seriously endangered and unique species.

5. REFERENCES CITED

Boss, K. J. and W. J. Clench
1967 Notes on Pleurobema collina (Conrad) from the James River, Virginia. Occasional Papers on Mollusks 3 (7):45-52, pl. 15. Museum of Comprehensive Zoology, Harvard University.

Briggs, J. C and J. F. Ficke
1977 Quality of Rivers of the United States (etc.) U. S. Geological Survey, Open-File Report 78-200.

Chambers, S. M.
1982 Protection of Mollusks Under the Endangered Species Act of 1973. Bulletin of the American Malacological Union for 1981, pp. 55-59.

Clarke, A. H.
1970 (Editor) Symposium on Rare and Endangered Mollusks. Malacologia 10 (1):1-56.

1982 (Editor) Proceedings of the Second American Malacological Union Symposium on the Endangered Mollusks of North America. Bulletin of the American Malacological Union for 1981, pp. 41-59.

1983 Status Survey of the Tar River Spiny Mussel. Final Report to the U. S. Fish and Wildlife Service, Asheville, N.C.

Clench, W. J. and K. J. Boss
1967 Freshwater Mollusca from James River, Va. and a New Name for Mudalia of Authors. The Nautilus 80 (3):99-102.

Conrad, T. A.
1836-40 Monography of the Family Unioidae, or Naiades of Lamarck, (Fresh Water Bivalve Shells) of North America. Issued in parts. 119 pages, 56 plates. Philadelphia:J. Dobson.

1846 Notes on Fresh Water Shells, etc., of Rockbridge Co., Virginia. American Journal of Science (series 2) 1:405-407.

Diaz, R. J.
1874 Asiatic Clam, Corbicula manilensis (Philippi) in the Tidal James River, Virginia. Chesapeake Science 15 (2):118-120.

Fuller, S. L. H.
1973 Fusconaia masoni (Conrad, 1834) (Bivalvia: Unionacea) in the Atlantic Drainage of Southeastern United States. Malacological Review 6:105-117.

Johnson, R. I.
1970 The Systematics and Zoogeography of the Unionidae (Mollusca: Bivalvia) of the Southern Atlantic Slope Region. Bulletin of the Museum of Comparative Zoology 140 (6):263-449.

Johnson, R. I. and A. H. Clarke
1983 A New Spiny Mussel, Elliptio (Canthyria) steinstansana (Bivalvia: Unionidae). From the Tar River, North Carolina. Occasional Papers on Mollusks 4 (61):289-298, pl. 40. Museum of Comparative Zoology, Harvard University.

Simpson, C. T.
1900 Synopsis of the Naiades, or Pearly Fresh-Water Mussels. Proceedings of the United States National Museum 22:501-1044, pl. 18.

Stansbery, D. H.
1970 Eastern Freshwater Mollusks (1): The Mississippi and St. Lawrence River Systems. Malacologia 10 (1):9-22. (Part of the 1968 AMU Symposium on the Rare and Endangered Mollusks of North America).

SUPPLEMENT TO FINAL REPORT

ON THE

STATUS SURVEY OF THE JAMES RIVER

SPINY MUSSEL, CANTHYRIA COLLINA,

IN THE JAMES RIVER, VIRGINIA

SUMMARY OF PERTINENT DATA

ON THE STATUS OF

CANTHYRIA COLLINA

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Historical Collection Records

1. Johns Creek near Maggie, Craig County, VA; 1975 (OSUM).
2. Calfpasture River (Conrad, 1846), Rockbridge County, VA, (Johnson 1970).
3. North (= Maury) River, Lexington, Rockbridge County, VA; (Johnson 1970).
4. Mill Creek near Millboro, Bath County, VA; 1970 (OSUM).
5. Rivanna River near Columbia, Fluvanna County, VA; 1966 (Clench and Boss 1967)
6. Rivanna River near Columbia, Fluvanna County, VA; 1966 (OSUM).
7. Rivanna River near Palmyra, Fluvanna County, VA; 1968 (OSUM).
8. Rivanna River at Crofton, Fluvanna County, VA; 1968 (OSUM).
9. James River near Natural Bridge, Rockbridge County, VA (Johnson 1970).
10. James River at Buchanan, Botetourt County, VA (Johnson 1970).
11. James River at Buchanan, Botetourt County, VA; 18--? (OSUM).
12. James River at Columbia, Fluvanna County, VA; 1966 (OSUM).
13. James River at New Canton, Buckingham County, VA; 1966 (OSUM).
14. James River opposite Maidens, Goochland County, VA; 1966 (Clench and Boss 1967)
15. James River at Maiden, Goochland County, VA; 1966 (OSUM).
16. James River at Rock Castle, Goochland County, VA; 1966 (OSUM).
17. James River at Pemberton and Cartersville, Goochland and Cumberland Counties, VA; 1966 (OSUM).

Present Collection Records - This Survey

1. South Fork Potts Creek near Waiteville, Monroe County, WV.
2. Johns Creek near Maggie, Craig County, VA.
3. Johns Creek along Sevenmile Mountain, Craig County, VA.
4. Craig Creek near New Castle, Craig County, VA.
5. Craig Creek near Silent Dell, Botetourt County, VA.
6. Craig Creek near Eagle Rock, Botetourt County, VA.

Range of *Canthyria collina*

Collection records examined for the James River basin indicate that *C. collina* occurred in the James River mainstem and several of its tributaries in the following counties: Craig, Botetourt, Rockbridge, Bath, Fluvanna, Buckingham, Goochland, and Cumberland Counties, VA; and Monroe County, WV. As judged by these records and suitable tributaries of the James River between these two groups of counties, the historical distribution of *C. collina* probably included locations in Alleghany, Amherst, Bedford, Campbell, Appomattox, Nelson, Albemarle, and Powhatan Counties, VA as well. Likely precolonial range was therefore the upper James River drainage above Richmond.

The documented and likely historic range of *C. collina* now has been significantly reduced to the following populations: South Fork Potts Creek, Monroe County, WV; Johns Creek, Craig County, VA; Craig Creek, Craig and Botetourt Counties, VA.

Status of Populations

The populations of *C. collina* in Craig Creek and its tributary, Johns Creek, appear healthy as judged by their abundance and the range of size classes present. Roughly 60 miles of stream are occupied disjunctly by this species in Craig and Johns Creek. Because of the disjunct distribution, it is not possible to provide an accurate population estimate. However, based on the sites visited, relative abundance of the species, and my experience with mussel populations in headwater streams, I would estimate that 50,000 - 75,000 specimens of *C. collina* reside in this 2 stream system.

The population of *C. collina* in the South Fork Potts Creek is probably of the magnitude estimated by Dr. Clarke (2,500) for the 500 m section visited. Mike Zeto (West Virginia Department of Natural Resources, pers. commun.) feels that a 2 to 3 mile stretch of the South Fork, beginning

0.25 mi above the North Fork-South Fork confluence to just west of Waiteville on the South Fork, is probably occupied by this species, although in low abundance. A conservative estimate of population size in the South Fork is therefore 5,000 specimens. A minimum estimate of the total number of individuals of *C. collina* is therefore 55,000 in all three populations. This population estimate is roughly twice that postulated by Dr. Clarke.

Population Threats

The decline of *C. collina* probably began with settlement and industrialization in the upper James River watershed. Changes in water quality, dams, and environmental contaminants undoubtedly contributed to the loss of populations in the basin. Current threats may very well include upstream dispersal of the Asiatic clam (*Corbicula fluminea*), poor logging practices in the upper Craigs Creek watershed (Jefferson National Forest), and municipal effluents from New Castle. However, no immediate threat to the continued survival of *C. collina* was evident during this survey.

Addendum to Table 1

Sequence No.	Location Rivanna River Drainage
74	Rivanna R., 0.5 mi SSW of Goochland
75	Rivanna R., 1.5 mi WNW of Columbia
76	Rivanna R., Crofton bridge at Crofton

No *C. collina* collected at these sites.