FINAL REPORT

to

United States Fish & Wildlife Service

Office of Endangered Species

Jackson Mall Office Center

300 Woodrow Wilson Avenue, Suite 316

Jackson, Mississippi 39213

for

Status Survey of *Lampsilis streckeri* Frierson (1927) and *Arcidens wheeleri* (Ortmann & Walker, 1912).

(Contract No. 14-16-0004-86-057)

from

ECOSEARCH, Inc.

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Portland, Texas 78374

September 25, 1987

ECOSEARCH, INC.

Ecological Surveys and Research

Status Survey of Lampsilis streckeri Frierson and Arcidens (Arkansia) wheeleri (Ortmann & Walker, 1912)

ERRATA

MAP 1: Station labelled 2347 should be 2348 and station labelled 2348 should be 2349

MAP 2: Station labelled 2356 on right (near word "River") should be 2366

Page 15, Table 3 :first entry under Kiamichi River :"2½ mi E of Tuskahoma" should read "2½ mi E of Albion"

Page 19, line 3 under " (b) Little River" : change station numbers "2353, 2354" to "2367, 2368".

Data Sheet 2308 : under Notes add the following : "Of the 19 specimens identified as Lampsilis streckeri, 7 specimens (5 complete specimens and 2 single valves) are darker and more poorly preserved than the others; they may represent Lampsilis radiata siliquoidea."

ABSTRACT

Surveys were carried out in 1986 and 1987 by ECOSEARCH, Inc., on behalf of the U.S. Fish and Wildlife Service, to determine the endangerment status of *Lampsilis streckeri* Frierson, 1927 and *Arcidens wheeleri* (Ortmann & Walker, 1912) (both Mollusca, Unionidae).

Our work revealed that *Lampsilis streckeri* now occurs only within a six-mile reach of the Middle Fork of the Little Red River in Stone and Van Buren Counties, Arkansas. Only one or two hundred individuals, or even fewer, are believed to exist. The habitat of *L. streckeri* is in gravel or sandy substrates in or near riffles. Its numbers and its range have been recently greatly reduced by dam and reservoir construction and its surviving population appears to be threatened by unstable river flow, pollution, and another federal water project. *L. streckeri* is a distinct species.

Arcidens wheeleri now occurs only within a five-mile reach of the Little River in Sevier and Little River Counties, Arkansas, and in a 50-mile reach of the Kiamichi River in Pushmataha County, Oklahoma. The Little River population is estimated at fewer than 100 individuals and the Kiamichi River population at between 100 and 1000. Its typical habitat is in muddy backwaters near riffles. *A. wheeleri* has been extirpated from its type locality in Clark County, Arkansas probably by natural eutrophication, and elsewhere its range has been constricted by flooding, hypolimnetic discharge at dams, and pollution. The Little River population is now threatened by further pollution, siltation, and possible enhancement of hypolimnetic discharge and the Kiamichi River population is threatened by a planned federal dam and lake construction project. Classification of this species as *Arcidens* (*Arkansia*) *wheeleri* is in accordance with the only recent monographic revision and is believed to be correct.

I. INTRODUCTION

This report describes the results of a status survey involving two rare species of freshwater mussels (Mollusca, Unionidae) from south-central United States. The survey was carried out in 1986 and 1987 by ECOSEARCH, Inc. for the U.S. Fish and Wildlife Service under Contract No. 14-16-0004-86-057. These mussels, originally described as Lampsilis streckeri by L.S. Frierson in 1927, and as Arkansia wheeleri by A.E. Ortmann and Bryant Walker in 1912, were both considered as possibly endangered. Field work on L. streckeri was to be carried out, as appropriate, in the Little Red River system in northern Arkansas and in Onion Creek and Salado Creek in central Texas and work on A. wheeleri was to be done in the Ouachita River near Arkadelphia, Arkansas, in the Little River in southeastern Oklahoma and southwestern Arkansas, and in the Kiamichi River in southern Oklahoma.

The tasks or work elements to be completed were specified in detail in the contract (see Appendix). They are essentially the same for each species and may be briefly described as follows:

(1) review available information regarding range, habitat, and life history;
(2) conduct field surveys;
(3) define present geographical distribution and characterize habitats and habitat requirements;
(4) review available information regarding the decline of the species and degradation of its habitat, if applicable;
(5) investigate and describe current threats to species survival;
(6) identify federal activities which might threaten each species; and
(7) resolve taxonomic issues, i.e. for L. streckeri re-evaluate its status at the species level and for A. wheeleri reconsider its generic placement.

A reconnaissance survey of the entire region was done in preparation for the contract bid. After the contract was awarded, detailed investigations were carried out as weather permitted. These occurred during two periods between late August and early October in 1986 and during three periods between late June and early September in 1987. Fifty-five survey sites (listed under 49 station numbers) were carefully studied. Collections in the Museum of Comparative Zoology at Harvard University and in the Strecker Museum at Baylor University were also examined and information from other workers with local field experiences involving L. streckeri or A. wheeleri was assembled. A progress report was completed on March 16, 1987 describing the survey results up to that point, which dealt principally with L. streckeri.

The main body of this, the final report, contains two narrative discussions, one dealing with L. streckeri and the other with A. wheeleri, and an Appendix. Both narrative discussions are comprised of seven sections and each section addresses one of the seven work elements specified in the contract. The Appendix contains detailed data sheets describing the results of work at each of the survey sites, a copy of the contract, and copies of permits.

Acknowledgements: - The results of this survey were materially enriched by the contributions of several friends, colleagues and institutions. Of special significance was the help provided by my wife Judith, who accompanied me during all of the field activities and participated in many gruelling episodes, and the valuable field assistance and advice freely given by three colleagues, Dr. Mark E. Gordon, Dr. John L. Harris, and Dr. Charles M. Mather. Others who loaned material and/or contributed other valuable information are: Mr. Joseph Bergmann, Dr. Arthur Bogan, Dr. Kenneth J. Boss, Dr. John B. Burch, Mr. Richard I. Johnson, and Dr. Raymond W. Neck. Useful information was also provided by the Arkansas Natural Heritage Commission and the Strecker Museum, Baylor University and helpful field assistance was also given by Mr. William McFall, Mr. Brett Williams, and Mr. Leo Fraser. Gratitude is also expressed to the U.S. Fish & Wildlife Service, Office of Endangered Species, who provided the funding which enabled this interesting program to be carried out.

II. STATUS OF *LAMPSILIS STRECKERI*

(1) Background Information on Range, Habitat, and Life History.

The first literature citations concerning the geographical distribution of *Lampsilis streckeri* Frierson are in Frierson's original description of the species (Frierson, 1927:74). There he gives the type locality as Little Red River, Arkansas and adds "Other shells... came from Union County, Texas..." The latter locality was immediately amended in a footnote by J.K. Strecker (*in* Frierson, 1927:74) to "Onion Creek, Travis County, Texas". Later Strecker (1931) listed "Salado Creek, Bell County, Texas" as also containing *L. streckeri*.

More recently Valentine and Stansbery (1971:32) reported this species (as "*Actinonaias streckeri*") as occurring in the Arkansas River drainage but Johnson (1980:98, 120) concluded that that record was in error, having been based on misidentified specimens of another species, *Actinonaias rafinesqueana* (Frierson, 1927). Johnson (1980:98, 133) also asserted that the holotype of *L. streckeri*, and the specimens from Onion Creek previously identified as *L. streckeri*, are all actually *Villosa vibex* (Conrad, 1834), a species otherwise stated to occur in coastal streams from southeastern Texas (Guadalupe River) to North Carolina (Cape Fear River System). Johnson (p. 183) provided excellent photographs of the holotype of *L. streckeri* and of specimens from Onion Creek and cited another locality for *L. streckeri* (as "*Villosa vibex*"), viz. Archey Fork, Clinton, Van Buren County, Arkansas.

Most recently Gordon and Kraemer (1984:99-100) reviewed the literature on *L. streckeri*, cited the Little Red River and Onion Creek localities as authentic and the Salado Creek locality as unconfirmed, restricted the type locality to Little Red River, Clinton, Van Buren County, Arkansas, showed that *L. streckeri* is probably distinct from *Villosa vibex*, and suggested that *L. streckeri* may now be extinct.

The only other site-specific information available is a record of several live *L. streckeri* from the South Fork of Little Red River, 75 yards below its junction with Archey Fork in Clinton, collected by Drs. Mark Gordon and John Harris in 1984 and again by Harris in 1985. These records were supplied by the Arkansas Natural Heritage Commission and by the Philadelphia Academy of Natural Sciences.

No specific information about the habitat of L. streckeri has been published. Gordon and Kraemer (1984:99-100) pointed out that all of the records are from upland streams, however, and that such habitats are characteristically rocky and with fairly rapid current.

No information has been published about the life history of this species.

(2) Field Survey Results.

Preliminary reconnaissance had indicated that, among the largest tributaries of Little Red River above Greer's Ferry Reservoir, the Middle Fork appeared to be the most productive. The Middle Fork has continuous water flow in lower reaches even during dry summers whereas Archey Fork and South Fork recede to a series of unconnected pools. Further, fishermen reported that live mussels are sometimes seen in Middle Fork but not in other tributaries. Initial field work was therefore concentrated in Middle Fork and 21 survey sites there were intensively studied (see Map 1). A diversity of mussels were found at some sites but not in others. This reinforced out hypothesis that constant flow was necessary for L. streckeri (discussed below), but for completeness one site near the mouth and another a few miles upstream in both Archey Fork and in South Fork were also carefully examined. A brief inspection was also done in 1986, in company with Dr. Gordon, of the site below the junction of Archey Fork and South Fork which yielded L. streckeri to Gordon and Harris in 1984 and to Harris in 1985. No live mussels were found there. The area has now been grossly altered by torrential episodic floods and L. streckeri is believed to now be absent there. Below this point the river is backed up from Greer's Ferry Reservoir.

A summary of some of the results from these studies is given in Table 1 and complete results are given in Station Data Record sheets in the Appendix. All of these sites except one (Station 2305, a pool) contained both riffle and pool habitats.

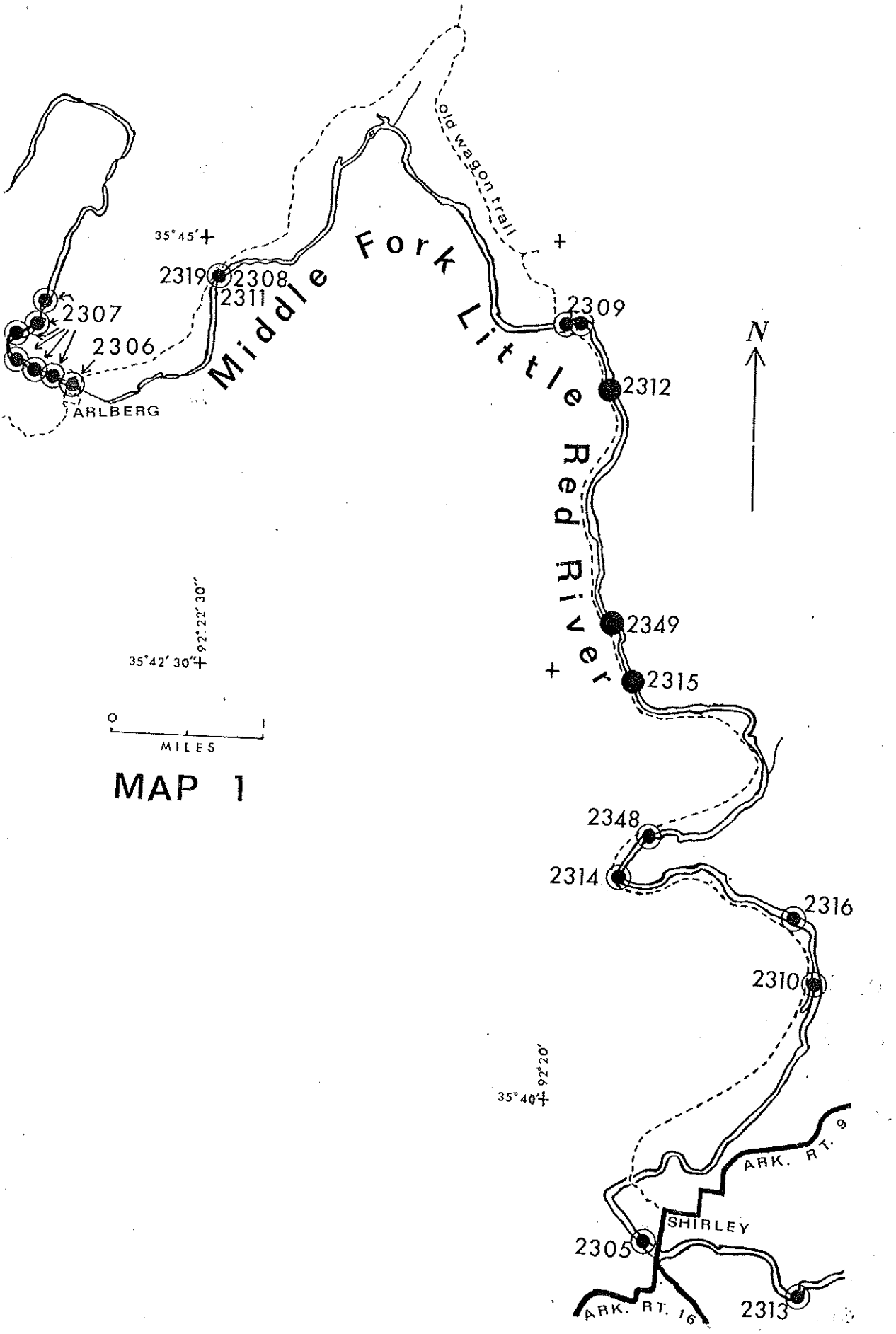
Although improbable on zoogeographic and ecological grounds, since L. streckeri had been reported from Onion Creek in Travis County and Salado Creek in Bell County, both in central Texas, those reports required evaluation. These localities are both more than 600 miles away from Little Red River, are in separate Gulf of Mexico drainage systems which are not connected with that of Little Red River (White River Mississippi River drainage) and represent low-gradiant habitats rather than the generally high-gradient of Little Red River tributaries. Further, we observed that both Onion Creek and Salado Creek are heavily managed and as confirmed by colleagues, access is difficult and often impossible because of landowner restrictions. We did manage to search one site in Salado Creek (Station 2372) and one near its outlet in Lampasas River (Station 2371) but the results were inconclusive.

Fortunately, however, excellent photographs of specimens on which Frierson and Strecker based their 1972 record from Onion Creek have been published (Johnson, 1980), other specimens of "Lampsilis streckeri" presumably identified by Strecker are available in the Strecker Museum at Baylor University, and other experienced collectors have recently searched both regions. The photographs in Johnson (1980, plate 17, figures 7 and 8) show two single valves from immature specimens which resemble Lampsilis bracteata (Gould, 1855) a somewhat similar but

TABLE 1

Data on Site Locations, *Lampsilis streckeri* Occurrences, and Unionid Diversity, Van Buren and Stone Counties, Arkansas

Sequence No.	Station No.		*L. streckeri* presence	Total Unionid Spp. Alive	Alive & Dead
		MIDDLE FORK LITTLE RED RIVER			
1	2307	0-2 MI w of Arlberg	No	0	6
2	2306	Arlberg	11/2 old shells	4	7
3	2308 2311 2319	1.3 mi NE of Arlberg	many fairly fresh shells in midden	7	11
4	2309	Lydalisk	No	0	2
5	2312	1/2 mi SE of Lydalisk	2 alive	6	11
6	2349	4 mi N of Shirley	1 alive	1	7
7	2315	31/2 mi N of Shirley	2 alive	9	10
8	2348	21/2 mi of Shirley	No	0	2
9	2314	21/4 mi N of Shirley	No	0	5
10	2316	21/4 mi NNE of Shirley	No	0	5
11	2310	2 mi NNE of Shirley	No	1	6
12	2305	Shirley	No	1	2
13	2313	3/4 mi ESE of Shirley	No	7	7
		ARCHEY FORK LITTLE RED RIVER			
1	2347	6 mi N of Clinton	No	0	0
2	2345	N side of Clinton	No	0	0
		SOUTH FORK LITTLE RED RIVER			
1	2302	2 mi NE of	No	0	1
2	2302	S side of	No	0	3


Middle Fork Little Red River
old wagon trail
35°45'
2319
2308
2311
2307
2306
ARLBERG
2309
2312
N
2349
2315
35°42' 30"
92° 22' 30"
0
1
MILES
2348
2314
2316
2310
35°40'
92°20'
ARK. RT. 9
SHIRLEY
2305
ARK. RT. 16
2313

MAP 1

distinct species occuring in central and southern Texas. The two specimens in the Strecker Museum originally identified as L. streckeri are from the North Fork of the Bosque River at Highway No. 6 near Iredell, Bosque County, Texas (SM 6663) and from the Colorado River at Austin, Texas (SM 5145 A,B) and both are L. bracteata. Finally, both Dr. Raymond W. Neck and Mr. Joseph Bergmann have collected mussels in Onion Creek and have found only L. bracteata there. The latter gentleman has also loaned me a specimen which he collected in Onion Creek, and it is L. bracteata, not L. streckeri. Mr. Bergmann has also not found L. streckeri or L. bracteata in Salado Creek in Bell County or in the Lampasas River. He has collected L. bracteata in a different stream bearing the name Salado Creek, however, a creek which runs through San Antonio in Bexar County, Texas. It seems possible that Strecker's Salado Creek record may have been based on L. bracteata from the Bexar County stream. At any rate, since there is no evidence that L. streckeri even occurred in Onion Creek or in either of the two Salado Creeks cited, those records for L. streckeri should be discarded.

(3) Range and Habitat.

Our survey has revealed that although none of the sites which had been reported to harbor Lampsilis streckeri now support that species, a remnant population still survives. The populations reported from Texas apparently never existed, since their presumed occurrences were based on misidentified specimens of another species. We conclude that L. streckeri was, and is still, restricted to the Little Red River System, (White River Drainage) in northern Arkansas but that most of its populations there have been extirpated because of flooding at Greer's Ferry Reservoir and because the cold hypolimnetic discharge from the Greer's Ferry Dam has altered the downstream ecology such that the lower river cannot support L. streckeri. Among the tributaries above Greer's Ferry Reservoir only the Middle Fork Little Red River appears to have sufficient year round flow to support L. streckeri, and that is probably the only stream where the species now exists.

Our data indicate that Lampsilis streckeri now occurs with certainty only throughout a 2.2 mile reach of Middle Fork Little Red River in Van Buren and Stone Counties, Arkansas. This reach extends from a point 0.5 mi SE of Lydalisk in Stone County (Station 2312) to a point 3.5 mi N of Shirley in Van Buren County (Station 2315). Without a meter by meter search of the river, which was impossible under this contract, the precise upstream and downstream limits beyond those cited cannot be stated definitely, but bases do exist for plausible estimates. We estimate that the upstream limit may be about 2.6 mi NE of Arlberg near the mouth of Meadow Creek, indicated at the top of Map 1 near the word "old", because that is the only point where sudden ecological change occurs (increased flow) between Lydalisk and Arlberg. Near and above Arlberg the river recedes to form a series of isolated pools during dry summer months and we are convinced that this is inimical to L. streckeri survival. We further estimate that the lower limit may be about 2.7 mi N of Shirley near the mouth of Tick Creek (on the east side of Middle Fork about halfway between Stations 2315 and 2348) since that is the point at which the greatest probability exists for substantial ecological change (pollution) between Station 2315 and Simkins Point. From Simkins Point to the vicinity of Shirley, although empty mussel shells of several species were fairly common, no live mussels of any species occurred. This is indicative of past or present pollution.

In summary, L. streckeri has been demonstrated to occur in a 2.2 mile reach of Middle Fork Little Red River, and we believe it likely that it occurs beyond that reach about 2.5 miles upstream and about 1.3 miles downstream. Its positively established range therefore spans 2.2 river miles and its probable range spans 6.0 miles.

The five living specimens of Lampsilis streckeri which we found all occurred in riffles (Stations 2312 and 2315, 4 specimens) or at the edge of a riffle (Station 2349, 1 specimen). An in situ empty shell of L. streckeri also occurred in a riffle (Station 2306) and the live specimens previously found by Gordon and Harris in South Fork also occurred in a riffle. Substrates occupied varied from coarse sand to muddy sand and water depths varied from about 0.2 M to 0.4 M. All of the sites yielding live specimens were in reaches of constant water flow. These attributes are consistent with a need for the large dissolved oxygen concentrations which occur in riffles . Of course shallow reaches in small streams are the first to dry up during drought, mussels in such riffles would be stranded, and mussels in nearby pools would be denied well-oxygenated water. This appears to explain why L. streckeri does not live in reaches where average flow is so low that summer no-flow situations take place.

Associated fauna included eight other mussel species at one site (2315), five other species at another (2312), and no other species at a third (2349). The latter occurrence may be anomalous, however, because rare mussel species ordinarily occur as elements of species-diverse mussel communities. See Field Data Record sheets for correlations.

Some life history data are available but much more, especially the identity of the fish host, remains to be determined. Two female L. streckeri were seen at Station 2312 on October 4, 1986 and both were gravid. The topographic anatomy of one was examined and it was observed that only the posterior half of the outer gills was marsupial; that 21 swollen, cylindrical ovisacs were present in one marsupium; that the marsupium in each demibranch was bordered ventrally with black pigment, and that the glochidia were purse-shaped and without stylets. All of these features, including the approximate size of the glochidia, are generally in agreement with those of Lampsilis radiata siliquoidea.

In addition none of the specimens collected by Dr. Harris on July 24, 1985 were gravid, and therefore all of the dates relative to gravidity are also in agreement with those of L. r. siliquoidea. That species ordinarily becomes gravid in August and retains glochidia until the following June.

Studies which seek to determine the host fish for L. streckeri might begin by testing some of the fishes which serve as hosts for L. r. siliquoidea (see Clarke, 1973) and some of the fishes which are endemic to Little Red River.

4. Population Declines and Habitat Degradation.

Little Red River, the original type area of Lampsilis streckeri, has been severely disrupted by the imposition of lentic conditions caused by the creation of Greer's Ferry Reservoir and by hypolimnetic discharge from the Greer's Ferry Dam which, according to sources, has markedly chilled the river below the dam.

Upstream tributaries of Little Red River have also been impacted. Evidence discussed above points to the conclusion that pollution may have extirpated L. streckeri from the Middle Fork in the 5-mile reach above Shirley, in Van Buren County. The occurence of empty shells also indicates that L. streckeri previously existed in Middle Fork from Arlberg downstream for about 1.5 miles in Stone County and that its population there has recently been killed. Reduction in flow during summer periods appears to be the proximate cause but the ultimate cause is unknown. The land around upstream Middle Fork still appears to be well forested and faulty land management, although a probable cause, is not an obvious one. Torrential floods seem also to have fatally disrupted the mussel's habitat in South Fork below Clinton, Van Buren County. Again, the cause for an unusual pertubation (if it is unusual) is unknown, but it may also relate to excessive lumbering operations in the watershed.

5. Present Threats

Fortunately the reach of Middle Fork which supports Lampsilis streckeri is not easily accessible. The old wagon trail which parallels the river above Shirley is impassable between Simkins Point and Lydalisk except by a four wheel drive vehicle and the land is also posted. The population is very small, however, probably containing only a few hundred individuals or possibly even fewer, and it appears to be decreasing. This remnant population is also restricted to a short reach of a single river and it is therefore susceptible to extirpation from a single pollution event. In our opinion, therefore, Lampsilis streckeri is critically endangered and prompt remedial action will be necessary to save it from extinction.

6. Federal Activities

A landowner on the west side of Middle Fork opposite Simkins Point informed us that Army Corps of Engineers personnel traversed his land and carried out a reconnaissance of the area harboring L. streckeri during the summer of 1987. This may indicate that a water project there is being contemplated, and such an activity would surely result in the extinction of the species.

The presumed pollution from Tick Creek, if it exists, also severely limits expansion space available for the L. streckeri population. If Middle Fork was unpolluted in the reach between Tick Creek and Shirley, the area of suitable habitat for L. streckeri would double. Such pollution might violate federal and/or state laws.

7. Taxonomic Considerations.

The taxonomic status of Lampsilis streckeri was discussed in our Progress Report but restatement of some of the points and addition of others is appropriate here.

A series of shells presumed to be L. streckeri was collected from Station 2308/2311 i.e. within the vicinity of the type locality of that species. The shells showed moderate variability in ray pattern (see photograph supplied with Progress Report) and several of them showed great similarity to the photograph of the holotype of L. streckeri published by Johnson (1980, plate 17, figure 6). We were therefore

convinced that those specimens, and other comparable specimens from other stations in the Middle Fork, were conspecific with the holotype of L. streckeri. As required by this contract specimens were sent to other authorities (in this case to Dr. J.B. Burch at the University of Michigan and Dr. Arthur E. Bogan at the Academy of Natural Sciences, Philadelphia) for their opinions of their identity based on comparisons with museum specimens available to them. Both workers have concluded that our specimens are Lampsilis streckeri.

Some previous authors, however, have questioned whether or not L. streckeri is a distinct species. Johnson's (1980) proposed synonymy of L. streckeri under Villosa villosa has already been discussed and has been judged to be erroneous. Later Gordon and Kraemer (1984) concluded that L. streckeri is closely related to, and perhaps identical with, Lampsilis reeveiana (Lea, 1852). They also provided a useful table of comparative behavioral and anatomical features of L. reeveiana, L. radiata siliquoidea (Barnes, 1823) and L. ventricosa (Barnes, 1824). Based on our material of L. streckeri which includes a relaxed, fixed and alcohol-preserved gravid specimen, and information from the paper by Gordon and Kraemer (1984) and from other sources, a tabular character comparison of L. streckeri, L. reeveiana, and L. radiata siliquoidea has been assembled (Table 2). (L. ventricosa has not been included because it is not closely related to L. streckeri and is irrelevant to the problem being considered here).

The evidence presently available indicates that Lampsilis streckeri is probably a distinct species related both to L. r. siliquoidea and to L. reeveiana. L. streckeri shares general morphological similarities with both of those species but it achieves a much smaller maximum size than typical L. r. siliquoidea. With L. r. siliquoidea alone it shares a similar pattern of sexual dimorphism and similar "eyespots" on the mantle. With L. reeveiana alone it shares similar mantle pigmentation and similar ecology. Its unique features include the characteristic nature of its periostracal rays (wavy, with chevron- like spots or with narrow cross-lines oriented in ribbons) which can be seen in many specimens, its nacre color (grayish in many specimens), and the shape and number of accessory processes on the "tail" of the mantle flaps.

Both J. B. Burch and R.I. Johnson have recently informed me that they also consider Lampsilis streckeri probably to represent a distinct species.

Questions regarding the generic placement of L. streckeri have also recently arisen. Haas (1969:438) placed it in the genus Ligumia, Valentine and Stansbery (1971:32) placed it in Actinonaias, Johnson (1980:98) placed it in Villosa and several other authors placed it in Lampsilis. This divergence of opinion probably occurred because living or properly preserved material was unavailable prior to the collections of Gordon and Harris (1984,1985) and those of the present survey.

There can be no doubt: L. streckeri is a Lampsilis. The major structural differences between the genera cited above involve characters of the mantle flaps. The mantle flaps of L. streckeri agree closely with those of L. radiata radiata, L. r. siliquoidea, and L. ventricosa. They are quite different from the mantle configurations of the species of Ligumia and Villosa. All Actinonaias, in fact, lack mantle flaps entirely and, unlike species of Lampsilis, they do not exhibit obvious

Table 2

Character Comparisons of *L. streckeri*, *L. reeveiana*, and *L. r. siliquoidea*.

Character	*L. streckeri*	*L. reeveiana*	*L.r. siliquoidea*
1. General shell morphology	Up to about 80 mm long and fairly thin.	Up to about 80 mm long, fairly thick to thin.	Up to about 140 mm long, fairly thick to moderately thin.
2. Periostracal rays	Narrow and wide, wavy, and in some specimens with chevron-shaped spots or with rays like ribbons of cross-lines.	Narrow and wide and principally straight. Without chevron-like spots and without rays like ribbons of cross-lines.	Narrow to wide and principally straight. Without chevron-like spots and without rays like ribbons of cross-lines.
3. Nacre color	Grayish to whitish, slightly iridescent.	Whitish, slightly to moderately iridescent.	Whitish, slightly to moderately iridescent.
4. Sexual dimorphism in shell	Females broader posteriorly and more evenly rounded posteriorly than males; not emarginate.	Females broader and more inflated posteriorly than males; post-basally emarginate in many specimens.	Females broader posteriorily and more evenly rounded posteriorly than males; not emarginate.
5. "Eyespots" on mantle.	Inconspicuous but visible on outside & inside of mantle.	Inconspicuous, visible on outside of mantle only.	Inconspicuous, visible on outside and inside of mantle.
6. Mantle flap pigmentation.	Uniform dark gray on outer surface; small pigment spot near "tail".	Uniform dark gray on outer surface; conspicuous large pigment spot near "tail".	Variegated, many pigment spots on outer surface; conspicuous pigment spot near "tail".
7. "Tail" of mantle flap.	About 5 narrow triangular processes provide flaring appearance.	5-10 long papillae provide flaring appearance.	10-20 long papillae provide tail with fringed, flaring appearance.
8. Ecology	In upland streams, principally riffles.	In upland streams, principally riffles.	In lakes & rivers of all sizes, very rare in riffles.

sexual dimorphism in the shell. In L. streckeri shell sexual dimorphism is well developed and is in full agreement with other species of Lampsilis.

III. STATUS OF ARCIDENS WHEELERI (=ARKANSIA WHEELERI).

(1) Background Information on Range, Habitat, and Life History.

Arcidens wheeleri was originally described as Arkansia wheeleri by Ortmann and Walker (1912) and its type locality was originally designated (loc cit) as "Old River, Arkadelphia, Arkansas". Later, Wheeler (1918:116) published a map showing that Old River corresponds to what is now an interconnected series of narrow lakes which extends from a point about 3.9 miles NE of, to a point about 2.2 miles NNE of, the center of Arkadelphia, Clark County, Arkansas, i.e. from 34 09'40" N and 93 01'91"W to 34 08'55"N, 93 02'46"W. Wheeler (p. 121) also gave Ouachita River below Arkadelphia as another locality for A. wheeleri but said that it was rare there.

Subsequently a few other authors reported sites where A. wheeleri occurred. Ortmann (1921:141) reported that he had received, from Mr. D.K. Gregor of Fulton, Missouri, "a single dead shell in fair condition" of A. wheeleri collected in the Kiamichi River at Antlers, Pushmataha County, Oklahoma. Isely (1925:56) confirmed the existence of A. wheeleri in the Kiamichi and reported that he had collected it there in 1910 at Tuskahoma, also in Pushmataha County. Frierson (1927:21) gave Arkansas River as an additional general locality but without specific data.

No further occurrences were published for many years, not until Valentine and Stansbery (1971:6) again reported A. wheeleri from the Kiamichi, at Spencerville Crossing, 1 mile S of the bridge at Oklahoma Highway 93, 8.5 miles NE of Hugo, Choctaw County, Oklahoma. (That locality has now been flooded by recently-created Hugo Reservoir). Later Johnson (1980:120) added another A. wheeleri locality from material in the University of Michigan Museum of Zoology, viz. Little River, White Cliffs, Little River County, Arkansas, and Clarke (1981:81) added yet another locality from specimens in the Ohio State University Museum of Zoology, viz. Kiamichi River, 1.2 miles SE of Clayton, Pushmataha County, Oklahoma collected by D.H. Stansbery in 1971. Finally, from information supplied by the Arkansas Natural Heritage Program and J.L. Harris (pers. comm.), one more locality for A. wheeleri may be listed, viz. Little River, 4 miles NW of U.S. Highways 59 and 71 crossing of Millwood Lake, Little River County Sevier County boundary, Arkansas collected by Gordon and Harris in 1983 (several fairly old, empty shells).

Information about the habitat requirements of A. wheeleri was available from three sources. Wheeler (1918:112-113) wrote as follows: ""Old River", the type locality of the genus Arkansia, is really an "ox bow" lake, a former channel of the Ouachita and it is still connected with it by a small creek which does not appear to dry up in summer. Its mouth is about two miles north of Arkadelphia on the left bank, almost lost in a dense and a difficultly passable swamp. Here, and for a mile

or more upstream. Old River is deep and rather wide, with a very sluggish current. In this habitat are found very large specimens of Anodonta suborbiculata Say, which are of great beauty, and the largest specimens of Arkansia wheeleri Walker and Ortmann. One of the latter measured 109.25 by 87 by 58 mm. In the summer "Half-Moon Lake", the upper channel of Old River, is set off by the subsidence of water on the sand bars, and through the narrow creek which connects it with its lower course, it is quite impossible to navigate even a small canoe. Young Arkansia are found in the shallow waters both on the sand bars and muddy bottoms, but like other anodontine species, they prefer the oozy mud of the river margins where there is little or no current. So far, the most patient effort to secure gravid females of this new genus have not been successful, the breeding season being winter, and the localities just described being almost inaccessible at this season." In the same paper Wheeler cites some 43 other mussel species which also occur in Old River, but their relative abundance is not described.

Isely (1925:56) reported that the specimen of A. wheeleri that he had found in the Kiamichi River occurred with several other species, all of which live "in side channels and bends of the river with mud bottom, water 2-3 feet deep, no current". Unfortunately it is not clear whether the A. wheeleri came from a side channel or a bend. Other species found in those two habitats taken together, in descending order of abundance and using modern nomenclature, are: Amblema plicata (55), Lampsilis ventricosa [sic, probably satura] (20), Actinonaias carinata (18), Fusconaia flava (14), Tritogonia verrucosa (14), Quadrula pustulosa (12), Ptychobranchus occidentalis (9), Potamilus purpurata (8), Obovaria jacksoniana (3), Toxolasma parva (1), Anodonta grandis(1), and Anodonta imbecillis (1).

Dr. C.M. Mather informed me that he had found a live specimen of A. wheeleri in a small, muddy backwater close to a riffle in the Kiamichi River. He also accompanied me to that site and to several other locations in the Kiamichi. At each of those locations, and at other locations later visited by me alone, a search was made for these muddy-backwater-near-a-riffle habitats and such sites were intensively sampled, with gratifying results.

No direct information is available about the life history of A. wheeleri, but based on its systematic classification some assumptions are justified. Like it congener Arcidens confragosus (Say, 1829) and other members of the anodontine Tribe Alasmidontini, A. wheeleri is probably a long-term breeder (i.e. becoming gravid in the fall and discharging glochidia in the spring) and has glochidia which possess stylets ("hooks") and which attach to the fins, tail, or scales of a fish. The fish host is unknown, but future investigations which seek to establish its identity should probably begin by testing those fishes which are known to be hosts for A. confragosus, i.e. the American eel, gizzard shad, rock bass, white crappie, and freshwater drum. For further details on A. confragosus see the monographs by Johnson (1980) and Clarke (1981).

2. Field Work.

During this survey 30 field stations were carefully searched for Arcidens wheeleri. These included three in the Ouachita River in Clark and Hot Springs Counties, Arkansas; 15 in the Little River and its tributaries in Sevier and Little River Counties, Arkansas and in McCurtain County, Oklahoma; and 12 in the Kiamichi River in Choctaw and Pushmataha Counties, Oklahoma. It was believed that the Ouachita River did not merit geographically extensive investigation because its fauna has been sufficiently well studied to indicate that, except possibly for one site near the type locality (Station 2352, discussed below), A. wheeleri no longer occurred there. Our major efforts were therefore directed toward searching for A. wheeleri in the Little River and the Kiamichi River Systems. See Maps 2 and 3 for site locations in those river systems.

Some of the results of our work are summarized in Table 3 and complete details are given in the Field Data Records in the Appendix. We are happy to be able to report that Arcidens wheeleri still occurs as a healthy but rather small and diffuse population in the Kiamichi River and as a very small population in one short reach of the Little River. It has apparently been extirpated from the Ouachita River near Arkadelphia, Arkansas. These findings and others are discussed below.

3. Range and Habitat.

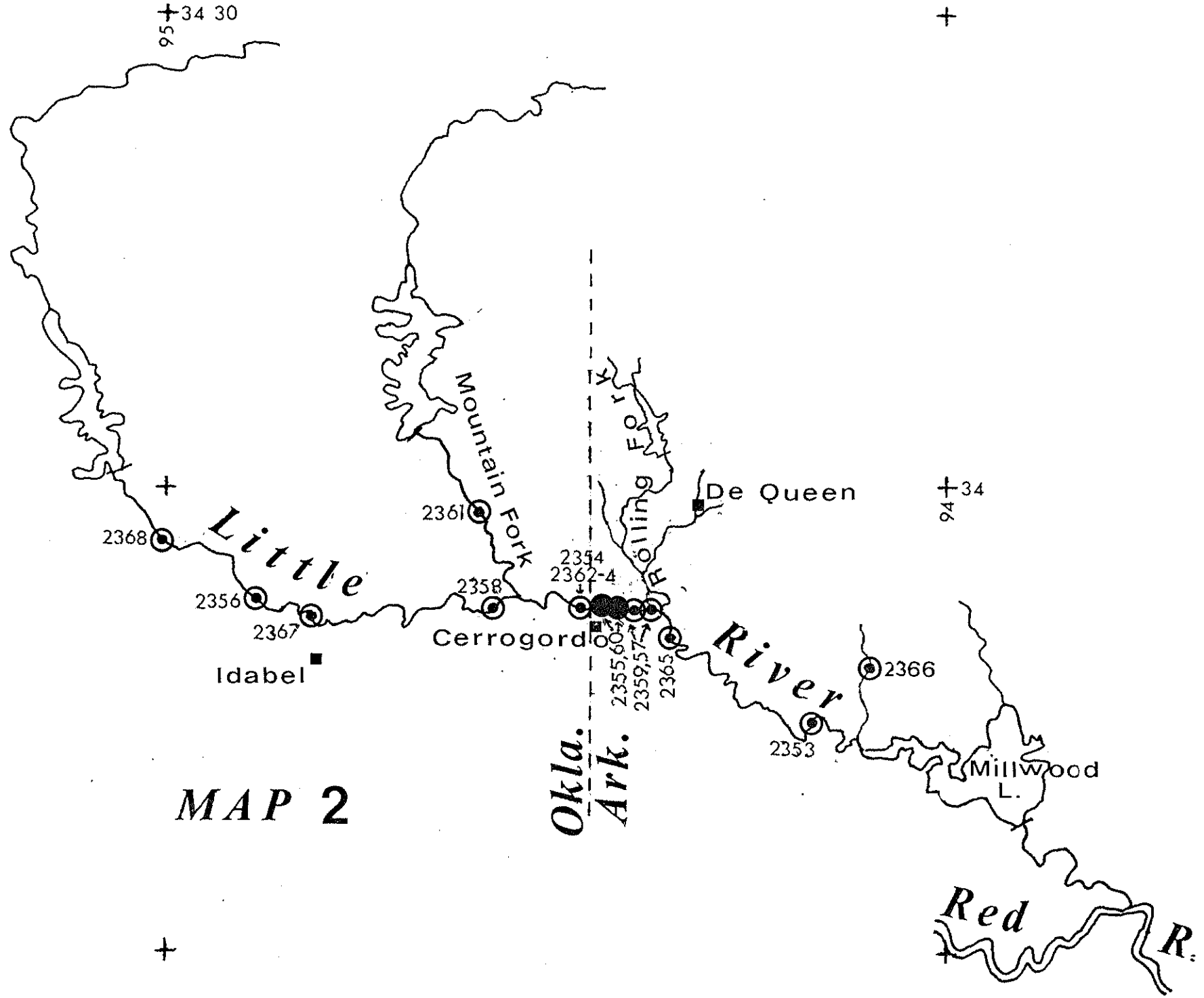
Our survey revealed that Arcidens wheeleri has now been extirpated from its type locality and that, as already deduced from previous studies by Gordon and Harris (personal communication), it is probably also absent from the Ouachita River in the vicinity of Arkadelphia, Arkansas. We also determined, however, that a small population of A. wheeleri does exist in Arkansas, i.e. in the Little River from the Oklahoma-Arkansas boundary to about 5 miles east of that boundary. A more attenuated but alarmingly sparse population also occurs in an approximately 50-mile reach of the Kiamichi River in Oklahoma from a point about 2.5 miles E of Albion downstream to a point about 1.5 miles N of Antlers, all in Pushmataha County.

The habitat of A. wheeleri is typically in muddy coves or backwaters adjacent to riffles, or at the least close to areas of moderate to rapid current. This habitat is not ordinarily sought out for detailed study by most malacologists, probably because sandy shoals have been traditionally regarded as the most productive sites. Although previous authors had stated that muddy side channels, river bends, and oxbow lakes are the habitats from whence A. wheeleri had been collected, it was the more precise observation by Dr. Mather, that a living specimen which he had seen occurred in a small, muddy backwater close to a riffle, that led to our unusual success in finding A. wheeleri. Within the 50-mile reach from the Albion area to the Antlers area, on every occasion after a muddy-backwater-near-a-riffle habitat was located and intensively searched, Arcidens wheeleri was found. This indicates that the population, although sparse, is probably continuous in suitable habitats throughout its 50-mile range. Such habitats are estimated to occupy somwhere between 1000 and 5000 square meters per linear mile. The average population density of A. wheeleri is estimated at about 2 to 4 per 1000 M^2. These figures lead to an approximate total population estimate in Kiamichi River of only between 100 and 1000 individuals.

TABLE 3

Summary of Some Data from Field Studies in the Ouachita, Little, and Kiamichi Rivers.

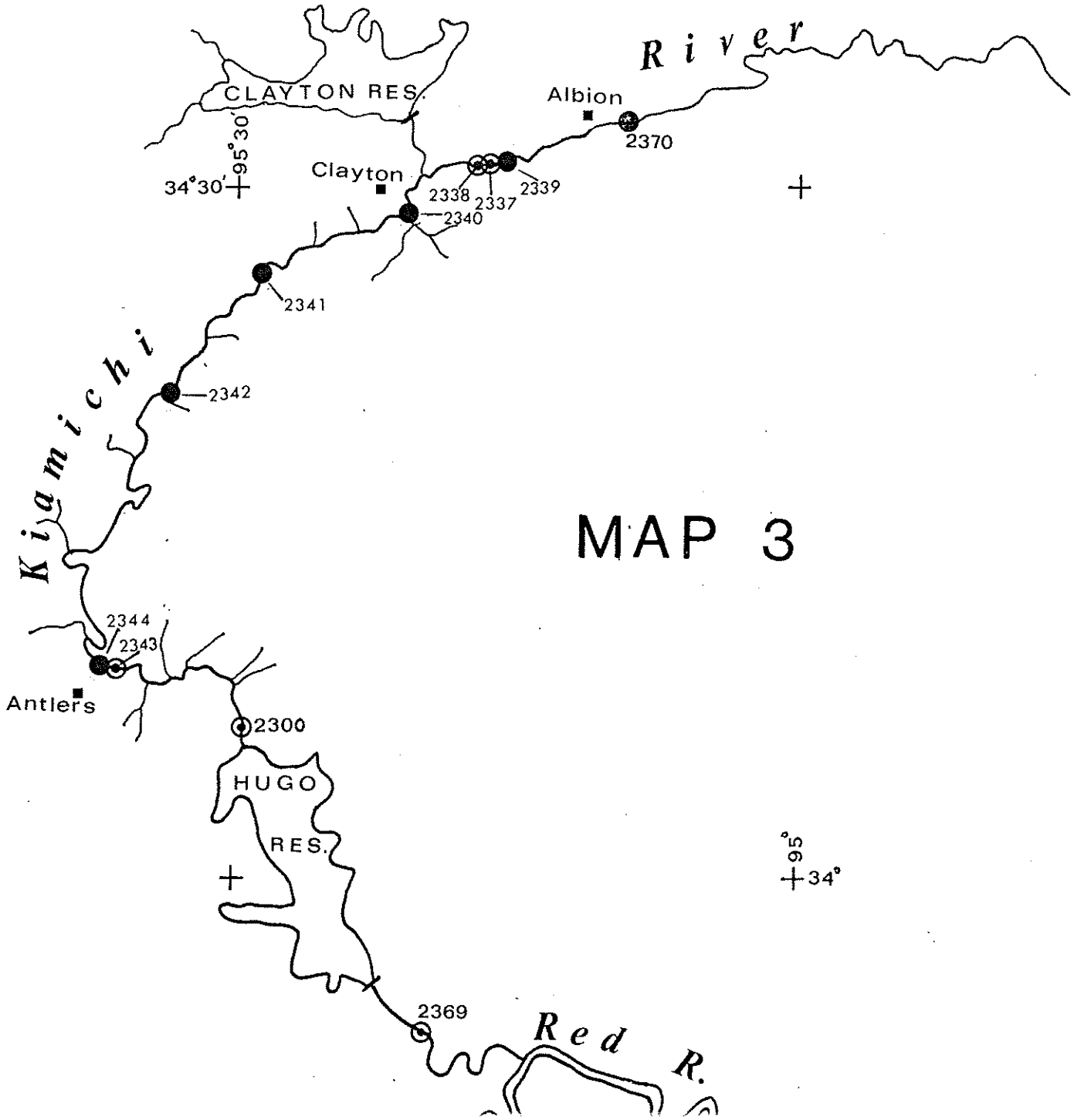
Seq. No.	Sta. No.	Location	Habitat	Arcidens wheeleri present	No. of other Unionid Spp. Alive	Alive/Dead
OUACHITA RIVER SYTEM, HOT SPRINGS & CLARK COUNTIES, ARKANSAS						
1	2350	Ouachita R. near Friendship	Muddy backwater nr. channel	No	7	12
2	2351	"Old River", type locality	Muddy, polluted	No	0	0
3	2352	Ouachita R 2 mi NE of Arkadelphia	Muddy cover off main river	No	17	18
LITTLE RIVER SYSTEM, OKLAHOMA AND ARKANSAS						
1	2368	Little R. 4 mi N of Millerton	Slackwater, mud bottom	No	0	0
2	2356	" " 2 mi NE of Garvin	Riffle & pool	No	2	6
3	2367	" " 2 mi N of Idabel	Slow current, mainly mud	No	2	2
4	2358	" " 2 mi N of Goodwater	Medium current, sand & mud	No	7	8
5	2354 2302	" " 0.3 mi W of OK-AR bound.	Nr. mouth of trib.mud & sand	No	10	10
6	2355	" " 0.2 mi E of OK-AR bound.	Muddy backwater	2 alive	11	12
7	2360	" " 0.7 mi NE of OK-AR bound.	Backwater, mud & sand	1 alive	12	12
8	2359	" " 0.9 mi E of OK-AR bound.	Straight channel, cs. gravel	No	0	3
9	2357	" " 5 mi E of OK-AR bound.	Nr. creek, mixed hab.,gravel & mud	No	1	3
10	2365	" " 3 mi SW of Horatio	Current v. slow, gravel & mud	No	0	0
11	2353	" " 3 mi NE of Alleene	Medium current, gravel & mud	No	5	11
A	2361	Mountain Run Fk. 7.5 mi E. of Broken Bow	Current slow, mud & gravel	No	6	10
B	2364	Oxbow Lake, 0.4 mi W of OK-AR bound.	Stagnant, deadfalls & mud	No	0	2


34 30
95
34
94
Little
Mountain Fork
Rolling Fork
River
Red R.
Okla.
Ark.
De Queen
Cerrogordo
Idabel
Millwood L.
2368
2356
2367
2361
2358
2354
2362-4
2355,60
2359,57
2365
2366
2353

MAP 2

TABLE 3 cont.

C	2363	Channel below Oxbow Lake.OK-AR bound.	No current, mud overhanging trees	No	2	2
D	2366	Cossatot R 8 mi ENE of Horatio	Riffles & pools gravel & mud	No	0	3
		KIAMICHI RIVER, PUSHMATAHA & CHOCTAW COUNTIES, OKLAHOMA				
1	2370	Kiamichi R, 2 1/2 mi E of Albion	Backwater at base of pool near riffles	1 alive	7	8
2	2339	" " 3 1/2 mi E of Tuskahoma	Backwater off channel w/riffles	1 alive 1 1/2empty	11	11
3	2338	" " 2 mi E of Tuskahoma	Pool, gravel, sand & mud	No	0	1
4	2338	" " 1.8 mi E of Tuskahoma	Base of pool above channel	2 1/2 empty	15	16
5	2340	" " 1.2 mi SSE of Clayton	Cove off base of pool, outlet with riffles	3 alive	13	16
6	2341	" " Stanley	Muddy backwater off riffles	2 alive	7	11
7	2342	" " 2 mi NNE of Eubanks	Cove off pool below riffles	1 alive	12	12
8	2301	" " at Eubanks	Slow, boulders, sand, reconnaissance only	No	1	4
9	2344	" " 1.5 mi N of Antlers	Backwater off riffles below pool	2 alive	12	21
10	2343	" " 1.2 mi NNE of Antlers	Long pool, rocks, mud, Justicia	1 empty	9	14
11	2300	" " 7.7 mi ESE of Antlers	Slow, sand & mud, backed up from Hugo Reservoir	No	0	0
12	2369	" " 3.5 mi S of Ft. Towson	No current, sandy mud, v. deep	No	0	0


River
CLAYTON RES.
Albion
2370
95°30'
34°30'
Clayton
2338
2337
2339
2340
2341
Kiamichi
2342
MAP 3
2344
2343
Antlers
2300
HUGO
RES.
95°
34°
2369
Red R.

The situation in Little River is more complex. Above Pine Creek Reservoir the river appears to be too small to support A. wheeleri. For about 30 miles below the Pine Creek Reservoir the river is strongly influenced by hypolimnetic discharge from the reservoir dam and dead mussel beds are abundant in that reach. Surprisingly, no deleterious downstream effects from the Broken Bow Reservoir on Mountain Fork were evident, and near its confluence with Mountain Fork the faunal diversity in Little River shows marked improvement. A few miles farther on, near the Oklahoma-Arkansas boundary (Stations 2354, 2362), mussel communities are seen which appear to be almost natural, i.e. which are virtually unaffected by anthropogenic pertubations. Sadly, a little farther downstream, at a point about 5 miles east of the state boundary, mussel diversity crashes again. This is believed to be caused by pollution which periodically enters Little River at the point where the upstream end of the "old channel" begins, and which originates from Rolling Fork Creek. About 15 miles below that point (Station 2353) diversity begins to recover again, but immediately below Station 2353 the water backs up from Millwood Reservoir, lotic habitats give way to lentic, and riverine mussels such as Arcidens wheeleri cannot persist.

In summary, Little River supports healthy large-river mussel communities only in the reach which extends from the state boundary to about 5 miles east of the boundary. Within that reach the muddy-backwater-near-a-riffle habitats which are essential for Arcidens wheeleri were found to be well developed in the half-mile reach extending from 0.2 miles east, to 0.7 miles east, of the state boundary in Arkansas and this is where A. wheeleri was found. It is possible that A. wheeleri also occurs in other suitable habitats downstream to the vicinity of the upper effluent outlet of Rolling Fork Creek, for a total distance of about 5 river miles. Its population size in Little River is probably less than 100 individuals.

It is interesting to note that the sites which yielded A. wheeleri also harbored a rather large diversity of mussel species. Numbers of living species varied from eight to 14 (mean 11.6) and when species represented only as empty shells were added in, the totals ranged from 9 to 22 (mean 13.6). The species most commonly associated with A. wheeleri was Amblema plicata (Say), followed by Quadrula pustulosa (Lea), Actinonaias carinata (Barnes), and Potamilus purpurata (Lamarck). See Field Data Records for details.

4. Decline of Species and Habitat.

(a) Ouachita River

Old River, the type locality of Arcidens wheeleri, is now apparently devoid of mussels. In 1986 the lowermost lake of the series in Old River, which Reverend Wheeler had described in 1918 as a pristine and marvellously prolific mussel habitat, presented a tragic aspect indeed. A large tract along its south side was now a dump: expansive piles of trash littered the shore and extended far into the water and the entire water surface was covered with a thick, oily scum liberally sprinkled with floating cans, rotting garbage, and other debris. In 1987 the site had undergone partial restoration but the water was still obviously unfit for mollusks or for malacologists. The uppermost lake also exhibited pollution scum but since it did not cover

the whole surface, an effort was made to find mollusks. We found nothing, not even a fragment.

Although such gross pollution produces an environmental catastrophy, it should be pointed out that natural eutrophication would probably have been sufficient to drive most mussels, including Arcidens wheeleri, to extinction in Old River. In Wheeler's time some current was still apparent, sandbars still existed, and about 45 species of mussels lived in that series of river-lakes. Old River is now a chain of muddy, stagnant, semi-isolated pools, without any currents, and these pools are obviously unfit for any mussels except for those few species of Anodonta which can endure deep mud and low dissolved oxygen.

The situation is not hopeless, however. A large portion of the original fauna of Old River appears to have persisted in the large, muddy cove at the edge of the Ouachita River (Station 2352) into which the northern outlet of Old River still discharges. Although that cove does not now harbor A. wheeleri, it does appear to be ecologically suitable for it, and the cove might serve as a satisfactory site for transplant efforts involving A. wheeleri if such an activity is deemed desirable. In addition, a federally-listed endangered species, Lampsilis orbiculata (Hildreth), now lives in that cove and the site deserves federal protection on that score alone.

It should also be pointed out that the Ouachita River has now been impacted by several hydroelectric dams and artificial lakes. Recent field work by other collectors and by us, have failed to find A. wheeleri within its historically-documented range there, i.e. in the vicinity of Arkadelphia. It is possible that the species occurs elsewhere in the Ouachita River System or in other river systems nearby, but such an extensive search could not be done under this contract.

(b) Little River.

Our field work has shown that extensive beds of old, dead mussel shells containing many species occur at several sites below Pine Creek Reservoir (e.g. at stations 2356, 2358, 2367, and 2368). We believe that this was caused by cold hypolimnetic discharge from Pine Creek Dam. The living mussel fauna there is restricted principally to a very few old surviving specimens of Amblema plicata (a particularly hardy species) or of a few very young specimens which apparently represent the first tentative stages of new community recruitment following a crash. Much farther downstream, field work by Gordon and Harris in 1983 revealed several old empty shells of A. wheeleri in Little River at a site 4.0 miles NW of the US Highway 59/71 crossing of Millwood Lake in Little River County, Arkansas. That site was revisited by us (Station 2353). It is now in the early recovery phase following recent devastation believed to be pollution emanating from Rolling Fork Creek. A. wheeleri does not now occur there nor at other sites below the mouth of Rolling Fork Creek studied during this survey. According to other local sources the pollution in Rolling Fork Creek is from a creosote wood treatment plant located in or near DeQueen in Sevier County, Arkansas.

In addition to the harmful influence just mentioned, two other sources of possible environmental damage also exist. Sewage pollution from the city of Idabel, McCurtain County, Oklahoma is said to have been discharged into Mud Creek which in turn flows into the Little River, but this has been deemed a hazard to health and is now under litigation. A gravel dredging operation was also observed by me in August, 1987 in the Little River north of Goodwater, McCurtain County. Both of these harmful activities affect the Little River only a short distance upstream from the short reach where Arcidens wheeleri still manages to survive, and both activities should be curtailed.

(c) Kiamichi River

Except for the lower portion of the river which is now flooded by Hugo Reservoir, and the reach between that reservoir and Red River, the Kiamichi River is in remarkably good condition and its unique fauna, which includes Leptodea leptodon (a candidate species for possible endangered status) and many other species in addition to Arcidens wheeleri, is still healthy. No negative effects from discharge of Clayton Reservoir through Jack Fork Creek could be observed, and no significant municipal pollution from Clayton is evident.

Isely (1924:58) pointed out that the Kiamichi River "clearly stands apart from the rest" [of the rivers in southern Oklahoma] in having a uniquely diverse and abundant mussel fauna. At that time even the now federally-listed endangered species Potamilus capax occurred in the Kiamichi River at Roby, but unfortunately that site is now flooded by Hugo Reservoir. Isely believed that further exploration of the Little River would show that it also harbored an outstanding mussel fauna, but no extensive survey of the Little River fauna was ever made and no one ever knew what species might be wiped out by hypolimnetic discharge dams before it was too late. We are in a much better position with the Kiamichi. We now know that it is a national faunal treasure which must be preserved.

(5) Present Threats.

(a) Ouachita River.

As shown above, the Ouachita River near Arkadelphia, Arkansas apparently does not support A. wheeleri. At last one site (Station 2352) does harbor Lampsilis orbiculata, an endangered species, and also offers an apparently promising location for possible future propagation of A. wheeleri. Fortunately, the habitat is isolated and appears not to be threatened, but it should be periodically monitored to ensure its continued good condition.

(b) Little River.

Continued sewage pollution from Idabel and gravel dredging in the Little River north of Goodwater both pose immediate threats to the survival of the small population of Arcidens wheeleri which still exists in the Little River. Continued discharge of cold-hypolimnetic water from Pine Creek Reservoir, and periodic discharge of pollution into

Rolling Fork Creek also prevents that population from expanding its range beyond the five mile reach it still occupies. In addition, although the downstream effects of discharge from Broken Bow Reservoir appear not to have seriously harmed the fauna of Mountain Run Fork or of Little River below Mountain Run, the potential apparently exists for very serious damage, even to the point of wiping out Arcidens wheeleri in the Little River.

(c) Kiamichi River.

According to a 1984 publication by the State of Oklahoma, a man-made lake to be named Lake Tuskahoma is scheduled for construction for the Corps of Engineers. The dam would be located on the Kiamichi River SW of Albion in Pushmataha County and a lake would form whose surface area would be 11,600 acres.

That lake, if constructed, would flood a portion of the river now occupied by Arcidens wheeleri, (Station 2370) and perhaps other locations farther upstream which may support this species. It is reasonable to presume that downstream effects of the dam, especially the reduced temperature regime and increased siltation which would ensue would probably produce the same devastating effect that the Pine Creek Reservoir dam has produced the mussel fauna of the Little River.

We have pointed out previously that the Kiamichi River is not just any river. It is unique in that it supports the most species of unionid fauna in southern Oklahoma and one of the most diverse in the entire state. In addition to harboring Leptodea leptodon and other rare species it is also the only river in the world which supports a healthy population of Arcidens wheeleri. We urge, therefore, that the proposed Lake Tuskahoma either not be constructed at all, or at least that the dam not be constructed to produce hydroelectric power, since such use necessitates hypolimnetic discharge.

(6) Federal Activities.

We have already pointed out that the proposed Lake Tuskahoma on the Kiamichi River would negatively impact Arcidens wheeleri. We believe that A. wheeleri should be listed as an Endangered Species and that Lake Tuskahoma should probably not be built at this time. Other dam construction which might impact the small population of A. wheeleri in Little River, should also be prohibited.

(7) Taxonomic Considerations

Arcidens wheeleri was described under the name Arkansia wheeleri by Ortmann and Walker in 1912 and it was known under that name until 1980. In 1981 and 1985 I published parts 1 and 2 of a monograph on the Tribe Alasmidontini. No such comprehensive study had previously been done and therefore no sufficient basis had previously existed on which to make a coordinated re-evaluation of the generic and subgeneric categories contained therein or on which to reassign the species to those categories. Such re-evaluations were included in that monograph

and five genera were recognized, viz. Pegias, Alasmidonta, Arcidens, Lasmigona, and Simpsonaias. The genus-group name Arkansia was reassigned to subgeneric status under Arcidens.

The genus Arcidens now contains two species: Arcidens (Arcidens confragosus (Say, 1829) and Arcidens (Arkansia) wheeleri (Ortmann and Walker, 1912). Such an arrangement is consistent with the belief that A. wheeleri is more closely related to A. confragosus than is any other species and, by demonstrating relationship, it fulfills the primary role of taxonomy. Such as arrangement also has predictive value as demonstrated elsewhere in this report. The retention of the name Arkansia at the subgeneric level also emphasizes the fact that although A. wheeleri and A. confragosus are related, differences have also evolved which are of greater magnitude than exist between other species pairs in the Alasmidontini which are in the same subgenus elsewhere. Further details are given in the monograph cited above.

It is expected that some malacologists will resist this change. It should be kept in mind, however, that the reassignment of "Arkansia" wheeleri to Arcidens has value because it is based on a comprehensive biological evaluation. It is not simply the result of archaeological research in the literature or of arcane legalistic reasoning which serves no biological purpose.

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