FINAL REPORT

SECTION 6

ENDANGERED SPECIES ACT

FEDERAL AID PROJECT E-28

Status of Threatened and Endangered Fishes in Oklahoma

Status Survey of the Arkansas Darter in Eastern Oklahoma

JUNE 1, 1993 - DECEMBER 29, 1995

FINAL REPORT

STATE: OKLAHOMA PROJECT NUMBER: E-28

PROJECT TITLE: Status of Threatened and Endangered Fishes in Oklahoma

STUDY TITLE: Status Survey of the Arkansas Darter in Eastern Oklahoma

PERIOD COVERED: 23 September 1994 through 29 December 1995

ABSTRACT

During this survey, 163 fish collections were made with seines and bottom nets at 151 localities in a status survey of the Arkansas darter (*Etheostoma cragini*) in northeastern Oklahoma. Forty-three additional localities were visited, of which 16 were dry and 27 had no fish. Sampled localities were primarily sites considered likely to produce the darter. A total of 363 Arkansas darters were captured at 14 localities within the Neosho and Spring river drainages. Reconnaissance work immediately preceding this survey indicated the presence of the species in at least three other localities in the Neosho River drainage. Fifteen localities reported in this study are new distributional records for the darter, ten of which are on streams without previous records of the species in Oklahoma. The Arkansas darter may be extirpated from all but two of its 11 historical localities in eastern Oklahoma. The largest number of Arkansas darters examined at a single locality during the study was 132, although available habitat at the locality supported greater numbers than were captured. Arkansas darters were most abundant in spring runs, where individuals occupied a range of microhabitats. In larger streams, the darter inhabited sloughs, other backwaters, and pool margins. Favored sites had cool water, shallow depths, predominantly fine substrates, low flow velocities, and an abundance of watercress (*Nasturtium officinale*) and other aquatic vegetation. Twenty-nine other fish species were collected at Arkansas darter localities, 17 of which were taken in

microhabitats used by Arkansas darters. The orangethroat darter (*Etheostoma spectabile*), central stoneroller (*Campostoma anomalum*), and western mosquitofish (*Gambusia affinis*) occurred most abundantly with the Arkansas darter. Reservoir construction appears responsible for loss of suitable habitat at most historical localities. Data were collected on other continuing and potential threats and on microhabitats occupied by Arkansas darters. The number of populations in northeastern Oklahoma appears similar to the number reported historically, but occurrence is in different localities. The species appears stable in northeastern Oklahoma, but populations and habitat should be monitored periodically. Given the relatively small sizes of the spring runs supporting the densest populations, Arkansas darters may respond well to efforts to conserve existing habitats and to restore degraded ones.

I. OBJECTIVE:

To determine the current status of the Arkansas darter (*Etheostoma cragini* Gilbert) in eastern Oklahoma by 1) intensively sampling areas of known historic occurrence, 2) evaluating evidence of threats potentially affecting populations or habitats, and 3) using literature and museum records to document any trends of change in abundance.

II. INTRODUCTION:

The Arkansas darter (*Etheostoma cragini* Gilbert) is a small (SL$\leq$50mm) percid occurring as localized populations in the Arkansas River drainage from eastern Colorado through southern Kansas and northern Oklahoma into southwestern Missouri and northwestern Arkansas (Cloutman 1980, Pigg et al. 1985). Reductions and extirpations of local populations have occurred in Kansas and Colorado, primarily because of reduced flows

from the vegetated springs and seeps inhabited by the species (Cross et al. 1985, Woodling 1985). These losses are attributable to human withdrawal of large quantities of water, principally for irrigation (Cloutman 1980, Kuehne and Barbour 1983). Extant local populations in the western and central portions of the species' range are not secure because of continuing flow depletions (Cross et al. 1985, Pigg 1987).

Impoundments, stream channelization, livestock production, cultivation, and other factors have also modified spring and seep habitats to the extent that they may affect the species' distribution (Cross et al. 1985, Harris and Smith 1985, Pigg et al. 1985, Woodling 1985). The Arkansas darter may maintain healthy populations in the eastern portion of its range (Taber et al. 1986, Robison and Buchanan 1988, Pflieger 1992, Martinez et al. 1994). However, in eastern Oklahoma, a large majority of historical populations appear to have been eliminated (Martinez et al. 1994) and extant populations appear vulnerable to urban and rural developments. In general, factors limiting eastern populations of the species are less well understood than those limiting western populations.

The purpose of this continuation of the initial survey (Martinez et al. 1994) was to provide a more comprehensive view of the status of the Arkansas darter in northeastern Oklahoma and to assess threats to local populations. Such information is essential for future management decisions regarding this species. It was also intended to identify additional information needed for management, such as conservation practices that might restore suitable habitat at previously occupied sites. The survey will contribute toward completing the data base to be used in preparing a listing decision, given that the Arkansas darter is a federal candidate (formerly termed Category 1) species (USFWS 1996). It also provides a basis for monitoring future changes in distribution or abundance of the species.

III. METHODS AND MATERIALS

In the first project segment, we surveyed literature and museum collections to identify historical localities for the Arkansas darter in eastern Oklahoma (Martinez et al. 1994). Museum records revealed no additional Oklahoma localities beyond those identified in the literature review. We contacted selected researchers involved in recent or historical fish collecting efforts for information on possible unpublished records or to clarify historical localities. During the second segment, additional researchers who had not been reached initially (James Schooley, Northeastern State University; Don Caskey and Mark Grigsby, Northeastern Oklahoma A & M College) were contacted; this confirmed a lack of additional records or museum specimens.

During the first project segment, we surveyed 137 localities for Arkansas darters and referenced collections from 28 localities made in 1992 and 1993 as part of reconnaissance work preceding the project. However, not all localities identified for surveying were sampled (including several with limited access and unknown ownerships), and we recommended continued work to sample those localities (Martinez et al. 1994). In this project segment, we spent additional time researching and contacting landowners. During this second segment, we surveyed 57 additional localities.

Throughout the two segments and the preceding reconnaissance, localities were selected using the following criteria: (1) historical localities, (2) other likely localities, based on habitat and proximity to historical localities or adjacent state populations (e.g., in the Illinois and Spring river drainages), (3) springs identified on USGS 1:24,000 topographic maps (there are 117 such springs north and east of the Arkansas River in Oklahoma), and (4) other localities representing conditions of interest. Primary emphasis was directed at or near known localities of prior occurrence of the species. The Illinois and Spring river drainages in

Oklahoma were included despite the lack of historical records of occurrence, because the species is known from those drainages in, respectively, Arkansas and Missouri (Harris and Smith 1985, Taber et al. 1986, Robison and Buchanan 1988, Pflieger 1992).

We sampled primarily with small seines (mainly a 3.7-m x 1.2-m, 3.2-mm Delta-mesh, heavily-leaded seine) at stream localities. A bottom, aquatic kick-net (45.7 cm x 20.3 cm x 25.4 cm, 0.9-mm x 0.8-mm mesh) was used at spring localities too small to be effectively sampled by seines. Samples of fishes for the distributional survey were collected over a period of about 20 minutes sampling time. A variety of aquatic habitats at each locality were sampled, with emphasis on typical Arkansas darter habitat. All fishes except Arkansas darters were routinely preserved in 10% formalin and returned to the lab for identification and enumeration. Arkansas darters were counted, measured, and released alive at each collection site except for voucher samples of up to five specimens. Where large numbers of associated fish species were encountered, representative series of those species were preserved and the remainder released after identification and enumeration. At each locality, records were made of general habitat conditions as well as human land-use activities adjacent to the site.

A number of localities were sampled more than once. At historical and current localities, a habitat sampling procedure was usually performed in addition to the distributional sampling. Habitat sampling involved collecting fish from 2-m^2 areas of uniform microhabitat type, using an approach very similar to that described by Ross et al. (1992). In swift waters, microhabitat sites were sampled using kick-sets; otherwise, the nets were normally pulled across the sites. Fish collected within each microhabitat site (seine haul) were kept separate and the following habitat variables were measured: water temperature, dissolved oxygen, pH, conductivity, turbidity, alkalinity, total hardness, depth, dominant and subdominant substrata,

substratum penetration, water velocity, canopy cover, shading, vegetation, bank distance, and bank slope. For water quality parameters other than temperature, samples were secured in the field and analyzed immediately upon return to the lab. Dissolved oxygen was normally measured with a YSI Model 54 oxygen meter; other water quality parameters were measured with a Hach DREL/5 Portable Laboratory. Substratum penetration was measured as the average penetration into the substratum of a wooden rod having a cross-sectional area of 6.4 cm^2. A standardized force of 12 kg was applied by pulling down on a spring balance mounted at the top of the rod. We determined water velocity with a Marsh-McBirney Model 201 current meter.

We evaluated relationships among fish species abundances and habitat measurements obtained at localities inhabited by Arkansas darters by using multivariate analysis techniques. Canonical Correspondence Analysis (CCA) is a direct gradient analysis technique and belongs to the Correspondence Analysis family of ordination methods (Ter Braak and Prentice 1988). We used a stepwise CCA to identify an informative subset of the parameters recorded in habitat sampling. In both the stepwise selection of variables and resulting CCA, we used a square root transformation of the data to dampen the effect of extreme abundance values in some samples. We used a $p \leq 0.15$ as our cutoff point for inclusion of a variable in the resulting partial CCA. "P-values" in stepwise procedures are not valid for such purposes as hypothesis testing, but are acceptable and informative within exploratory analyses.

IV. RESULTS:

DISTRIBUTION

Historical (i.e., pre-1992) records of the Arkansas darter consist of 11 localities in eastern Oklahoma (Figure 1, Table 1). Original workers varied in the precision by which they

described historical localities, and in a few cases (e.g., sites 5, 6, and 10) the precise locations are approximations. All historical records of the species in eastern Oklahoma are from eastern tributaries of the Neosho River, except for one record from the drainage of Big Cabin Creek, a western tributary of the river (Matthews et al. 1985). As Blair (1959) observed about localities known at the time, most historical localities are close to the mainstem of the Neosho River.

During the second survey segment, fish were collected at 46 of 58 selected localities (three were dry and nine had water but no fish were found). Data collected in an equivalent manner included first-segment fish collections from 105 of 137 localities and reconnaissance fish collections from 28 of 36 localities. Some localities were sampled more than once during or among years. Combined, the sampling efforts provide data on 191 recent fish collections from 172 localities in northeastern Oklahoma (Appendices A and B).

Arkansas darters were collected at three localities (sites 15-17, Table 2) during the second survey segment. Survey work in the preceding segment and reconnaissance found Arkansas darters at 14 additional localities (sites 1-14, Table 2). These data provide evidence of Arkansas darters at 17 localities in 11 streams in eastern Oklahoma. The streams include the following: (i-iv) Fivemile Creek, Warren Branch, Flint Branch, and Lost Creek, all eastern tributaries to the Spring River, itself an eastern tributary to the Neosho River, all in Ottawa County, (v-vi) Rock Branch and Little Fivemile Creek, both tributaries of Fivemile Creek in the Spring River drainage, also in Ottawa County, (vii) Council Hollow Creek, an eastern tributary of the Neosho River in Ottawa County, (viii) Locust Creek, tributary to Big Cabin Creek, a western tributary of the Neosho River, in Craig County, (ix) Spring Creek, an eastern tributary of the Neosho River in Mayes County, (x) Snake Creek, a tributary of Spring Creek in Mayes

County, and (xi) Fourteenmile Creek, an eastern tributary of the Neosho River in Cherokee County.

Fifteen of the combined localities are new distribution records and ten are on streams having no previous records of the species in Oklahoma. The Arkansas darter was taken at only two localities of historical occurrence (sites 7 and 11, Table 1), despite the fact that sampling was performed at or very near all but one (site 2) of the historical localities. Four localities presently inhabited (sites 1, 3, 4, and 14, Table 2) are relatively close (within 1-2 stream miles) to historical localities. Other inhabited localities included six in the Spring River drainage, a system where there were no historical Oklahoma records of the species. No Arkansas darters were found in the Illinois River system in Oklahoma, despite sampling from 42 localities (Nos. 131-174, Appendix A) in the River drainage.

Collections included 203 Arkansas darter specimens preserved as vouchers for the survey. Voucher specimens were preserved from each locality visit where Arkansas darters were found, including 16 occasions where distributional sampling was performed and 11 occasions where habitat sampling was performed (the latter representing 58 microhabitat sites). All Arkansas darter voucher specimens will be deposited in the Collection of Vertebrates at Oklahoma State University. Procedures to accomplish this are underway, and should be completed shortly.

ABUNDANCE

Literature records of the Arkansas darter vary in quality of information (Table 1). For some, numbers of specimens were reported by locality, in others numbers were totaled for all collections, and in still others no numbers were reported. Reports of Arkansas darters commonly vary from high concentrations in optimum habitat to small numbers in limited or suboptimum habitats.

In the second survey segment, 29 Arkansas darters were found among the three newly discovered localities, 15 being the highest number captured at a single locality (Table 3). This compares to the first segment's findings of 346 Arkansas darters among 14 inhabited localities, 132 of which were captured at a single locality. Numbers collected were similar to those reported elsewhere historically (Table 1), although comparisons are difficult because of differences in sampling effort and locations. At most of our inhabited localities, suitable habitat extended beyond the area sampled, and additional Arkansas darters were often seen (but not captured and examined). We are confident in estimating Arkansas darter populations at the springs and spring-fed creeks with more extensive and suitable habitat as ranging from a few hundred individuals to more than 1,000. Lower, but substantial population densities occur at the stream localities in the Spring River drainage, except in Lost Creek, where the population may be more limited.

HABITAT

Microhabitat sampling was performed at only one additional locality during this survey segment. This is because considerable data, not yet thoroughly evaluated, were available from microhabitat sampling performed during the first survey segment. That data represented 26 localities, including 8 historical, 11 current, 1 both historical and current, and 6 comparison localities. The locality sampled in the second survey segment (site 15, Table 2) is a presently occupied, previously unknown locality of occurrence. Microhabitat sampling was not performed at one locality (historical site 11, current site 2) because the landowner no longer permits sampling of the spring. At another locality (current site 14), a single Arkansas darter was collected from uncertain habitat. We returned and searched an extensive reach of the creek but found no additional specimens. We concluded that the locality had little habitat of suitable quality for the species. Microhabitat sampling was not performed at two additional

localities (sites 16 and 17, Table 2) because they were discovered late in the project period and timely arrangements could not be made with landowners.

The Arkansas darter is generally characterized as inhabiting seeps, springs, and spring-fed streams containing watercress or other aquatic plants (Cloutman 1980, Kuehne and Barbour 1983, Page 1983). For localities in northeastern Oklahoma, Arkansas darters were most abundant in characteristic habitats. Considering data from both survey segments, greatest numbers of Arkansas darters occurred in spring runs, where individuals were found in a range of available microhabitats. Arkansas darters found in larger streams were collected from sloughs, other backwaters, and pool margins, similar to observations reported for Missouri populations (Pflieger 1992).

Favored sites typically exhibited cool water temperatures, shallow depths, substrates with fine particles, low flow velocities, and an abundance of watercress and other aquatic vegetation (Table 4). Measured chemical parameters were consistently within moderate ranges and appeared to correlate little with distribution.

A total of 62 fish species were collected during the survey (Appendix B). Twenty-eight fish species were collected with the Arkansas darter (Table 3). Seventeen of these species were taken in seine hauls that also contained Arkansas darters, indicating some degree of microhabitat overlap. Species collected most abundantly with the Arkansas darter included the orangethroat darter, *Etheostoma spectabile*, central stoneroller, *Campostoma anomalum*, and western mosquitofish, *Gambusia affinis*. Sampling of four localities inhabited by Arkansas darters included dates when no *E. cragini* were collected. Although not included in Table 3, such collections identified one additional species (*Etheostoma gracile*) inhabiting the localities where Arkansas darters were found.

The Oklahoma Department of Wildlife Conservation specifically requested information on any Oklahoma salamanders (*Eurycea tynerensis*) found during sampling. None of the mature salamanders nor identifiable larval salamanders collected during the survey were found to be *E. tynerensis*.

The habitat variables retained in the CCA were (1) dissolved oxygen concentration, (2) silt as the dominant substrate material, (3) coarse gravel as the subdominant substrate material, (4) live vegetation as the subdominant substrate material, and (5) partial shading. Species scores and locality/habitat scores on the first and second axes are shown in Figures 2A and 2B, respectively. Members of three species pairs (*Ambloplites rupestris* and *Catostomus commersoni, Etheostoma whipplei* and *Fundulus notatus*, and *Ameiurus natalis* and *Lepomis megalotis*) and one species triad (*Fundulus catenatus*, *Micropterus salmoides*, and *Etheostoma blennioides*) had identical plot coordinates.

Axes for the CCA plots are linear combinations of the environmental variables. The plotted scores and arrows depict relationships among species abundances, habitat variables, and sampling localities. Vectors of individual environmental variables actually extend in each direction beyond the arrow segments shown. The lengths and endpoints of the arrow segments indicate the relative importance and direction of the variables' influence within CCA axes 1 and 2.

Summary statistics of the CCA are presented in Table 5. About 72% of total variance in the spread of species scores was "explained" by the selected environmental variables. Because stepwise procedures attempt to seek out optimum solutions, it is common for models guided by such procedures to "explain" very high proportions of variation (Draper and Smith 1981). Eigenvalues of the first two CCA axes are, however, large enough to suggest biologically meaningful gradients. Our selected environmental variables had fairly low inflation

factor scores (less than 6). Increasing size of such scores (above 1) indicates redundancy among variables, and a reduced ability to relate variation confidently to a single variable.

The CCA results indicate that Arkansas darters are both ecologically specialized yet tolerant of certain habitat gradients in northeastern Oklahoma. We resolved two primary environmental vectors: Axis 1 was associated with presence of coarse gravel or live plants as the subdominant substratum material. Axis 2 was associated with dissolved oxygen concentrations, live plants as the subdominant substratum material, and silt as the dominant substratum material. Axis 1 represents a gradient from streams and fishes typical of the Ozarks into streams and associated fishes typical of the Great Plains. Species essentially restricted to the Ozarks in Oklahoma had low scores on this axis; these included *Ambloplites rupestris, Catostomus commersoni, Cottus carolinae, Nocomis asper, Luxilis cardinalis, Phoxinus erythrogaster, Semotilus atromaculatus, Notropis nubilis, Fundulus catenatus*, and *Etheostoma blennioides*. Species with higher scores on Axis 1 (*Etheostoma cragini, Fundulus notatus, Etheostoma whipplei, Lepomis cyanellus*, and *Gambusia affinis*) occur in Ozark streams, but also thrive in prairie streams to the west. The plots of habitat variables are concordant with this interpretation; e.g., in Ozark streams, coarse gravel is more likely to be dominant rather than subdominant, and in prairie streams aquatic vegetation is more likely to grow extensively.

The second axis represents a gradient from deeper, downstream environments to shallower, headwater environments. Species with low scores on this axis (e.g., *Micropterus salmoides, Fundulus catenatus, Etheostoma blennioides, Ameiurus natalis*, and *Lepomis megalotis*) are most typically found in larger waters downstream from the headwaters. Species with higher scores (*Phoxinus erythrogaster, Semotilus atromaculatus, Campostoma anomalum, Luxilis cardinalis, Etheostoma cragini*, and *Etheostoma punctulatum*) regularly

ascend upstream into small brooks. A headwater-to-downstream gradient would be expected in both Ozark and Plains streams.

Some of the species near the center of the plot, notably *Gambusia affinis, Lepomis cyanellus*, and *Etheostoma spectabile*, are habitat generalists. The Arkansas darter's habitat specialization shows up in its relative isolation in the species plot, lying close to the vector for aquatic plants as subdominant substrate material. Arkansas darter abundance is closely centered around its optimum environments (spring runs with aquatic vegetation), and outside of them, its numbers drop off quickly.

THREATS

Most surveyed localities exhibited chronic disturbances, but little evidence of new or impending disturbances that might affect existing Arkansas darter populations. At least five, and probably six historical localities (sites 1, 2, 4, 6, 8, and 9, Table 1) are flooded periodically or permanently by major impoundments. Stream conditions still exist at or near five of these, but produced no Arkansas darters in our survey. One (site 16, Table 2) of the 17 localities currently inhabited is probably affected by a major impoundment, at least occasionally. Other prevalent disturbances included roads (present at historical localities 3-11 and all current localities except 4 and 16) and cattle grazing (present at historical localities 3, 5, 7, and 8 and current localities 1-3, 5-9, 11-13, and 15). The highest density of Arkansas darters ($36/m^2$) was found at a locality (current site 4) where neither roads nor grazing were adjacent to the site. Clearing of terrestrial vegetation from the general vicinity of the stream was evident at most historical localities (sites 1, 3, 5, 8, 10, and 11) and current localities (sites 2-15 and 17). Evidence of grading or other earthwork in or adjacent to the stream was observed at historical sites 3 and 9 and current sites 9 and 12. Three historical localities (5, 6, and 10) appeared vulnerable to periodic desiccation.

During this second study segment, conditions suitable for Arkansas darters deteriorated further at the historical localities in Snake Creek (sites 3 and 7). During the summer of 1995, we noticed that a beaver had dammed the slough just west of State Highway 82, creating deeper, less spring-like conditions. More significantly, the highway is being reconstructed to four lanes between Locust Grove and Tahlequah, including its crossings of Snake and Spring creeks. Bridge and highway reconstruction at the Snake Creek crossing was observed to have greatly disturbed the creek and slough in September 1995. Our sampling had not shown large numbers of Arkansas darters persisting at those sites; however, they have been regarded by Oklahoma ichtyologists as perhaps the most reliable sources of Arkansas darters over time. In addition, the Snake Creek slough at S.H. 82 is one of the few locations from which the plains topminnow, *Fundulus sciadicus*, has been reported for Oklahoma. Although road and bridge reconstruction have greatly modified the former conditions at this site, the S.H. 82 crossing is one significant location where restoration of historical habitat and populations could be tested.

V. DISCUSSION:

The Arkansas darter is maintaining populations at a number of localities in the Neosho and Spring river drainages in northeastern Oklahoma. Those localities generally are not the exact localities of historical occurrence in the area. The discovery of the species in Spring River and new localities in the Neosho River drainage cannot be attributed to a lack of previous surveys because the area has been sampled intensively in prior surveys for small stream fishes (e.g., Blair 1959 and Branson 1967). Populations found were similar in size to numbers reported historically. The species presently appears stable in northeastern Oklahoma, but should be monitored periodically.

Major impoundments now cover or influence at least 5 of the 11 historical localities for the Arkansas darter in eastern Oklahoma. The species is adapted to a specialized habitat quite unlike conditions in large impoundments, and all evidence indicates the species does not inhabit reservoirs. Impoundment eliminated the species from the only known Elk River locality in Oklahoma (site 1, Table 1), and no Arkansas darters have been found at Elk River localities in adjacent Missouri (Pflieger 1992). Other prominent anthropogenic factors prevalent at localities sampled during the two survey segments included roads and livestock production. Arkansas darters inhabited several localities where one or both of these factors were present and influenced the stream environment. However, active road and bridge construction clearly altered former Arkansas darter habitat at one locality, at least temporarily. In addition, cattle concentrations visibly affected natural conditions at some surveyed localities, especially by trampling, increased turbidity, and waste contribution to small springs. In most cases, the effects of roads and livestock production may be reflected in such aspects as Arkansas darter abundance and condition, rather than presence at a site. Furthermore, the significance of these effects probably relates to such considerations as time since completion of construction, road construction practices used, intensity of livestock use, and land/animal management practices used by livestock owners. As a final human factor, minor channel modifications were commonly observed in portions of the study area, especially Ottawa County. These modifications included small rock dams across streams, stream meander bypasses, channel straightenings, gravel excavation, and impoundment of stock ponds. The effects of these modifications on the Arkansas darter are probably variable, and related to size, age, and frequency of the modifications. In terms of natural threats, conditions observed during this study agree with Blair's (1959) statement that some Arkansas darter habitats are particularly vulnerable to drying, causing elimination or relocation of local populations. Should drought (or

other factors) eliminate stream populations, the presense of impoundments would impede recolonization from remaining populations.

We identified 7 localities on streams with previous Arkansas darter records and 10 localities on streams with no previous records in Oklahoma. The populations on known streams, while perhaps not significant biogeographic additions, are important to interests in conserving Arkansas darters in Oklahoma and understanding their population dynamics. In addition, because the centers of Arkansas darter reproduction and abundance are relatively small, it may be relatively feasible to reclaim suitable conditions for Arkansas darters at localities not impaired by major impacts.

VI. CONCLUSIONS:

1. The Arkansas darter may be extirpated from 9 of 11 historical localities in eastern Oklahoma.

2. The species presently exists at 17 localities on 11 streams in eastern Oklahoma: (i) Fivemile Creek, in Ottawa County, (ii) Little Fivemile Creek, in Ottawa County, (iii) Rock Branch, in Ottawa County, (iv) Warren Branch, in Ottawa County, (v) Flint Branch, in Ottawa County, (vi) Lost Creek, in Ottawa County, (vii) Council Hollow Creek, in Ottawa County, (viii) Locust Creek, in Craig County, (ix) Spring Creek, in Mayes County, (x) Snake Creek, in Mayes County, and (xi) Fourteenmile Creek, in Cherokee County.

3. The species maintains populations in northeastern Oklahoma similar to numbers reported historically, but in different specific localities.

4. Arkansas darters were most abundant in habitats previously described as characteristic for the species (e.g., vegetated spring runs and pools). Canonical

Correspondence Analysis effectively summarized some of the most important structural features and relationships among stream components where Arkansas darters were found.

5. Reservoir construction is the primary factor responsible for loss of suitable Arkansas darter habitat at historical localities.

VII. RECOMMENDATIONS:

1. Periodically monitor the status and condition of localities found to be inhabited by Arkansas darters. A significant decline in the populations at these localities and other portions of the species' range might indicate a need for federal listing of the species.

2. Protect populations and habitat at presently inhabited localities, to the extent possible with existing conservation programs.

3. Identify proposed development projects in northeastern Oklahoma that may affect suitable habitat for the Arkansas darter.

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LITERATURE CITED

Blair, A.P. 1959. Distribution of the darters (Percidae, Etheostomatinae) of northeastern Oklahoma. Southwest. Nat. 4(1):1-13.

Blair, A.P. and J. Windle. 1961. Darter associates of *Etheostoma cragini* (Percidae). Southwest. Nat. 6(3,4):201-202.

Branson, B.A. 1967. Fishes of the Neosho River system in Oklahoma. Amer. Midl. Nat. 78(1):126-154.

Cloutman, D.G. 1980. *Etheostoma cragini* Gilbert Arkansas darter. Page 639 In: D.S. Lee, C.R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. McAllister, and J.R. Stauffer, Jr. (eds.). Atlas of North American freshwater fishes. North Carolina State Mus. Nat. Hist., Raliegh, NC, x + 854 p.

Cross, F.B., R.E. Moss, and J.T. Collins. 1985. Assessment of dewatering impacts on stream fisheries in the Arkansas and Cimarron Rivers. Kansas Fish and Game Com., Nongame Wildl. Contract #46, 161 p.

Draper, N.R. and H. Smith. 1981. Applied regression analysis. 2nd ed. John Wiley, New York, NY, 709 p.

Harris, J.L. and K.L. Smith. 1985. Distribution and status of *Etheostoma cragini* Gilbert and *E. microperca* Jordan and Gilbert in Arkansas. Ark. Acad. Sci. 39:135-136.

Kuehne, R.A. and R.W. Barbour. 1983. The American darters. Univ. Kentucky Press, Lexington, KY, v + 177 p., 24 pl.

Martinez, D., W.L. Fisher, and A.A. Echelle. 1994. Status survey of the Arkansas darter in eastern Oklahoma. Final rep., Endangered Species Project E-28-1, Oklahoma Department of Wildlife Conservation, Oklahoma City, OK, 24 p.

Matthews, W.J., J.J. Hoover, and W.B. Milstead. 1985. Fishes of Oklahoma springs. Southwest. Nat. 30(1):23-32.

McNeely, D.L. 1986. Longitudinal patterns in the fish assemblages of an Ozark stream. Southwest Nat. 31(3):375-380.

Moore, G.A. and F.B. Cross. 1950. Additional Oklahoma fishes with validation of *Poecilichthys parvipinnis* (Gilbert and Swain). Copeia 1950(2):139-148.

Page, L.M. 1983. Handbook of darters. TFH Publications, Inc., Neptune City, NJ, 271 p.

Pflieger, W.L. 1992. Distribution and status of the Arkansas darter (*Etheostoma cragini*) in Missouri. Final report, Endangered Species Project SE-01-22, Missouri Department of Conservation, Jefferson City, MO, iii + 22 p.

Pigg, J. 1987. Survey of fishes in the Oklahoma Panhandle and Harper County, northwestern Oklahoma. Proc. Okla. Acad. Sci. 67:45-59.

Pigg, J., W. Harrison, and R. Gibbs. 1985. Records of the Arkansas darter, *Etheostoma cragini* Gilbert, in Harper and Beaver Counties in Oklahoma. Proc. Okla. Acad Sci. 65:61-63.

Robins, C.R., R.M. Bailey, C.E. Bond, J.R. Brooker, E.A. Lachner, R.N. Lea, and W.B. Scott. 1991. Common and scientific names of fishes from the United States and Canada. 5th ed. American Fisheries Society, Spec. Publ. 20, Bethesda, MD, vi + 183 p.

Robison, H.W., and T.M. Buchanan. 1988. Fishes of Arkansas. Univ. Arkansas Press, Fayetteville, AR, xviii + 536 p.

Ross, S.T., J. G. Knight, and S.D. Wilkins. 1992. Distribution and microhabitat dynamics of the threatened bayou darter, *Etheostoma rubrum*. Copeia 1992(3):658-671.

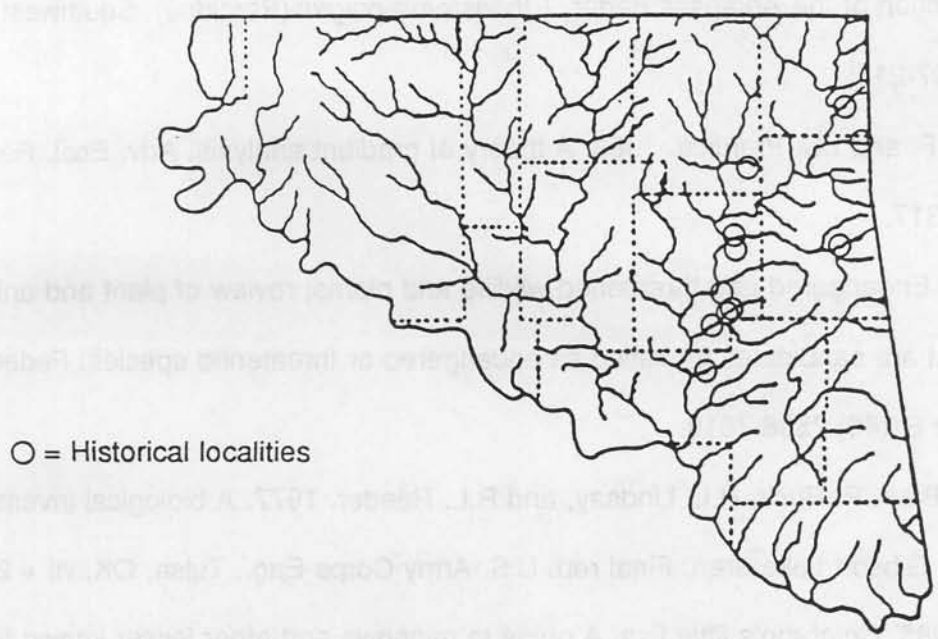
Taber, C.A., B.A. Taber, and M.S. Topping. 1986. Population structure, growth and reproduction of the Arkansas darter, *Etheostoma cragini* (Percidae). Southwest. Nat. 31(2):207-214.

Ter Braak, C.J.F. and I.C. Prentice. 1988. A theory of gradient analysis. Adv. Ecol. Research 18:271-317.

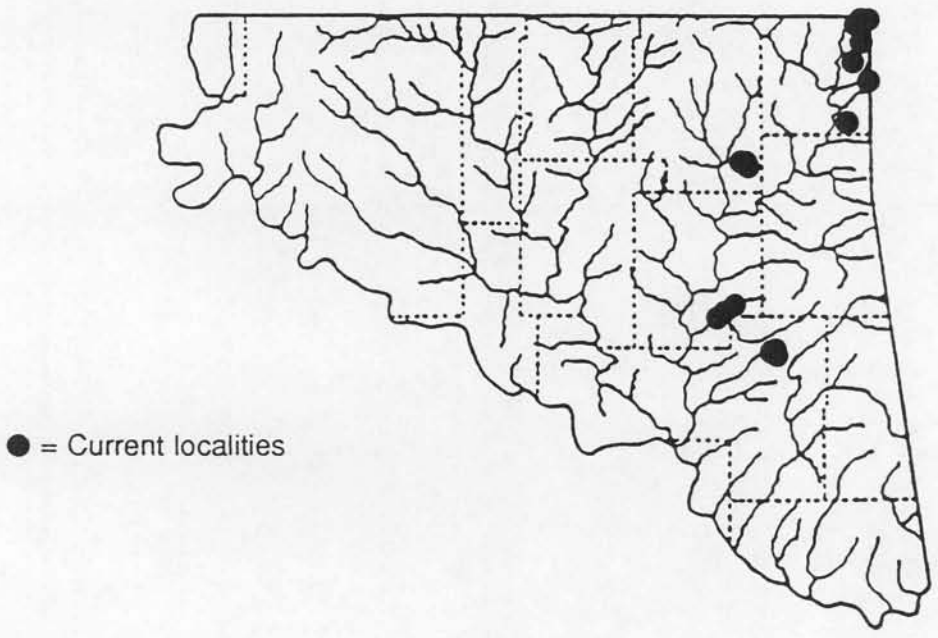
USFWS. 1996. Endangered and threatened wildlife and plants; review of plant and animal taxa that are candidates for listing as endangered or threatened species. Federal Register 61(40):7596-7613.

Vial, J.L., A.P. Blair, P. Buck, H.L. Lindsay, and R.L. Reeder. 1977. A biological inventory of the Fort Gibson Lake area. Final rep. U.S. Army Corps Eng., Tulsa, OK, vii + 253 p.

Woodling, J. 1985. Colorado's little fish. A guide to minnows and other lesser known fishes in the state of Colorado. Colo. Div. Wildl., Denver, CO, iv + 77p.



○ = Historical localities



● = Current localities

Figure 1. Distributional records of the Arkansas darter in northeastern Oklahoma (modified from Blair 1959).

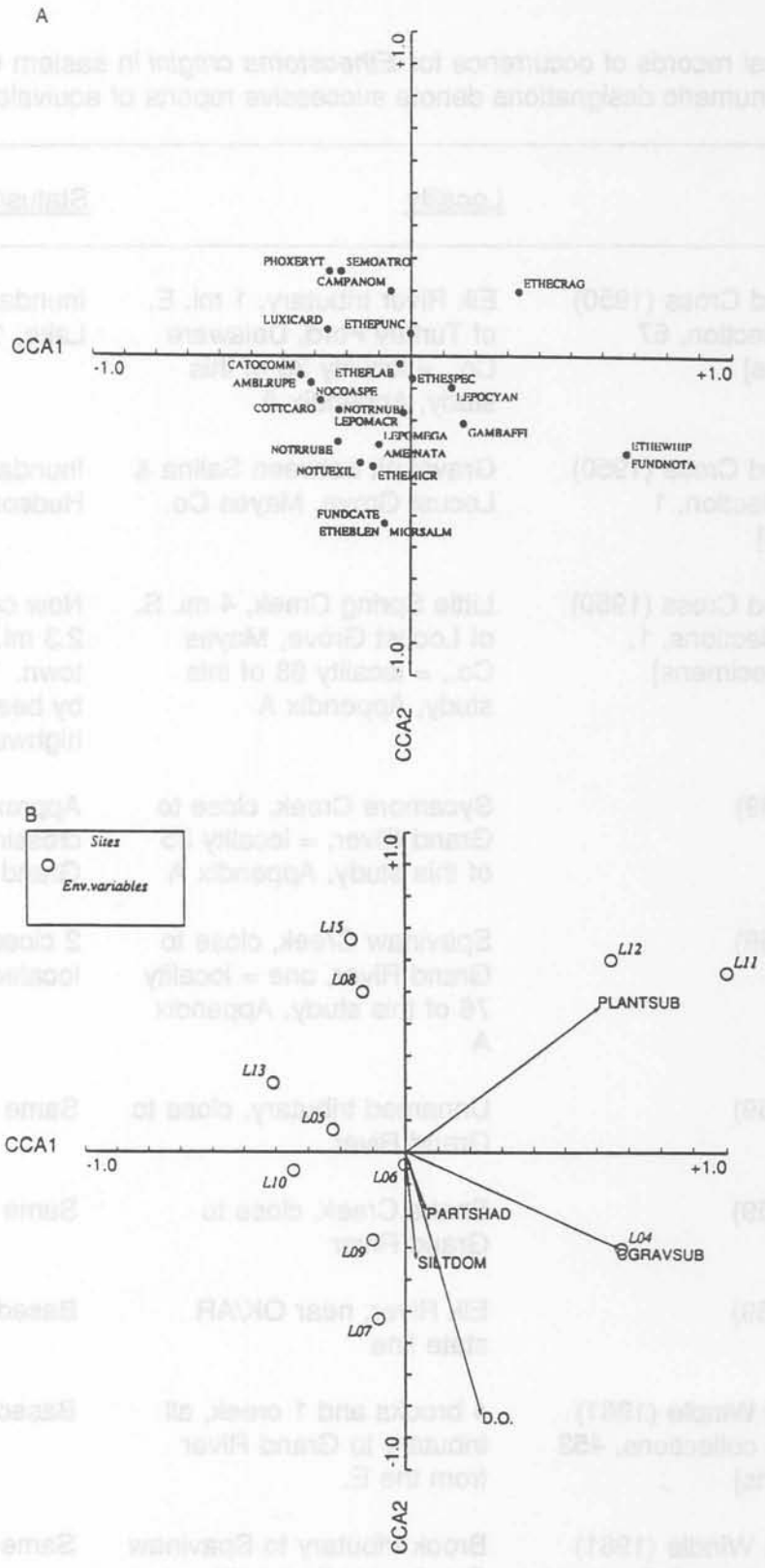


Figure 2. Scatterplot of species scores (A) and biplot of locality scores and habitat variables (B) from the first two CCA axes. Locality numbers are as listed in Table 2. Habitat variables are as described in the text (cf. METHODS AND MATERIALS) and listed in Table 4.

Table 1. Historical records of occurrence for *Etheostoma cragini* in eastern Oklahoma. Letters following numeric designations denote successive reports of equivalent localities.

Site No.	Source	Locality	Status/Comment
1.	Moore and Cross (1950) [1940 collection, 67 specimens]	Elk River tributary, 1 mi. E. of Turkey Ford, Delaware Co., = locality 38 of this study, Appendix A	Inundated by Grand Lake, 1940
2.	Moore and Cross (1950) [1948 collection, 1 specimen]	Gravel pit between Salina & Locust Grove, Mayes Co.	Inundated by Lake Hudson, 1964
3.	Moore and Cross (1950) [1949 collections, 1, 6, & 5 specimens]	Little Spring Creek, 4 mi. S. of Locust Grove, Mayes Co., = locality 98 of this study, Appendix A	Now called Snake Creek, 2.3 mi. S. of relocated town. Degraded recently by beaver damming and highway reconstruction
4.	Blair (1959)	Sycamore Creek, close to Grand River, = locality 35 of this study, Appendix A	Approx. OK Hwy 10 crossing; influenced by Grand Lake
5-6.	Blair (1959)	Spavinaw Creek, close to Grand River, one = locality 76 of this study, Appendix A	2 closely placed records located on this creek
2a.	Blair (1959)	Unnamed tributary, close to Grand River	Same as No. 2
3a.	Blair (1959)	Snake Creek, close to Grand River	Same as No. 3
1a.	Blair (1959)	Elk River, near OK/AR state line	Based on No. 1
1-6b.	Blair and Windle (1961) [1948-55 collections, 453 specimens]	4 brooks and 1 creek, all tributary to Grand River from the E.	Based on Nos. 1-6
5-6c.	Blair and Windle (1961) [1960 capture, 2-3 specimens]	Brook tributary to Spavinaw Creek near its mouth	Same as No. 5 or 6

Table 1 (continued).

Site No.	Source	Locality	Status/Comment
3c.	Blair and Windle (1961) [1961 capture]	Brook tributary to Little Spring Creek near OK Hwy 82	Same as No. 3
7.	Branson (1967) [1956 collection]	Little Spring Creek .25 mi. below U.S. 82 bridge, Mayes Co., = locality 99 of this study, Appendix A	Just downstream of No. 3
1c.	Branson (1967)	Elk River, 1 mi. E. of Turkey Ford, Delaware Co.	Based on No. 1
2c.	Branson (1967)	Gravel pit between Salina & Locust Grove	Based on No. 2
3d.	Branson (1967)	Little Spring Creek, 4 mi. S. of Locust Grove	Based on No. 3
1-6e.	Branson (1967)	1 locality in Ottawa Co., 1 in Delaware Co., & 4 in Mayes Co.	Based on Nos. 1-6
5-6f	Branson (1967)	Spavinaw Creek tributary, near mouth, Delaware Co.	Based on Nos. 5-6c
3f.	Branson (1967)	Little Spring Creek tributary, near OK Hwy 82	Based on No. 3c
8.	Vial et al. (1977) [1977 collection, 14 specimens]	Spring Creek, just above Cedar Crest, = locality 103 of this study, Appendix A	Influenced by Fort Gibson Lake
9.	Vial et al. (1977) [1977 collection, 13 specimens]	Clear Creek, elev. 558-562, Cherokee Co., = locality 104 of this study, Appendix A	Influenced by Fort Gibson Lake
10.	Matthews et al. (1985) [1981/82 collection]	Unnamed spring, Sec.29 T22N R24E, Delaware Co., = localities 66-67 of this study, Appendix A	

Table 1 (continued).

Site No.	Source	Locality	Status/Comment
11.	Matthews et al. (1985) [1981-82 collections]	Unnamed spring, Sec.11 T24N R21E, Craig Co., = locality 42 of this study, Appendix A	
3G.	McNeely (1986) [1980 collection, 1 specimen]	Snake Creek, Mayes Co.	Same as No. 3

Table 2. Localities of occurrence for *Etheostoma cragini* in eastern Oklahoma during this study.

Site No.	Description	Dates Surveyed
1.	Snake Creek, 1/4 mi. downstream from OK Hwy 82, Mayes Co., SW 1/4, SE 1/4, Sec. 34, T20N, R20E, IM. Same as historical locality No. 7; locality 99 in Appendix A	22 AUG 1992 24 JUL 1993 19 SEP 1993
2.	Spring run, unnamed tributary of Locust Creek, Craig Co., NE 1/4, SE 1/4, Sec. 10, T24N, R21E, IM. Same as historical locality No. 11; locality 42 in Appendix A	3 OCT 1992
3.	Unnamed tributary of Locust Creek, Craig Co., NW 1/4, NW 1/4, Sec. 10, T24N, R21E, IM; locality 44 in Appendix A	3 OCT 1992 18 SEP 1993
4.	Unmapped spring, unnamed tributary of Locust Creek, Craig Co., NE 1/4, SW 1/4, Sec. 10, T24N, R21E, IM; locality 43 in Appendix A	2 OCT 1993
5.	Flint Branch, Ottawa Co., SE 1/4, SE 1/4, Sec. 25, T28N, R24E, & SW 1/4, SW 1/4, Sec. 30, T28N, R25E, IM; locality 22 in Appendix A	10 OCT 1993 13 NOV 1993
6.	Warren Branch, Ottawa Co., SE 1/4, SE 1/4, Sec. 31, T29N, R25E, IM; locality 20 in Appendix A	10 OCT 1993 18 NOV 1993
7.	Fivemile Creek, Ottawa Co., SW 1/4, SW 1/4, Sec. 18, T29N, R25E, IM; locality 13 in Appendix A	10 OCT 1993 9 NOV 1993
8.	Little Fivemile Creek, Ottawa Co., NE 1/4, SE 1/4, Sec. 26, T29N, R24E, IM; locality 14 in Appendix A	10 OCT 1993 13 NOV 1993
9.	Rock Branch, Ottawa Co., SE 1/4, NE 1/4, Sec. 20, T29N, R25E, IM; locality 12 in Appendix A	10 OCT 1993 9 NOV 1993
10.	Lost Creek, Ottawa Co., SW 1/4, NW 1/4, Sec. 9 T27N, R25E, IM; locality 24 in Appendix A	1 DEC 1993 19 MAR 1994
11.	Unnamed spring run, Delaware Co., C, NE 1/4, Sec. 21, T18N, R22E, IM; locality 106 in Appendix A	12 DEC 1993 19 FEB 1994
12.	Unnamed spring run, Delaware Co., SE 1/4, NE 1/4, Sec. 21, T18N, R22E, IM; locality 107 in Appendix A	12 DEC 1993 27 FEB 1994

Table 2 (continued).

Site No.	Description	Dates Surveyed
13.	Snake Creek slough, Mayes Co., NE 1/4, SE 1/4, Sec. 19, T20N, R21E, IM; locality 96 in Appendix A	6 FEB 1994 27 MAR 1994
14.	Spring Creek, Mayes Co., NW 1/4, NW 1/4, Sec. 16 & NE 1/4, NE 1/4, Sec. 17, T19N, R20E, IM; locality 90 in Appendix A	22 AUG 1992 6 FEB 1994
15.	Unnamed tributary of Fourteenmile Creek, Cherokee Co., W 1/2, SE 1/4, Sec. 24, T18N, R21E, IM; locality 111 in Appendix A	21 DEC 1994 24 JUN 1995
16.	Council Hollow branch, Neosho River, Ottawa Co., SE 1/4, NE 1/4, Sec. 20, T26N, R24E, IM; locality 37 in Appendix A	13 AUG 1995
17.	Unnamed tributary of Locust Creek, Craig Co., SW 1/4, SW 1/4, Sec. 9 & NW 1/4, NW 1/4, Sec. 16, T24N, R21E, IM; locality 45 in Appendix A	26 AUG 1995

Table 3. Numbers of each fish species collected at localities where and when *Etheostoma cragini* was collected during this study. Columns show numbers collected on each locality visit when *E. cragini* was found. Locality numbers are identified in Table 2. Asterisks signify times when a locality was subjected to microhabitat sampling. In such instances, the total seined from all habitats is given first, and the number taken in seine hauls with *E. cragini* is given in parentheses.

Species	Locality number							
	1	2	3	4*	5	5*	6	6*
Campostoma anomalum			1	5(3)	5	1(1)	9	104(6)
Cyprinella lutrensis			1					
Luxilus cardinalis	33						5	11(0)
Nocomis asper	2							
Notropis nubilus	1							
Notropis rubellus								
Phoxinus erythrogaster	5							2(2)
Pimephales notatus			5					
Semotilus atromaculatus	8						1	4(0)
Catostomus commersoni								
Ameiurus natalis							1	
Noturus exilis								
Fundulus catenatus								
Fundulus notatus				6(4)				
Gambusia affinis		127	101	139(112)			21	44(44)
Cottus carolinae	25							
Ambloplites rupestris								
Lepomis cyanellus			5	6(5)	1	3(2)		
Lepomis macrochirus				3(1)				
Lepomis megalotis								
Micropterus dolomieu								
Micropterus salmoides	1							
Etheostoma blennioides								
Etheostoma cragini	**1**	**10**	**1**	**59(59)**	**8**	**15(15)**	**6**	**15(15)**
Etheostoma flabellare	12			6(5)			1	53(8)
Etheostoma microperca								1(1)
Etheostoma punctulatum	2						2	26(14)
Etheostoma spectabile	6	5	2	77(58)	6	25(16)	73	297(124)
Etheostoma whipplei				3(1)				

Table 3 (continued).

Species	Locality number							
	7	7*	8	8*	9	9*	10	10*
Campostoma anomalum	11	15(2)	5	2(1)		38(9)	11	34(1)
Cyprinella lutrensis								
Luxilus cardinalis	29	4(0)					41	48(0)
Nocomis asper	5	4(0)					8	39(5)
Notropis nubilus	4				4	2(1)		2(0)
Notropis rubellus		4(0)					1	6(0)
Phoxinus erythrogaster			2	1(1)				13(1)
Pimephales notatus								
Semotilus atromaculatus							4	2(0)
Catostomus commersoni								1(0)
Ameiurus natalis					1	2(0)		
Noturus exilis		3(0)				1(0)		1(0)
Fundulus catenatus		5(2)						
Fundulus notatus								
Gambusia affinis	10	36(25)			21	38(12)		2(0)
Cottus carolinae		2(0)					3	6(0)
Ambloplites rupestris	1						4	1(0)
Lepomis cyanellus		2(0)		1(0)	2	7(0)	1	1(0)
Lepomis macrochirus	4	8(2)				33(2)		1(0)
Lepomis megalotis						1(0)		
Micropterus dolomieu	1						1	
Micropterus salmoides	1	1(1)						
Etheostoma blennioides		1(0)						
Etheostoma cragini	**2**	**6(6)**	**5**	**4(4)**	**2**	**4(4)**	**1**	**1(1)**
Etheostoma flabellare	2	2(0)			4	26(0)	2	14(0)
Etheostoma microperca	6	23(20)			1	4(0)		2(0)
Etheostoma punctulatum		1(0)		2(0)	7	4(0)		
Etheostoma spectabile	10	60(30)	11	7(1)	26	76(17)	12	47(0)
Etheostoma whipplei								

Table 3 (continued).

Species	Locality number							
	11	11*	12	12*	13	13*	14	15
Campostoma anomalum				17(17)	28	8(0)	21	
Cyprinella lutrensis								
Luxilus cardinalis					29	37(5)	70	12
Nocomis asper					7	6(0)	1	
Notropis nubilus							1	7
Notropis rubellus								
Phoxinus erythrogaster					12	9(0)		2
Pimephales notatus								
Semotilus atromaculatus						4(1)		3
Catostomus commersoni								
Ameiurus natalis								
Noturus exilis								
Fundulus catenatus								
Fundulus notatus								
Gambusia affinis				1(1)	18	9(0)	6	
Cottus carolinae						1(0)	1	
Ambloplites rupestris								
Lepomis cyanellus		1(1)						
Lepomis macrochirus					1			
Lepomis megalotis								
Micropterus dolomieu								
Micropterus salmoides								
Etheostoma blennioides								
Etheostoma cragini	**20**	**27(27)**	**15**	**132(132)**	**7**	**4(4)**	**1**	**2**
Etheostoma flabellare		2(0)			7	21(0)	2	1
Etheostoma microperca							2	
Etheostoma punctulatum		1(1)			1	1(0)	2	2
Etheostoma spectabile		3(3)			27	15(0)	17	3
Etheostoma whipplei								

Table 3 (continued).

Species	Locality number 15*	16	17	T
Campostoma anomalum	370(85)	14		699(125)
Cyprinella lutrensis				1
Luxilus cardinalis	9(0)			328(5)
Nocomis asper				72(5)
Notropis nubilus				21(1)
Notropis rubellus				11(0)
Phoxinus erythrogaster	13(4)			59(8)
Pimephales notatus				5
Semotilus atromaculatus	8(1)			34(2)
Catostomus commersoni				1(0)
Ameiurus natalis				4(0)
Noturus exilis				5(0)
Fundulus catenatus				5(2)
Fundulus notatus		1		7(4)
Gambusia affinis		11	7	591(194)
Cottus carolinae				38(0)
Ambloplites rupestris				6(0)
Lepomis cyanellus			5	35(8)
Lepomis macrochirus	4(4)			54(9)
Lepomis megalotis				1(0)
Micropterus dolomieu				2
Micropterus salmoides		2		5(1)
Etheostoma blennioides				1(0)
Etheostoma cragini	**7(7)**	**15**	**5**	**375(274)**
Etheostoma flabellare	2(0)	2	2	161(13)
Etheostoma microperca				39(21)
Etheostoma punctulatum	1(0)	3		55(15)
Etheostoma spectabile	10(4)	32	7	854(253)
Etheostoma whipplei				3(1)

Table 4. Characteristics of microhabitat sites where *Etheostoma cragini* was collected. Locality numbers are identified in Table 2. Number of sites denotes numbers of microhabitat sites where *E. cragini* was taken and where data were collected to characterize the species' microhabitats. Under each locality, three statistics are given for each parameter: for most variables, (1) mean, (2) range, and (3) standard deviation; for classed variables [substrate materials, canopy cover, shading, aquatic vegetation, and bank slope], (1) mode, (2) range, and (3) number of classes represented in the range.

Characteristic	Locality number										
	4	5	6	7	8	9	10	11	12	13	15
No. of sites	7 of 14	9 of 15	5 of 15	3 of 15	3 of 9	2 of 15	1 of 15	9 of 14	12 of 12	2 of 15	5 of 15
No. of	8.4	1.7	3.0	2.0	1.3	2.0	1.0	3.0	11.0	2.0	1.4
E. cragini per	1-36	1-3	1-6	1-3	1-2	1-3	1	1-7	1-25	2	1-2
occupied site	12.7	1.0	1.9	1.0	0.6	1.4	-	1.7	6.1	0.0	0.5
Temperature	18.1	14.2	10.6	11.9	13.2	11.6	17.0	15.0	13.1	12.3	18.6
(° C)	17.1-18.5	14.0-14.8	10.5-10.8	11.8-11.9	13.0-13.5	11.0-12.1	17.0	15.0	13.0-14.0	12.0-12.5	18-19
	0.51	0.30	0.13	0.058	0.25	0.78	-	0.00	0.29	0.35	0.55
Dissolved	6.1	6.1	6.2	7.2	5.2	6.0	5.7	6.2	5.6	5.2	4.9
oxygen	4.6-7.2	4.1-7.2	4.0-7.0	6.8-7.8	5.0-5.5	5.3-6.7	5.7	6.0-6.3	5.0-7.5	5.0-5.4	4.2-5.6
(mg/L)	1.0	0.98	1.2	0.51	0.25	1.0	-	0.11	0.73	0.28	0.57
pH (s.u.)	7.2	7.7	6.9	7.9	7.1	7.1	7.0	6.5	6.1	6.9	6.5
	7.2-7.3	7.4-7.8	6.9-7.0	7.8-7.9	7.1-7.2	7.0-7.1	7.0	6.4-6.6	5.8-6.4	6.9	6.5-6.6
	0.053	0.14	0.045	0.058	0.058	0.071	-	0.071	0.22	0.00	0.040
Conductivity	306	388	145	273	210	245	300	106	61.5	161	123
(µmhos/cm)	185-380	370-390	143-147	270-280	210	240-250	300	105-107	60-62	158-164	120-127
	66.0	6.7	1.5	5.8	0.00	7.1	-	0.78	0.67	4.2	3.03
Turbidity	3.1	5.7	7.0	0.67	1.7	2.5	5.0	2.3	4.3	4.5	0.6
(FTU)	0-10	3-10	5-8	0-2	1-2	1-4	5	2-3	3-9	2-7	0-2
	3.3	1.9	1.2	1.2	0.58	2.1	-	0.50	1.9	3.5	0.89
Alkalinity	107	118	39.6	113	65	93.5	103	25.7	12.7	60.0	42.6
(mg/L)	58-123	114-123	39-40	105-117	64-66	93-94	103	24-29	8-16	54-66	41-46
	22.4	2.6	0.55	6.7	1.0	0.71	-	1.8	2.4	1.8	8.5
Total	133	156	61.0	132	100	115	137	40.8	16.4	73.5	51.9
hardness	77-159	145-161	58-63	129-134	99-102	112-117	137	38-44	16-17	73-74	49-55
(mg/L)	27	5.0	1.9	2.5	1.5	3.5	-	1.9	0.41	0.71	2.1
Depth (cm)	12.5	19.1	14.4	16.2	12.6	10.0	9.7	11.0	9.2	16.5	21.9
	6-24	9-43	6-24	8-27	10-17	10	9.7	7-19	5-14	11-22	10-41
	5.9	11.1	6.5	9.5	3.9	0.00	-	3.8	2.8	7.8	12.1
Substrate	5.7	2.1	2.7	2.3	1.7	3.0	1.7	2.7	8.5	25.2	1.7
penetration	1-13	0-6.7	2-4	1-4.7	1-2.3	2-4	1.7	1-8.3	1-23	19-31	0.3-2.7
(cm)	5.7	2.3	0.79	2.1	0.65	1.4	-	2.2	7.0	8.7	1.0
Dominant	b	b	n	b	none	none	b	o	b	b	n
substratum[1]	a-k,o	b-m,n	i-n	b	i-j	g-n	b	b-o	b-h	b	b-o
	5	4	4	1	1	2	1	2	3	1	3
Subdominant	i	d	none	n	g	none	d	o	o	none	g
substratum[1]	b-i,n	d-m,n	g-j	n	g	i-j	d	b-h,o	b-g,o	n-o	g-h,n
	5	4	4	1	1	2	1	5	4	2	3
Velocity	0.079	0.029	0.11	0.00	0.00	0.00	0.00	0.053	0.034	0.00	0.15
(ft/sec)	0-.55	0-.13	0-.46	0.00	0.00	0.00	0.00	0-.33	0-1.13	0.00	0-.57
	0.21	0.057	0.20	0.00	0.00	0.00	-	0.11	0.35	0.00	0.247

Table 4 (continued).

Characteristic	Locality number 4	5	6	7	8	9	10	11	12	13	15
Canopy cover	none	<25%	<25%	<25%	>75%	none	<25%	<25%	<25%	none	<25%
	<25->75%	<25->75%	<25-50%	<25%	50->75%	50-75%	<25%	<25-75%	<25-75%	<25-50%	<25-50%
	4	2	2	1	2	2	1	3	3	2	2
Shading[2]	2	1	1	1	3	2	2	none	2	2	none
	1-3	1-4	1-2	1-2	2-3	2	2	1-3	1-3	2	1-3
	3	4	2	2	2	1	1	3	3	1	3
Aquatic vegetation[3]	3	2	0	2	0	0	2	3	3	3	2
	0-3	0-3	0	1-2	0	0	2	3	2-3	3	2-3
	3	3	1	2	1	1	1	1	2	1	2
Bank distance (m)	0.00	0.056	0.00	0.00	0.00	0.00	0.00	0.72	0.21	0.25	0.20
	0.00	0-0.5	0.00	0.00	0.00	0.00	0.00	0-1.5	0-1.0	0-0.50	0-0.5
	0.00	0.17	0.00	0.00	0.00	0.00	-	0.57	0.34	0.35	0.27
Bank slope (°)	5-29	5-29	5-29	30-59	5-29	none	5-29	5-29	5-29	5-29	5-29
	0-undercut	0-undercut	5-29	5-59	5-undercut	5-59	5-29	0-29	5-undercut	5-29	0-undercut
	3	4	1	2	2	2	1	2	2	1	3

Coded parameter values:

1 Substratum sizes
- a = clay
- b = silt
- c = very fine to fine sand
- d = medium to coarse sand
- e = very coarse sand
- f = very fine gravel
- g = fine gravel
- h = medium gravel
- i = coarse gravel
- j = pebble
- k = cobble
- l = boulder
- m = bedrock
- n = organic debris
- o = live vegetation

2 Shading
- 1 = full sun
- 2 = partial shade
- 3 = temporary full shade
- 4 = permanent full shade

3 Aquatic vegetation
- 0 = absent
- 1 = watercress
- 2 = other species
- 3 = watercress and other species

Table 5. Summary results of Canonical Correspondence Analysis (CCA) of fish species and environmental data from habitat sampling at localities inhabited by Arkansas darters.

Axes	CCA1	CCA2	CCA3	CCA4	
Eigenvalues	.263	.238	.160	.113	
Species-environment correlations	.896	.976	.969	.916	
Cumulative percent variance					
of species data	22.2	42.2	55.7	65.2	
of species-environment relation	30.8	58.7	77.5	90.7	
Sum of all unconstrained eigenvalues					1.186
Sum of all canonical eigenvalues					.853

Appendix A. Localities in northeastern Oklahoma sampled for the Arkansas darter from 1992 through 1995. Dry localities, designated by D, and localities without fish, designated by NF, are numbered separately. At localities where multiple collections were made, successive collections after the first have lower case letters (e.g., b, c) appended to the locality numbers. Collections in which habitat sampling was performed have H appended to the locality number. Asterisks designate collections that contained Arkansas darters. General descriptions use straight-line distances; counties and reference communities are in Oklahoma unless noted otherwise. Geographic features are as mapped and spelled on USGS 1:24,000 maps.

No.	Waterbody	Date	County	Legal description; General description
	Upper Arkansas River drainage			
1	Arkansas River	7APR1995	Pawnee	T21N R7E S5 3.1 mi. SE of Blackburn
NF1	Unnamed spring	24MAR1995	Osage	T21N R7E S4 4.2 mi. SE of Blackburn, spring and run, tributary to Arkansas River
NF2	Unnamed spring	29OCT1994	Tulsa	T18N R14E S31 4.9 mi. SW of Broken Arrow, spring and run, tributary to Haikey Creek
2	Unnamed spring	28NOV1994	Rogers	T22N R15E S10 3.6 mi. S of Oolagah, spring and run, tributary to Verdigris River
3	Verdigris River	3DEC1994	Rogers	T22N R15E S14 3.6 mi. S of Oolagah, upstream and downstream from county bridge
4	Ponce De Leon Spring	1DEC1995	Osage	T25N R11E S14&15 5.0 mi. SE of Okesa, spring and run, tributary to Little Rock Creek
5	Tributary of Little Rock Creek	1DEC1995	Osage	T25N R11E S16 4.8 mi. S of Okesa, possible spring, upstream and downstream from county road
6	Wim Wigor Spring	1DEC1995	Osage	T25N R11E S10 4.1 mi. SE of Okesa, spring and run, tributary to Little Rock Creek
NF3	Daddy Miller Spring	1DEC1995	Osage	T25N R11E S10 4.1 mi. SE of Okesa, spring and run, tributary to Little Rock Creek
NF4	Spencer Spring	1DEC1995	Osage	T25N R11E S10 3.8 mi. SE of Okesa, spring and run, tributary to Little Rock Creek
7	Nehawaski Spring	15JAN1996	Osage	T25N R11E S14&15 4.0 mi. SE of Okesa, spring and run, tributary to Little Rock Creek
D1	Unnamed spring	15JAN1996	Osage	T25N R11E S2 3.5 mi. SE of Okesa, spring and run, tributary to Little Rock Creek

8	Little Rock Creek	15JAN1996	Osage	T25N R11E S2 3.5 mi. SE of Okesa, directly W of dry spring run, downstream from private road crossing
9	Unnamed spring	28NOV1994	Tulsa	T21N R14E S21 2.4 mi. NE of Owasso, spring and run, tributary to Elm Creek
NF5	Unnamed spring	29OCT1994	Rogers	T20N R14E S22 3.1 mi. NW of Catoosa, spring and run, tributary to Bird Creek
10	Unnamed spring	29OCT1994	Rogers	T20N R14E S15 3.25 mi. NW of Catoosa, spring and run, tributary to Bird Creek
	Upper Neosho River drainage, including Spring River			
11	Neosho River	19MAR1994	Ottawa	T28N R22E S9 4.5 mi. W of Commerce, upstream from Stepps Ford Bridge
12*	Rock Branch, Fivemile Creek	10OCT1993	Ottawa	T29N R25E S20 5.4 mi. NE of Peoria, upstream and downstream from low water crossing
12bH*	Rock Branch, Fivemile Creek	9NOV1993	Ottawa	T29N R25E S20 5.4 mi. NE of Peoria, upstream and downstream from low water crossing
13*	Fivemile Creek	10OCT1993	Ottawa	T29N R25E S18 5.1 mi. NE of Peoria, upstream and downstream from county bridge
13bH*	Fivemile Creek	9NOV1993	Ottawa	T29N R25E S18 5.1 mi. NE of Peoria, upstream and downstream from county bridge
14*	Tributary of Little Fivemile Creek	10OCT1993	Ottawa	T29N R24E S26 3.2 mi. N of Peoria, downstream from county road crossing
14bH*	Tributary of Little Fivemile Creek	13NOV1993	Ottawa	T29N R24E S26 3.2 mi. N of Peoria, downstream from county road crossing
15	Tributary of Spring River	1DEC1993	Ottawa	T29N R24E S20&21 3.9 mi. NE of Quapaw, upstream and downstream from county road crossing
16	Spring River	1DEC1993	Ottawa	T29N R24E S29 3.6 mi. E of Quapaw
17	Devils Hollow	10OCT1993	Ottawa	T29N R24E S33 3.0 mi. NW of Peoria, upstream and downstream from county road crossing
18	Spring River	13NOV1993	Ottawa	T28N R24E S5 2.7 mi. SE of Quapaw, downstream from Devils Promenade Bridge
19	Tributary of Spring River	1DEC1993	Ottawa	T28N R24E S5 2.5 mi. SE of Quapaw, downstream from county road crossing
D2	Tributary of Spring River	10OCT1993	Ottawa	T28N R24E S10 2.4 mi. W of Peoria, upstream and downstream from Oak Grove
D3	Tributary of Spring River	10OCT1993	Ottawa	T28N R24E S16 3.1 mi. W of Peoria, upstream and downstream from county bridge

20*	Warren Branch, Spring River	10OCT1993	Ottawa	T29N R25E S31 3.0 mi. NE of Peoria, downstream from ford
20bH*	Warren Branch, Spring River	18NOV1993	Ottawa	T29N R25E S31 3.0 mi. NE of Peoria, downstream from ford
21	Tributary of Warren Branch, Spring River	10OCT1993	Ottawa	T28N R25E S19 1.6 mi. S of Peoria, downstream from county road crossing
22*	Flint Branch, Spring River	10OCT1993	Ottawa	T28N R24E S25 3.0 mi. S of Peoria, just N of S.H. 10C
22bH*	Flint Branch, Spring River	13NOV1993	Ottawa	T28N R24E S25 3.0 mi. S of Peoria, just N of S.H. 10C
23	Shawnee Branch, Spring River	1DEC1993	Ottawa	3.8 mi. NW of Wyandotte, downstream from S.H. 10
24*	Lost Creek	1DEC1993	Ottawa	T27N R25E S9 0.9 mi. W of Seneca, MO, upstream from county road crossing
24bH*	Lost Creek	19MAR1994	Ottawa	T27N R25E S9 0.9 mi. W of Seneca, MO, upstream from county road crossing
D4	Modoc Valley branch, Lost Creek	1DEC1993	Ottawa	T28N R25E S32 3.5 mi. SE of Peoria, upstream and downstream from S.H. 10C
D5	Modoc Valley branch, Lost Creek	1DEC1993	Ottawa	T28N R25E S31 4.1 mi. SE of Peoria, upstream and downstream from county road crossing
D6	Modoc Valley branch, Lost Creek	1DEC1993	Ottawa	T27N R25E S6 4.8 mi. SE of Peoria, upstream and downstream from county road crossing
25	Modoc Valley branch, Lost Creek	1DEC1993	Ottawa	T27N R25E S7 5.1 mi. NE of Wyandotte, downstream from county road crossing
	Neosho River drainage downstream of Spring River			
NF6	Cave Spring	11DEC1993	Ottawa	T26N R24E S8 5.25 mi. E of Fairland, spring and run, tributary to Neosho River
26	Sycamore Creek	10OCT1992	Ottawa	T27N R25E S16 1.9 mi. S of Seneca, MO, downstream from county road crossing
27	Mason Springs Valley branch, Sycamore Creek	8NOV1992	Ottawa	T27N R25E S20 2.75 mi. SW of Seneca, MO, upstream of county bridge
28	Sycamore Creek	10OCT1992	Ottawa	T27N R25E S19&20 4.6 mi. E of Wyandotte, between confluence with Mason Springs Valley branch and low water crossing
28bH	Sycamore Creek	8AUG1993	Ottawa	T27N R25E S19&20 4.6 mi. E of Wyandotte, between confluence with Mason Springs Valley branch and low water crossing

29	Sycamore Creek	10OCT1992	Ottawa	T27N R24E S25 & T27N R25E S30 3.5 mi. E. of Wyandotte, both sides of county bridge
30	Sycamore Creek	8NOV1992	Ottawa	T27N R24E S35 2.7 mi. SE of Wyandotte, upstream of county bridge near Sycamore Chapel
D7	Brush Creek	8NOV1992	Ottawa	T26N R25E S7 5.2 mi. SE of Wyandotte, county road crossing
NF7	Unnamed spring	8NOV1992	Ottawa	T26N R25E S7 4.6 mi. SE of Wyandotte, spring and impounded run, tributary to Brush Creek
D8	Brush Creek	8NOV1992	Ottawa	T26N R25E S6 4.5 mi. SE of Wyandotte, private road crossing
D9	Brush Creek	8NOV1992	Ottawa	T26N R25E S6 & T27N R25E S31, 4.35 mi. SE of Wyandotte, E of South Eight School
31	Brush Creek	8NOV1992	Ottawa	T27N R25E S31 4.0 mi. E of Wyandotte, 0.1 mi. upstream of confluence with Rourk Creek
32	Rourk Creek	8NOV1992	Ottawa	T27N R25E S31 4.0 mi. E of Wyandotte, just upstream of confluence with Brush Creek
NF8	Tributary of Brush Creek	8NOV1992	Ottawa	T27N R25E S29 4.8 mi. E of Wyandotte, upstream of ranch road
33	Unnamed spring	8NOV1992	Ottawa	T27N R25E S31 4.3 mi. E of Wyandotte, spring and run upstream of Brush Creek tributary
D10	Unnamed spring	8NOV1992	Ottawa	T27N R24E S36 3.4 mi. SE of Wyandotte, tributary to Brush Creek
34	Brush Creek	10OCT1992	Ottawa	T27N R24E S36 2.8 mi. SE of Wyandotte, upstream of county bridge
34bH	Brush Creek	5SEP1993	Ottawa	T27N R24E S36 2.8 mi. SE of Wyandotte, upstream of county bridge
35	Sycamore Creek	10OCT1992	Ottawa	T26N R24E S2 2.5 mi. SE of Wyandotte, downstream of S.H. 10
35bH	Sycamore Creek	5SEP1993	Ottawa	T26N R24E S2 2.5 mi. SE of Wyandotte, downstream of S.H. 10
X36	Council Hollow branch, Neosho River	13AUG1995	Ottawa	T26N R24E S21 5.0 mi. S of Wyandotte, just E of S.H. 10, no sampling: landowner denied sampling of creek
37*	Council Hollow branch, Neosho River	13AUG1995	Ottawa	T26N R24E S20 5.0 mi. S of Wyandotte, just upstream of reservoir pool
38H	Tributary of Elk River	1AUG1993	Delaware	T25N R24E S11 1.75 mi. E of Turkey Ford, downstream from newer county bridge

39	Unnamed spring and Whitewater Creek	22DEC1994	Delaware	T23N R24E S10 6.3 mi. NE of Jay, spring run and creek downstream
40H	Summerfield Creek	18SEP1993	Delaware	T23N R22E S18 0.9 mi. SE of Disney, upstream and downstream from county bridge
41	Tributary of Locust Creek	9APR1995	Craig	T24N R21E S12 3.8 mi. N of Ketchum, 2.1 mi. E of S.H. 82
42*	Unnamed spring	3OCT1992	Craig	T24N R21E S10&11 3.3 mi. NW of Ketchum, tributary to Locust Creek
X42b	Unnamed spring	18SEP1993	Craig	T24N R21E S10&11 3.3 mi. NW of Ketchum, tributary to Locust Creek, no sampling: landowner denied further sampling of spring
43H*	Unnamed spring	2OCT1993	Craig	T24N R21E S10 3.5 mi. NW of Ketchum, 0.45 mi. E of S.H. 82, unmapped spring and run, tributary to Locust Creek
44*	Tributary of Locust	3OCT1992	Craig	T24N R21E S10 4.2 mi. NW of Ketchum, upstream of S.H. 82
44bH	Tributary of Locust Creek	18SEP1993	Craig	T24N R21E S10 4.2 mi. NW of Ketchum, upstream of S.H. 82
45*	Tributary of Locust Creek	26AUG1995	Craig	T24N R21E S9&16 3.9 mi. NW of Ketchum, 0.8 mi. W of S.H. 82, upstream and downstream from county road crossing
46	Tributary of Locust Creek	26AUG1995	Craig	T24N R21E S4 4.6 mi. NW of Ketchum, 0.6 mi. W of S.H. 82, downstream from county road crossing
47	Tributary of Locust Creek	3OCT1992	Craig	T24N R21E S5 5.1 mi. NW of Ketchum, 1 mi. W of S.H. 82
48	Locust Creek	3OCT1992	Craig	T24N R21E S6 5.8 mi. NW of Ketchum, 2 mi. W of S.H. 82
NF9	Tributary of Locust Creek	9APR1995	Craig	T24N R21E S18 4.3 mi. NW of Ketchum, 2.0 mi. W of S.H. 82, downstream from county road crossing
49	Tributary of Locust Creek	9APR1995	Craig	T24N R21E S7 5.1 mi. NW of Ketchum, 2.4 mi. W of S.H. 82, downstream from county road crossing
50	Tributary of Mustang Creek	9APR1995	Craig	T24N R21E S26 0.5 mi. NW of Ketchum, 1.5 mi. E of S.H. 82, upstream and downstream from county road crossing
NF10	Tributary of Mustang Creek	9APR1995	Craig	T24N R21E S26 0.75 mi. W of Ketchum, 1.1 mi. E of S.H. 82, unmapped tributary upstream from county road
51	Tributary of Mustang Creek	9APR1995	Craig	T24N R21E S26 0.9 mi. W of Ketchum, 1.0 mi. E of S.H. 82, upstream from county road crossing

52	Tributary of Mustang Creek	9APR1995	Craig	T24N R21E S22 2.5 mi. NW of Ketchum, E side of S.H. 82
53	Tributary of Mustang Creek	9APR1995	Craig	T24N R21E S22 2.1 mi. NW of Ketchum, 0.5 mi. E of S.H. 82, drainage from fish hatchery
54	Tributary of Mustang Creek	9APR1995	Craig	T24N R21E S15 2.6 mi. NW of Ketchum, 0.75 mi. E of S.H. 82, upstream and downstream from county road crossing
55	Tributary of Mustang Creek	9APR1995	Craig	T24N R21E S22 1.9 mi. NW of Ketchum, 0.1 mi. E of S.H. 82, upstream from county road crossing
56	Unnamed spring	9APR1995	Craig	T24N R21E S16 3.3 mi. NW of Ketchum, 0.9 mi. W of S.H. 82, unmapped spring and run, tributary to Mustang Creek
57	Mustang Creek	9APR1995	Craig	T24N R21E S32 3.4 mi. W of Ketchum, downstream from county road crossing
58	Locust Creek	26AUG1995	Craig	T25N R21E S25 6.4 mi. N of Ketchum, 2.5 mi. E of S.H. 82, upstream from county bridge
59	Locust Creek	26AUG1995	Craig	T25N R21E S26&35 5.9 mi. N of Ketchum, 2.25 mi. E of S.H. 82, upstream and downstream from county bridge
60	Spavinaw Creek	7NOV1993	Delaware	T21N R25E S3 6.0 mi. NE of Colcord, downstream from county bridge
61	Unnamed spring	7NOV1993	Delaware	T21N R25E S22 4.6 mi. NE of Colcord, N of Tonnece, spring and run, tributary to Cherokee Creek
62	Unnamed spring	7NOV1993	Delaware	T21N R25E S28 3.25 mi. E of Colcord, spring and run, tributary to Cherokee Creek
63	Unnamed spring	7NOV1993	Delaware	T22N R25E S28 7.45 mi. NE of Colcord, spring and run, tributary to Hog Eye Creek
NF11	Unnamed spring	5DEC1993	Delaware	T20N R24E S4 3.2 mi. SW of Colcord, spring and run, tributary to Cloud Creek
64	Tributary of Cloud Creek	7NOV1993	Delaware	T21N R24E S34 1.65 mi. W of Colcord, downstream from S.H. 116
65	Unnamed spring	19DEC1993	Delaware	T21N R24E S8 7.2 mi. SE of Jay, spring and run, tributary to Cloud Creek
66H	Unnamed spring	12SEP1993	Delaware	T22N R24E S29 4.5 mi. SE of Jay, most eastern of three mapped springs, tributary to Beaty Creek
NF12	Unnamed spring	12SEP1993	Delaware	T22N R24E S29 4.4 mi. SE of Jay, middle one of three mapped springs, tributary to Beaty Creek

67H	Unnamed spring	12SEP1993	Delaware	T22N R24E S29 4.3 mi. SE of Jay, most western of three mapped springs and run, tributary to Beaty Creek
68H	Beaty Creek	12SEP1993	Delaware	T22N R24E S29 4.35 mi. SE of Jay, downstream from transmission line right-of-way
69	Unnamed spring	19DEC1993	Delaware	T22N R23E S13 2.0 mi. S of Jay, spring and run, tributary to Brush Creek
70	Unnamed spring	5DEC1993	Delaware	T20N R23E S1 2.0 mi. N of Kansas, spring and run, tributary to Dry Creek
71	Unnamed spring	19DEC1993	Delaware	T21N R23E S10 7.5 mi. S of Jay, Spring and run, tributary to Dry Creek
72	Unnamed spring	19DEC1993	Delaware	T22N R23E S21 4.75 mi. SW of Jay, most northern of three springs and run, tributary to Rattlesnake Creek
73	Unnamed spring	19DEC1993	Delaware	T22N R23E S21 4.8 mi. SW of Jay, middle one of three springs and run, tributary to Rattlesnake Creek
74	Unnamed spring	19DEC1993	Delaware	T22N R23E S21 4.85 mi. SW of Jay, most southern of three springs and run, tributary to Rattlesnake Creek
75	Spavinaw Creek	14NOV1992	Mayes	T22N R21E S15 Spavinaw Recreation Area, downstream from Spavinaw Dam
D11	Tributary of Spavinaw Creek	7AUG1993	Mayes	T22N R21E S29 3.5 mi. SE of Spavinaw, county road crossing
D12	Tributary of Spavinaw Creek	7AUG1993	Mayes	T22N R21E S29 3.1 mi. SE of Spavinaw, county road crossing
76H	Tributary of Spavinaw Creek	7AUG1993	Mayes	T22N R21E S20&29 2.75 mi. SE of Spavinaw, county road crossing
77	Tributary of Spavinaw Creek	14NOV1992	Mayes	T22N R21E S18 3.0 mi. W of Spavinaw, downstream from county bridge
78H	Tributary of Spavinaw Creek	7AUG1993	Mayes	T22N R21E S19 3.7 mi. SW of Spavinaw, Indian Springs Fishing Resort
79	Unnamed spring	19DEC1993	Delaware	T21N R23E S28 5.0 mi. NW of Kansas, spring and run, tributary to Saline Creek
80	Unnamed spring	5JAN1994	Delaware	T21N R22E S8 0.85 mi. E of Kenwood, spring and run, tributary to Saline Creek
81	Unnamed spring	27MAR1993	Mayes	T20N R20E S4 2.7 mi. N of Locust Grove, spring and run, tributary to Neosho River

82	Unnamed spring	27MAR1993	Mayes	T20N R19E S1 4.4 mi. NW of Locust Grove, spring and run, tributary to Neosho River
83	Unnamed spring	27MAR1993	Mayes	T20N R20E S15 0.4 mi. N of Locust Grove, spring and impounded run, tributary to Crutchfield Branch, Neosho River
D13	Unnamed spring	2OCT1993	Craig	T25N R18E S27 6.3 mi. NE of Chelsea, 0.2 mi. S of Bowlin Spring, spring, tributary to Pryor Creek
NF13	Unnamed spring	18SEP1994	Craig	T25N R18E S27 6.3 mi. NE of Chelsea, 0.2 mi. S of Bowlin Spring, spring, tributary to Pryor Creek (same as D13)
84	Pryor Creek	18SEP1994	Craig	T25N R18E S28&33 6.0 mi. NE of Chelsea, 0.4 mi. S of Bowlin Spring
NF14	Unnamed spring	2OCT1993	Rogers	T24N R18E S3 4.8 mi. NE of Chelsea, spring and run, tributary to Pryor Creek
NF15	Unnamed spring	5JAN1994	Delaware	T209N R23E S30&31 2.8 mi. W of Oaks, spring and impounded run, tributary to Spring Creek
85	Unnamed spring	5JAN1994	Cherokee	T19N R23E S7 2.5 mi. SW of Oaks, spring and impounded run, tributary to Spring Creek
NF16	Unnamed spring	5JAN1994	Cherokee	T19N R22E S11 4.75 mi. SW of Oaks, spring and run, tributary to Spring Creek
86	Unnamed spring	6FEB1994	Cherokee	T19N R21E S36 4.4 mi. E of Peggs, spring and run, tributary to Spring Creek
87	Spring Creek	6FEB1994	Cherokee	T19N R21E S35 3.5 mi. E of Peggs, upstream from confluence with spring run
88	Luck Spring	6FEB1994	Cherokee	T19N R21E S35 3.45 mi. E of Peggs, spring and run, tributary to Spring Creek
89	Cave Spring	6FEB1994	Cherokee	T19N R21E S20 1.6 mi. N of Peggs, spring and run, tributary to Spring Creek
90	Spring Creek	22AUG1992	Mayes	T19N R20E S16 4.9 mi. S of Locust Grove, downstream of low water bridge
90b*	Spring Creek	6FEB1994	Mayes	T19N R20E S16 4.9 mi. S of Locust Grove, downstream of low water bridge
NF17	Unnamed spring	6SEP1992	Delaware	T20N R22E S18 1.3 mi. SE of Rose, more northern of two mapped springs, tributary to Snake Creek
NF18	Unnamed spring	6SEP1992	Delaware	T20N R22E S18 1.3 mi. SE of Rose, more southern of two mapped springs, tributary to Snake Creek

91	Snake Creek	6SEP1992	Delaware	T20N R22E S18 1.3 mi. SE of Rose, just W of Saline Courthouse
92	Snake Creek	27SEP1992	Mayes	T20N R21E S14 0.8 mi. S of Rose, downstream of county bridge
93	Snake Creek	27SEP1992	Mayes	T20N R21E S15 1.3 mi. SW of Rose, downstream of county bridge
94	Snake Creek	27SEP1992	Mayes	T20N R21E S16 2.2 mi. SW of Rose, downstream of ford
95	Unnamed spring	15AUG1992	Mayes	T20N R21E S21 3.1 mi. SW of Rose, 0.1 mi. W of Snake Cr. Church, tributary to Snake Creek
96*	Snake Creek	6FEB1994	Mayes	T20N R21E S19 3.5 mi. E of Locust Grove, creek and slough upstream of county road crossing
96bH*	Snake Creek	27MAR1994	Mayes	T20N R21E S19 3.5 mi. E of Locust Grove, creek and slough upstream of county road crossing
97H	Snake Creek	24JUL1993	Mayes	T20N R20E S34 2.5 mi. S of Locust Grove, upstream of S.H. 82 bridge
98	Snake Creek	22AUG1992	Mayes	T20N R20E S34 2.5 mi. S of Locust Grove, downstream of S.H. 82 bridge
98bH	Snake Creek	18JUL1993	Mayes	T20N R20E S34 2.5 mi. S of Locust Grove, downstream of S.H. 82 bridge
98cH	Snake Creek	19SEP1993	Mayes	T20N R20E S34 2.5 mi. S of Locust Grove, downstream of S.H. 82 bridge
99*	Snake Creek	22AUG1992	Mayes	T20N R20E S34 2.5 mi. S of Locust Grove, 0.15 mi. downstream from S.H. 82 bridge
99bH	Snake Creek	24JUL1993	Mayes	T20N R20E S34 2.5 mi. S of Locust Grove, 0.15 mi. downstream from S.H. 82 bridge
99cH	Snake Creek	19SEP1993	Mayes	T20N R20E S34 2.5 mi. S of Locust Grove, 0.15 mi. downstream from S.H. 82 bridge
100	Snake Creek	22DEC1994	Mayes	T19N R20E S3 C 3.1 mi. S of Locust Grove, creek and slough
101	Snake Creek	22DEC1994	Mayes	T19N R20E S9 4.0 mi. S of Locust Grove, upstream of confluence with Spring Creek
102	Unnamed spring	27MAR1993	Mayes	T19N R20E S23 3.25 mi. NW of Peggs, spring and run, tributary to Pipe Spring Branch, Spring Creek
103H	Spring Creek	4SEP1993	Mayes	T19N R20E S17&18 5.5 mi. SE of Locust Grove, main (N) channel and slough

104H	Clear Creek	11SEP1993	Cherokee	T18N R20E S29&30 6.3 mi. NE of Hulbert, upstream from Fort Gibson Reservoir
105	Fourteenmile Creek	17DEC1994	Cherokee	T18N R22E S15&22 0.1 mi. E of Moodys, upstream and downstream from county road crossing
106*	Unnamed spring	12DEC1993	Cherokee	T18N R22E S21 0.35 mi. SW of Moodys, spring and run, tributary to Fourteenmile Creek
106bH*	Unnamed spring	19FEB1994	Cherokee	T18N R22E S21 0.35 mi. SW of Moodys, spring and run, tributary to Fourteenmile Creek
107*	Unnamed spring	12DEC1993	Cherokee	T18N R22E S21&22 0.4 mi. S of Moodys, spring and run, tributary to Fourteenmile Creek
107bH*	Unnamed spring	27FEB1994	Cherokee	T18N R22E S21&22 0.4 mi. S of Moodys, spring and run, tributary to Fourteenmile Creek
108	Fourteenmile Creek	21DEC1994	Cherokee	T18N R22E S28&29 1.5 mi. SW of Moodys, upstream and downstream from county road crossing
109	Fourteenmile Creek	21DEC1994	Cherokee	T18N R22E S30 2.25 mi. E of Gideon, downstream from county road crossing
110	Fourteenmile Creek	21DEC1994	Cherokee	T18N R22E S25&36 0.85 mi. SE of Gideon, upstream and downstream from county road crossing
111*	Tributary of Fourteenmile Creek	21DEC1994	Cherokee	T18N R21E S24 SE1/4 1.1 mi. NE of Gideon, tributary and branch, upstream and downstream from county road crossing
111bH*	Tributary of Fourteenmile Creek	24JUN1995	Cherokee	T18N R21E S24 SE1/4 1.1 mi. NE of Gideon, tributary and branch, upstream and downstream from county road crossing
112	Blackbird Creek	17DEC1994	Cherokee	T18N R22E S4&5 2.3 mi. NW of Moodys, upstream and downstream from county road crossing
113	Blackbird Creek	21DEC1994	Cherokee	T18N R21E S12 3.6 mi. N of Gideon, upstream from county road crossing
114	Fourteenmile Creek	23JAN1994	Cherokee	T17N R21E S6 4.35 mi. NE of Hulbert, downstream from county road crossing
115	Unnamed spring	23JAN1994	Cherokee	T17N R20E S10 2.9 mi. NW of Hulbert, spring and run, tributary to Fourteenmile Creek
116	Unnamed spring	23JAN1994	Cherokee	T17N R20E S8 4.0 mi. NW of Hulbert, spring and run, tributary to Fourteenmile Creek
117	Seminary Spring	22JAN1994	Cherokee	T17N R21E S12 2.8 mi. S of Gideon, spring and impounded run, tributary to Double Spring Creek

NF19	Unnamed spring	23JAN1994	Cherokee	T17N R21E S21 1.75 mi. N of Thompson Corner, spring and run, tributary to Double Spring Creek
118	Ketcher Spring	23JAN1994	Cherokee	T17N R21E S16 2.4 mi. N of Thompson Corner, spring and run, tributary to Double Spring Creek
NF20	Unnamed spring	23JAN1994	Cherokee	T17N R21E S17 2.2 mi. N of Thompson Corner, more upstream of two mapped springs, tributary to Double Spring Creek
119	Unnamed spring	23JAN1994	Cherokee	T17N R21E S17 2.2 mi. N of Thompson Corner, more downstream of two mapped springs and impounded run, tributary to Double Spring Creek
	Lower Arkansas River drainage			
120	Metory Spring	22JAN1994	Cherokee	T16N R21E S25 1.7 mi. NE of Zeb, spring and run, tributary to Bobtail Creek
121	Black Valley Spring	22JAN1994	Cherokee	T16N R21E S24 1.9 mi. NE of Zeb, spring and impounded run, tributary to Bobtail Creek
122	Woodall Spring	22JAN1994	Cherokee	T15N R21E S5 3.0 mi. SW of Zeb, spring and run, tributary to Fire Branch, Bayou Manard
123	Unnamed spring	15JAN1995	Cherokee	T15N R22E S4 0.4 mi. NW of Keys, unmapped spring and impounded run, tributary to Greenleaf Creek
D14	Unnamed spring	23NOV1994	Cherokee	T15N R22E S9 N1/2 NW1/4 0.7 mi. W of Keys, supposed spring (possibly mismapped), tributary to Greenleaf Creek
124	Greenleaf Creek	23NOV1994	Cherokee	T15N R22E S9 0.8 mi. W of Keys, downstream from dry spring branch
125	Unnamed spring	16AUG1995	Cherokee	T15N R22E S9 S1/2 NW1/4 0.8 mi. SW of Keys, spring and impounded run, tributary to Greenleaf Creek
126	Unnamed spring	10DEC1993	Cherokee	T15N R22E S9 C W1/2 1.0 mi. SW of Keys, spring and run, tributary to Greenleaf Creek
127	Unnamed spring	10DEC1993	Cherokee	T15N R22E S8 1.3 mi. SW of Keys, spring and run, tributary to Greenleaf Creek
D15	White Man Spring	22JAN1994	Cherokee	T15N R22E S19 2.4 mi. W of Petitt, spring, tributary to Gibson Hollow branch, Greenleaf Creek
128	Petitt Spring	22JAN1994	Cherokee	T15N R21E S36 0.9 mi. NE of Qualls, spring and run, tributary to White Oak Branch, Greenleaf Creek

NF21	Unnamed spring	2APR1994	Sequoyah	T13N R21E S8 1.3 mi. W of Aqua Park, Gum Spring School, spring and impounded run, tributary to Deep Branch, Greenleaf Creek
129	Gum Spring	2APR1994	Sequoyah	T13N R21E S8 1.6 mi. W of Aqua Park, spring and run, tributary to Deep Branch, Greenleaf Creek
130	Unnamed spring	2APR1994	Sequoyah	T13N R21E S8 1.6 mi. SW of Aqua Park, Tee Hee Cemetery, spring and impounded run, tributary to Deep Branch, Greenleaf Creek
	Illinois River drainage			
131	Tributary of Illinois River	3OCT1993	Adair	T18N R26E S5 & T19N 26E S32 2.45 mi. SE of Ballard, upstream and downstream from county road crossing
132	Unnamed spring	3OCT1993	Adair	T18N R26E S28 1.95 mi. NE of Westville, tributary to Ballard Creek
133	Ballard Creek	3OCT1993	Adair	T18N R26E S28 1.9 mi. NE of Westville, upstream from county bridge
134	Unnamed spring	3OCT1993	Adair	T18N R26E S19 2.5 mi. N of Westville, tributary to Ballard Creek
135	Unnamed spring	3OCT1993	Adair	T19N R25E S25 0.7 mi. SW of Ballard, spring and run, tributary to Ballard Creek
136	Unnamed spring	3OCT1993	Adair	T19N R25E S36 0.65 mi. SW of Ballard, spring and run, tributary to Ballard Creek
137	Ballard Creek	18MAR1995	Adair	T19N R26E S20 0.5 mi. E of Watts, downstream from county road crossing
138	Illinois River	18MAR1995	Adair	T19N R26E S17 3.25 mi. S of West Siloam Springs, downstream of old Lake Francis dam
139	Tributary of Illinois River	28SEP1993	Adair	T19N R26E S7&18, 2.0 mi. N of Watts, just E of U.S. 59 and K.C.S. railroad tracks
D16	Tributary of Illinois River	28SEP1993	Adair	T19N R26E S7 NW1/4, 2.1 mi. S of West Siloam Springs, county road crossing
D17	Tributary of Illinois River	28SEP1993	Adair	T19N R25E S13, 2.2 mi. NW of Watts, county road crossing
NF22	Beaver Creek	28SEP1993	Delaware	T20N R25E S36, 0.5 mi. W of West Siloam Springs, just S of U.S. 412
NF23	Unnamed spring	28SEP1993	Delaware	T20N R25E S36, 0.55 mi. W of West Siloam Springs, 0.2 mi. S of U.S. 412, spring and run, tributary to Beaver Creek

X140	Dripping Springs	5DEC1993	Delaware	T20N R25E S32 2.4 mi. SE of Flint, no sampling: permission unavailable
141	Unnamed spring	5DEC1993	Adair	T19N R24E S1&2 2.25 mi. S of Flint, spring and run, tributary to Illinois River
142	Fagan Creek	28SEP1993	Delaware	T20N R25E S1 4.1 mi. N of West Siloam Springs, upstream from county road crossing
143	Flint Creek	28SEP1993	Delaware	T20N R25E S14 3.2 mi. NW of West Siloam Springs, upstream and downstream from county bridge
144	Sager Creek	28SEP1993	Delaware	T20N R25E S24 2.1 mi. NW of West Siloam Springs, bordering county road
145	Crazy Creek	28SEP1993	Delaware	T20N R25E S2 & T21N R25E S35 4.8 mi. SE of Colcord, upstream and downstream from county road crossing
146	Unnamed spring	5DEC1993	Delaware	T20N R25E S5 2.25 mi. SE of Colcord, spring and tributary of Flint Creek
147	Unnamed spring	5DEC1993	Delaware	T20N R25E S5 2.45 mi. SE of Colcord, spring and run, tributary to Flint Creek
NF24	Unnamed spring	5DEC1993	Adair	T19N R24E S3 2.8 mi. SW of Flint, spring and impounded run, tributary to Illinois River
NF25	Unnamed spring	5DEC1993	Adair	T19N R24E S3 2.6 mi. SW of Flint, spring and run, tributary to Illinois River
148	Black Fox Springs	5JAN1994	Cherokee	T19N R23E S2 2.0 mi. SE of Oaks, spring, tributary to Black Fox Hollow branch, Illinois River
149	Lost Spring	23NOV1994	Cherokee	T19N R23E S9 1.75 mi. S of Oaks, spring and run, tributary to Falls Branch, Illinois River
150	Unnamed spring	12DEC1993	Adair	T18N R24E S6 2.9 mi. S of Chewey, spring and run, tributary to Kirk Springs Hollow branch, Illinois River
151	Kirk Springs	12DEC1993	Cherokee	T18N R23E S1 3.0 mi. SW of Chewey, spring and impounded run, tributary to Kirk Springs Hollow branch, Illinois River
152	Pumpkin Spring	12DEC1993	Cherokee	T18N R22E S26 2.1 mi. SE of Moodys, spring and run, tributary to Illinois River
153	Steely Springs	16AUG1995	Cherokee	T17N R22E S3 5.2 mi. N of Tahlequah, spring and run, tributary to Steely Hollow branch, Illinois River
154	Unnamed spring	22OCT1994	Cherokee	T18N R23E S24 4.7 mi. NW of Proctor, spring and run, tributary to Pumpkin Hollow branch, Illinois River

X155	Unnamed spring	22OCT1993	Adair	T16N R26E S2 2.6 mi. SE of Wrights Chapel, private road gated, spring inaccessible
156	Tributary of Baron Fork, Illinois River	22OCT1993	Adair	T16N R26E S2 2.0 mi. SE of Wrights Chapel, branch carrying flows from inaccessible spring, upstream and downstream from county road
157	Baron Fork, Illinois River	22OCT1993	Adair	T17N R26E S34 1.2 mi. E of Wrights Chapel, upstream from county road crossing
158	Unnamed springs (3)	22OCT1993	Adair	T16N R26E S3&4 1.8 mi. S of Wrights Chapel, 0.2 mi. N of Piney, impounded springs and run, tributary to Evansville Creek
159	Evansville Creek	22OCT1993	Adair	T16N R26E S5 1.6 mi. SW of Wrights Chapel
NF26	Unnamed spring	22OCT1993	Adair	T16N R26E S5 1.5 mi. SW of Wrights Chapel, spring, tributary to Evansville Creek
NF27	Tyler Spring	24OCT1993	Adair	T16N R25E S22 2.3 mi. N of Stilwell, spring and run, tributary to Peavine Creek
160	Unnamed spring	22OCT1993	Adair	T17N R26E S9 2.0 mi. SE of Westville, spring and run, tributary to Shell Branch
161	Unnamed spring	24OCT1993	Adair	T17N R24E S25 2.7 mi. S of Christie, at Sanders, spring and run, tributary to Scraper Hollow branch
162	Unnamed spring	3OCT1993	Adair	T18N R25E S23 3.5 mi. NW of Westville, more northern of two mapped springs and run, tributary to Peacheater Creek
NF28	Unnamed spring	3OCT1993	Adair	T18N R25E S23 3.4 mi. NW of Westville, more southern of two mapped springs, tributary to Peacheater Creek
D18	Strawberry Spring	24OCT1993	Adair	T18N R25E S33 3.1 mi. NE of Christie, spring, tributary to Peacheater Creek
163	Unnamed spring	24OCT1993	Adair	T18N R25E S31 2.6 mi. N of Christie, spring and run, tributary to Crazy Hollow branch
164	Unnamed spring	24OCT1993	Adair	T17N R24E S23 2.1 mi. SW of Christie, spring and run, tributary to Baron Fork, Illinois River
165	Unnamed spring	12DEC1993	Cherokee	T17N R23E S13 1.9 mi. E of Proctor, spring, tributary to Baron Fork, Illinois River
166	Unnamed spring	12DEC1993	Cherokee	T17N R23E S25 1.6 mi. SE of Eldon, spring and run, tributary to Wall Trip Branch, Baron Fork, Illinois River
167	Keys Spring	10DEC1993	Cherokee	T16N R23E S18 3.4 mi. E of Park Hill, S of Welling, spring and run, tributary to Baron Fork, Illinois River

D19	Unnamed spring	12DEC1993	Cherokee	T16N R22E S20 2.3 mi. SW of Park Hill, spring, tributary to Park Hill Branch, Illinois River
NF29	Blue Spring	12DEC1993	Cherokee	T16N R22E S34 1.2 mi. NE of Keys, spring and run, tributary to Dripping Spring Hollow branch, Illinois River
168	Unnamed spring	10DEC1993	Cherokee	T15N R22E S11 N1/2 1.5 mi. E of Keys, spring, tributary to Illinois River
169	Unnamed spring	15JAN1995	Cherokee	T15N R22E S11 S1/2 1.75 mi. SE of Keys, spring and run, tributary to Illinois River
170	Unnamed spring	24OCT1993	Adair	T16N R25E S28 1.8 mi. NW of Stilwell, spring and run, tributary to Caney Creek
171	July Spring	10DEC1993	Adair	T16N R24E S22 7.1 mi. NW of Stilwell, 2.7 mi. N of Rocky Mountain, spring and run, tributary to Caney Creek
172	Unnamed spring	10DEC1993	Adair	T16N R24E S33 7.3 mi. W of Stilwell, 1.2 mi. N of Rocky Mountain, spring and run, tributary to Smith Hollow branch, Caney Creek
D20	Bitting Spring	22OCT1994	Adair	T16N R24E S16 2.7 mi. S of Titanic, supposed spring (likely mismapped), tributary to Bidding Creek
173	Unnamed spring	22OCT1994	Adair	T16N R24E S16 2.8 mi. S of Titanic, unmapped spring (possibly true Bitting Spring) and impounded run, tributary to Bidding Creek
174	Unnamed spring	10DEC1993	Adair	T16N R24E S8 2.1 mi. S of Titanic, spring and run, tributary to Bidding Creek
NF30	Unnamed spring	10DEC1993	Adair	T15N R24E S16 7.9 mi. SW of Stilwell, 2.3 mi. S of Rocky Mountain, spring and run, tributary to North Fork, Dry Creek
D21	Unnamed spring	10DEC1993	Cherokee	T15N R23E S22 7.25 mi. SE of Keys, 1.25 mi. E of Barber, spring, tributary to Dry Creek
	Lower Arkansas River drainage downstream of Illinois River			
NF31	Unnamed spring	22OCT1994	Sequoyah	T13N R23E S19&30 3.7 mi. E of Box, spring, tributary to Little Vian Creek
175	Yellow Spring	24OCT1993	Adair	T14N R25E S17 9.1 mi. SW of Stilwell, spring and run, tributary to Greasy Creek

Appendix B. Fish species collected in northeastern Oklahoma from 1992 through 1995. Numbers correspond with localities listed in Appendix A. Common and scientific names follow Robins et al. (1991).

Species	Locality Numbers
1. Gizzard shad *Dorosoma cepedianum*	75
2. Central stoneroller *Campostoma anomalum*	10, 12bH, 13, 13bH, 14, 14bH, 15, 20, 20bH, 21, 22, 22bH, 23, 24, 24bH, 25, 27, 28, 28bH, 29, 30, 31, 34, 34bH, 35, 35bH, 37, 38H, 40H, 41, 43H, 44, 46, 49, 51, 53, 54, 55, 56, 57, 58, 59, 60, 66H, 67H, 68H, 76H, 78H, 79, 84, 87, 89, 90, 90b, 93, 95, 96, 96bH, 97H, 98, 98bH, 98cH, 99bH, 99cH, 100, 101, 102, 103H, 104H, 105, 107bH, 109, 110, 111bH, 112, 113, 114, 118, 122, 123, 128, 129, 131, 133, 137, 138, 142, 143, 144, 145, 150, 154, 156, 157, 159, 162, 167, 169, 171
3. Bluntface shiner *Cyprinella camura*	16
4. Red shiner *Cyprinella lutrensis*	1, 3, 11, 44, 48, 84, 104H, 138
5. Common carp *Cyprinus carpio*	74
6. Cardinal shiner *Luxilus cardinalis*	13, 13bH, 15, 20, 20bH, 24, 24bH, 25, 26, 27, 28, 28bH, 29, 30, 34, 34bH, 35bH, 38H, 39, 40H, 60, 66H, 67H, 68H, 79, 80, 89, 90, 90b, 91, 92, 93, 94, 95, 96, 96bH, 97H, 98, 98bH, 98cH, 99, 99bH, 99cH, 100, 101, 103H, 104H, 105, 108, 109, 110, 111, 111bH, 114, 115, 118, 133, 137, 138, 142, 143, 144, 145, 156, 157, 159, 167, 171
Hybrid *L. cardinalis x Notropis nubilus*	145
7. Redfin shiner *Lythrurus umbratilis*	15, 19, 47, 84
8. Redspot chub *Nocomis asper*	13, 13bH, 24, 24bH, 28, 29, 30, 34, 34bH, 35, 35bH, 67H, 68H, 89, 90, 90b, 93, 94, 95, 96, 96bH, 99, 99bH, 100, 101, 103H, 104H, 105, 108, 109, 143, 144, 159
9. Golden shiner *Notemigonus crysoleucas*	15, 112
10. Emerald shiner *Notropis atherinoides*	1, 11, 48, 55
11. Bigeye shiner *Notropis boops*	55, 57, 110, 114, 124, 137, 138, 159, 165
12. Ozark minnow *Notropis nubilus*	12, 12bH, 13, 24bH, 28, 32, 34bH, 35bH, 60, 67H, 90, 90b, 98, 99, 101, 103H, 105, 108, 109, 110, 111, 114, 137, 138, 143, 156, 157, 159
13. Rosyface shiner *Notropis rubellus*	13bH, 15, 16, 18, 19, 24, 24bH, 100, 137, 138, 144

14. Sand shiner *Notropis stramineus*	1
15. Mimic shiner *Notropis volucellus*	11
16. Suckermouth minnow *Phenacobius mirabilis*	3
17. Southern redbelly dace *Phoxinus erythrogaster*	14, 14bH, 17, 20bH, 24bH, 25, 27, 28, 28bH, 31, 34bH, 39, 40H, 60, 63, 66H, 67H, 68H, 79, 80, 89, 90, 91, 92, 93, 94, 95, 96, 96bH, 97H, 98, 98bH, 98cH, 99, 99bH, 99cH, 100, 101, 102, 103H, 104H, 105, 111, 111bH, 113, 118, 131, 132, 133, 135, 136, 137, 139, 142, 143, 144, 145, 146, 147, 148, 150, 153, 154, 156, 157, 159, 161, 162, 163, 166, 167, 168, 171, 174
18. Bluntnose minnow *Pimephales notatus*	8, 18, 19, 44, 47, 48, 51, 54, 55, 84, 109, 110, 124, 137, 138
19. Fathead minnow *Pimephales promelas*	11, 162
20. Slim minnow *Pimephales tenellus*	11, 16, 137
21. Bullhead minnow *Pimephales vigilax*	1, 3, 8, 11, 16, 51
22. Creek chub *Semotilus atromaculatus*	20, 20bH, 24, 24bH, 27, 28bH, 34, 34bH, 38H, 39, 40H, 66H, 67H, 68H, 72, 79, 80, 89, 92, 93, 96bH, 97H, 98, 98bH, 98cH, 99, 99bH, 99cH, 103H, 104H, 105, 109, 111, 111bH, 113, 118, 131, 139, 142, 143, 144, 145, 147, 150, 156, 160, 163, 167
23. White sucker *Catostomus commersoni*	24bH, 27, 39, 79, 97H, 105
24. Northern hog sucker *Hypentelium nigricans*	104H, 110, 114, 165
25. Spotter sucker *Minytrema melanops*	15
26. Black redhorse *Moxostoma duquesnei*	110, 156
27. Black bullhead *Ameiurus melas*	23, 46, 54, 112
28. Yellow bullhead *Ameiurus natalis*	12, 12bH, 22, 28, 35bH, 51, 57, 58, 59, 84, 144
29. Channel catfish *Ictalurus punctatus*	3, 11
30. Slender madtom *Noturus exilis*	12bH, 13bH, 16, 24bH, 28, 28bH, 29, 34bH, 35, 60, 68H, 93, 102, 110, 114, 124, 137, 144
31. Freckled madtom *Noturus nocturnus*	3

32. Northern studfish *Fundulus catenatus*	13bH, 68H
33. Blackstripe topminnow *Fundulus notatus*	8, 15, 16, 19, 35, 35bH, 37, 41, 43H, 53, 57, 84
34. Blackspotted topminnow *Fundulus olivaceus*	143, 165
35. Western mosquitofish *Gambusia affinis*	3, 6, 8, 9, 11, 12, 12bH, 13, 13bH, 15, 16, 17, 18, 19, 20, 20bH, 24bH, 25, 29, 30, 34, 35, 35bH, 37, 41, 42, 43H, 44, 44bH, 45, 46, 47, 48, 50, 51, 53, 54, 55, 57, 75, 76H, 77, 78H, 79, 81, 82, 83, 84, 85, 87, 90, 90b, 95, 96, 96bH, 99cH, 100, 103H, 104H, 105, 107bH, 108, 109, 110, 114, 117, 121, 124, 133, 137, 138, 141, 142, 143, 144, 154, 157, 159, 164, 165, 167, 171
36. Brook silverside *Labidesthes sicculus*	15, 19, 55, 84, 133, 138, 175
37. Inland silverside *Menidia beryllina*	3
38. Banded sculpin *Cottus carolinae*	13bH, 24, 24bH, 25, 26, 27, 28, 28bH, 31, 32, 33, 34bH, 35, 35bH, 38H, 39, 40H, 60, 62, 63, 65, 67H, 68H, 69, 70, 71, 72, 73, 74, 79, 80, 86, 87, 89, 90, 90b, 93, 94, 95, 96bH, 97H, 98, 98bH, 98cH, 99, 99bH, 99cH, 100, 101, 103H, 104H, 108, 109, 131, 137, 138, 139, 142, 143, 144, 145, 146, 147, 148, 159, 161, 163, 168
39. Rock bass *Ambloplites rupestris*	13, 24, 24bH, 35bH, 100, 159
40. Green sunfish *Lepomis cyanellus*	2, 5, 7, 12, 12bH, 13bH, 14bH, 15, 16, 17, 18, 19, 21, 22, 22bH, 23, 24, 24bH, 25, 38H, 39, 41, 43H, 44, 44bH, 45, 46, 47, 48, 49, 53, 54, 58, 61, 66H, 67H, 83, 85, 88, 100, 106bH, 112, 117, 122, 123, 134, 139, 143, 151, 152, 158, 159, 161, 164, 169, 175
41. Warmouth *Lepomis gulosus*	3, 15, 16, 19, 21, 34bH, 35, 35bH, 77, 130
42. Orangespotted sunfish *Lepomis humilis*	1, 16, 48, 57
43. Bluegill *Lepomis macrochirus*	3, 8, 12bH, 13, 13bH, 15, 16, 19, 24bH, 34bH, 35bH, 43H, 47, 48, 54, 57, 58, 59, 77, 78H, 81, 95, 96, 103H, 111bH, 164
44. Longear sunfish *Lepomis megalotis*	3, 6, 8, 12bH, 23, 35bH, 55, 57, 84, 103H, 108, 110, 124, 144, 151, 157, 159
45. Redear sunfish *Lepomis microlophus*	35bH, 105
46. Smallmouth bass *Micropterus dolomieu*	13, 24, 34, 34bH, 35bH, 68H, 143, 144, 159
47. Spotted bass *Micropterus punctulatus*	39
48. Largemouth bass *Micropterus salmoides*	8, 13, 13bH, 35, 37, 44bH, 46, 51, 58, 75, 77, 99, 104H, 112

49. Greenside darter *Etheostoma blennioides*	13bH, 60, 114
50. Arkansas darter *Etheostoma cragini*	12, 12bH, 13, 13bH, 14, 14bH, 20, 20bH, 22, 22bH, 24, 24bH, 37, 42, 43H, 44, 45, 90b, 96, 96bH, 99, 106, 106bH, 107, 107bH, 111, 111bH
51. Fantail darter *Etheostoma flabellare*	12, 12bH, 13, 13bH, 16, 20, 20bH, 24, 24bH, 25, 26, 27, 28, 28bH, 29, 32, 33, 34, 34bH, 35, 35bH, 37, 38H, 40H, 43H, 45, 46, 48, 53, 55, 64, 68H, 89, 90, 90b, 92, 93, 94, 95, 96, 96bH, 98, 98bH, 98cH, 99, 99bH, 99cH, 100, 101, 102, 103H, 104H, 105, 106bH, 108, 109, 110, 111, 111bH, 114, 118, 136, 142, 143, 156, 166, 172
52. Slough darter *Etheostoma gracile*	44bH
53. Least darter *Etheostoma microperca*	12, 12bH, 13, 13bH, 20bH, 24bH, 87, 90, 90b, 100, 103H
54. Stippled darter *Etheostoma punctulatum*	12, 12bH, 13bH, 14bH, 20, 20bH, 25, 26, 27, 28, 28bH, 31, 34, 35bH, 37, 60, 68H, 73, 74, 76H, 79, 90, 90b, 96, 96bH, 98, 98bH, 98cH, 99, 99bH, 99cH, 100, 102, 103H, 104H, 105, 106bH, 108, 109, 110, 111, 111bH, 112, 114, 118, 119, 126, 127, 131, 142, 143, 147, 165, 167, 173
55. Orangethroat darter *Etheostoma spectabile*	3, 10, 12, 12bH, 13, 13bH, 14, 14bH, 15, 16, 18, 19, 20, 20bH, 21, 22, 22bH, 23, 24, 24bH, 25, 26, 27, 28, 28bH, 29, 30, 31, 32, 34, 34bH, 35, 35bH, 37, 38H, 40H, 42, 43H, 44, 44bH, 45, 46, 47, 48, 49, 50, 52, 53, 54, 55, 56, 57, 58, 59, 66H, 67H, 68H, 71, 72, 73, 75, 76H, 77, 78H, 79, 82, 87, 89, 90, 90b, 92, 93, 94, 95, 96, 96bH, 98, 98bH, 98cH, 99, 99bH, 99cH, 100, 101, 102, 103H, 104H, 105, 106bH, 108, 109, 110, 111, 111bH, 114, 116, 118, 120, 122, 127, 131, 133, 137, 138, 141, 142, 143, 144, 145, 150, 154, 157, 159, 161, 162, 163, 165, 167, 170, 171
56. Speckled darter *Etheostoma stigmaeum*	138
57. Redfin darter *Etheostoma whipplei*	7, 8, 11, 15, 43H, 44bH, 46, 52, 55, 57, 58, 59, 82, 84, 129, 175
58. Banded darter *Etheostoma zonale*	16, 75, 138
59. Logperch *Percina caprodes*	84, 103H, 104H
60. Channel darter *Percina copelandi*	16
61. Slenderhead darter *Percina phoxocephala*	11, 18
62. River darter *Percina shumardi*	11, 16