RECOVERY PLAN FOR THE ARKANSAS DARTER, *Etheostoma cragini* Gilbert, IN KANSAS

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for

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I. INTRODUCTION

The Arkansas darter, Etheostoma cragini Gilbert, is considered threatened in Kansas. The fish is endemic to the Arkansas River Basin from westernmost Missouri and northwest Arkansas westward to Colorado. Within Kansas the historical range of the species has been reduced with total loss of the species from the High Plains region. This species and its habitats have received legal protection from the Kansas Department of Wildlife and Parks under the authority (see Layher et al. 1986) of the state's Nongame and Endangered Species Conservation Act of 1975. The species is considered threatened under Kansas statute (K.A.R. 115-15-1). This plan, as outlined by K.A.R. 115-5-4, outlines specific strategies and methods to recover and delist the Arkansas Darter.

II. SPECIES ACCOUNT

A. TAXONOMY DESCRIPTION

1. Original Description

From Gilbert (1885) . . .

"**Etheostoma cragini**, sp. nov. – Body and head heavy and not closely compressed, the back not elevated; snout short and broad, less than diameter of orbit, about 5 in head; mouth terminal, broadly u-shaped, the maxillary reaching vertical front of pupil 3 ½ in head; premaxillaries not protractile; interorbital space narrow, less than diameter of pupil; eye 3 2/3 in head; gill membranes somewhat narrowly joined across isthmus, a conspicuous enlarged black humeral scale; preopercle entire.

Cheeks and opercles more or less complete covered with large scales; nape scaly, breast naked. Lateral line incomplete, not arched, continued on 20 to 22 scales. Scales weakly ctenoid.

Spinous dorsal connected at base with soft dorsal; the spines rather strong, the longest about 2/5 head; soft rays slightly longer. Anal with two spines, the first stronger and a little longer than the second 3 1/3 in head.

Pectorals small, 1 ¼ in head, extending but little behind ventrals. Caudal equaling pectorals.

Head 3 2/3 in length; depth 5. D. VI to IX, 11 or 12; A. II, 6 or 7. Lat. 1. 46, the tubes on about 21 scales.

Color in spirits: Dark olive above, irregularly mottled with blackish; below lateral line whitish, with some dusky specking; a series of about 12 small black blotches along lateral line, the interspaces silvery; a black blotch on opercle, one below and one in front of eye. Caudal very conspicuously barred with light and dark; soft dorsal and anal faintly barred; spinous dorsal with a dusky margin; traces or orange markings on lower side of head, and on bases of pectoral fins; the caudal fin seems to have been tinged with light yellow.

The types of this species were obtained by Prof. F. W. Cragin, in a small brook leading from the "Lake" at Garden City to the Arkansas River. The longest specimen is 1 ½ in. long."

2. Taxonomic Description

The Arkansas darter was originally described by Gilbert (1885); see Section II, A.1. above for the original description. The type locality for the species is in Finney County, Kansas. The species no longer occurs in that area (Eberle and Stark 1997). A second area inhabited by the species includes southwest Missouri, southeast Kansas, northeast Oklahoma, and northwest Arkansas. Meek (1894) described "A new Etheostoma from Arkansas," actually collected in Missouri, as Etheostoma pagle. This collection is considered a synonym for Etheostoma cragini. Moss (1981) and Eberle and Stark (1997) have each published a synonymy for the species.

The Arkansas darter is a member of the Order Perciforma and the Family Percidae. This Etheostoma species was included in the subgenus Oligocephalus by Bailey and Gosline (1955). Williams and Robison (1980) diagnosed and described a new subgenus, Ozarka, which includes five species: stippled darter (Etheostoma punctulatum), Arkansas darter, paleback darter (E. pallididorsum), slackwater darter (E. boschungi), and trispot darter (E. trisella). All of these species have similar breeding colors, tubercle patterns, and spawning habitats. Interestingly, three of these species have been observed spawning in open fields in seepage water from spring overflow. Spawning of the Arkansas darter has only been directly observed in the laboratory (see Distler 1972).

B. Historical and Current Distribution

1. Description of habitats and locations of occurrence.

Historically, the Arkansas darter occurred in Missouri, Oklahoma, Kansas, Colorado, and Arkansas (Figure 1). While at least isolated populations remain in all of those states, the primary and largest populations occur in Kansas (Figure 2). Habitat degradation and loss has resulted in extensive losses in states other than Kansas (see Section IV. Potential Threats to the Species or Its Habitats).

A number of authors have described habitats occupied by the Arkansas darter. Most authors associated habitat of this species with aquatic vegetation. Gilbert (1885) found the species "in shallow current among reeds." Cloutman (1980) summarizes the findings of previous descriptions of habitats occupied as "spring runs or small creeks with an abundance of watercress or other aquatic vegetation. It occurs most often in pools with sand, fine gravel, or organic detritus." Williams and Robison (1980) indicate the species preference for quiet pools of small spring branches and spring-fed creeks where thick growths of watercress, Nasturtium officinale, occur. Previous descriptions by other authors describe the Arkansas darters preferred habitat in a similar manner (Ellis and Jaffa 1918; Blair 1959; Branson 1967; Cross 1967; Pflieger 1971, 1975; Miller and Robison 1973). Cross and Collins (1995) use a similar description of habitat as does Collins et al. (1995). While watercress is most often referenced as the dominant vegetation at locations of occurrence of Arkansas darters, other vegetation types have been referenced: algae (Branson 1967), Potamogeton, algae, Cyperus (Cloutman 1970); Eleocharis, Carex, bullrush and Ludwigia repens (Layher and Wood 1986); Ranunculus, Potamogeton, Myriophyllum, Collatriche, and Radicula (Moore and Cross 1950); Spirogyra and Pithophora (Distler 1972); and stonewort (Chara sp.) (Miller 1984).

The Arkansas darter appears to occur primarily in small spring type habitats. Little quantitative information exists describing the species habitats. Many authors describe habitats as shallow runs (e.g. Gilbert 1885); isolated pools (e.g. Ellis and Jaffa 1918), et cetera. Ellis and Jaffa (1918) indicated streams of occurrence as less than three feet in depth in Colorado. Cloutman (1970) described collection sites on Bluff Creek in Clark County, Kansas as being 2 to 10 feet wide and 3 inches to 1 foot in depth with sand substrate and moderate current. Matthews and McDaniel (1981) report collecting Arkansas darters in deep, turbid, mud bottoms from Rattlesnake Creek; at locations 40 m wide at depths greater than 1 m in the Chikaskia River mainstem; and from the Arkansas River near Oxford where the stream was 200 m wide and turbid. Layher and Wood (1986) collected Arkansas darters at depths of 80 cm in some locations. Robison and Buchanan (1988) described three Arkansas populations as occurring at sites less than 3 feet wide and 1 foot in depth with substrates of gravel, sand or silt with watercress present. Interestingly some of the more quantitative site description data reported in the literature seems to represent collections at occurrence locations not typical for the species.

**2.	Analyses of data to describe habitats of occurrence versus habitats of nonoccurrence within the species current range**.

Data were obtained from the Kansas Department of Wildlife and Parks, Environmental Services Section representing some 107 sites from southcentral Kansas streams (Mitchell 2000). Data from sample site locations where Arkansas darters were present are summarized (Table 1). Highest darter densities occurred at sites less nutrient loaded although high nitrate and phosphorus values occurred at several sites with high population densities. Darter populations were also more abundant and occurred more often at sites with chloride values less than 250 mg/l. Optimum pH values range from 7.0 to 8.5. Highest densities occurred where dissolved oxygen was between 6.0 and 8.0 mg/l. Highest darter densities were found in clear water 0-50 NTU's and at relatively small discharges, 0-20 cfs. High densities of Arkansas darters also occurred in small streams from 0-10 m in width and 0-5 cm in depth. From these data one could describe habitats as small, clear, cool streams with low nutrient values and minimal salinity. Densities of darters were graphed against increments of habitat variables following Layher and Maughan (1988), (Figures 3 through 17). However, as one can see from data presented, it would appear that the Arkansas darter is also somewhat tolerant, at least under certain conditions, of higher turbidity, salinity, and nutrient levels. If mean values of physical and chemical stream data are compared between sites of occurrence and nonoccurrence, few differences stand out (Table 2).

Sites of occurrence (Table 3) and nonoccurrence (Table 4) were reviewed for presence of macrophytes and algae (Figures 18 and 19). Fifteen of 39 sites where darters were present contained no macrophytes. Interestingly the sites also contained no algae. Hence, 37.5% of all sites containing Arkansas darters contained no aquatic vegetation although current literature stresses the association between darter occurrence and vegetation. Vegetation may however increase abundance, possibly by increasing instream food sources. Layher (2000) recalls collecting the species in southcentral Kansas during the 1980's at sites with and without vegetation but sites without vegetation, especially with sand substrates and fairly strong currents, usually produced few specimens.

Various substrates are mentioned in the literature at locations where Arkansas darters were collected. Analysis of stream survey data from KDWP indicates that sand most commonly occurs at stream sites in south-central Kansas (59.7%) and makes up 85.9% of the substrate at Arkansas darter capture locations (Table 5). Additionally, sand occurred at 100% of capture locations but also occurred to some degree at 95% of sites without the species present (Table 6). It would appear that sand substrate may not be required for darter occurrence, but is coincidental with occurrence (Figure 19). In Missouri, Arkansas, and northeastern Oklahoma, sand is not typically associated with the species occurrence.

3. Known collection sites

Collections of Arkansas darters were plotted on county maps provided by Ken Herin, Kansas Department of Transportation (2000)

(Figures 20 – 37). Collection data for all known collections was compiled from numerous documents but primarily from the Kansas Department of Wildlife and Parks and the University of Kansas Museum of Natural History. Location data from the Kansas Biological Survey was not used in this effort as it was concluded to be contained within the former data sets (Busby, pers. communications 2000). Sites were coded with a triangle if pre-1960 collections; a square if collections were made between 1960 and 1979; and a circle if occurring during or after 1980. Multiple collections at single sites are marked with a number representing the number of individual collections found in databases and/or literature citations. With the exception of the Cherokee County collections, the predominance of locations occur in counties to the south of the "Big Bend" of the Arkansas River. Records of collections, dates, and legal descriptions by county were tabulated (Table 7).

4. Associated Fish Species and Communities

Numerous fish species have been collected at locations with Arkansas darters. In 1918, Ellis and Jaffa reported capture of the following at a Colorado spring: white sucker, Catostomus commersonii sucklii (Girard); central stoneroller, Campostoma anomalum (Rafinesque); Notropis scylla (Cope); red shiner, Cyprinella lutrensis (Baird and Girard); fathead minnow, Pimephales promelas (Rafinesque); and the plains killifish, Fundulus zebrinus (Jordan and Gilbert). Blair and Windle (1961) reported capturing redfin darters, Etheostoma whipplii along with the Arkansas darter at a location in Oklahoma. The least darter (Etheostoma microperca) was also described as a species associate. Branson (1967) lists orangethroat darters (Etheostoma spectabile), stippled darters and channel darters (Percina copelandi) as associates in Oklahoma. Taber et al. (1986) indicated occurrence along with stippled darters in southeast Kansas. Kilgore and Rising (1965) collected 1,019 fish specimens from a site on Crooked Creek, Meade County. Sixty-four of the fishes were Arkansas darters. Other fishes included 44 red shiners, 27 Arkansas River shiners (Notropis girardi), 253 sand shiners (Notropis ludibundus), 155 plains minnows (Hybognathus placitus), 68 fathead minnows, 242 plains killifish, 153 mosquitofish (Gambusia affinis), 3 green sunfish (Lepomis cyanellus), 1 bluegill (Lepomis macrochirus), and 1 central stoneroller. Cloutman (1970) found the darter at sites in Bluff Creek along with red shiners, sand shiners, fathead minnows, plains killifish, green sunfish, stonerollers, and mosquitofish. Matthews and McDaniel (1981) collected the Arkansas darter from the Chikaskia River along with red shiners being most abundant (94 specimens) and less than five specimens each of sand shiners, central stonerollers, bullhead minnows (Pimephales vigilax), and mosquitofish. Collections by the same investigators from Rattlesnake Creek also found red shiners as the most abundant member of the community as they did in a collection from the Arkansas River. Layher and Wood (1986) reported collecting Arkansas darters at several locations along with red shiners, sand shiners, green sunfish, mosquitofish, central stonerollers, emerald shiners (Notropis atherinoides), and plains killifish. Because of the rather large range, Missouri to Colorado, a number of species have been recorded at sites where the Arkansas darter occurs. Within the southcentral portion of Kansas, where the largest populations of Arkansas darters occur, red shiners and sand shiners predominate literature citations as potential species associates.

Species associations were considered from data provided by Mitchell (2000). Percent association reported herein represents the percent of sites of Arkansas darter occurrence where a specific species also occurred. Both sand shiners and red shiners occurred at greater than 97% of sites where Arkansas darters were collected. Over 89% of Arkansas darter locations also contained green sunfish and mosquitofish. Seventy-nine percent of occurrence sites contained central stonerollers. Other species found at over 50% percent of the sites where Arkansas darters occurred included fathead minnow (69%); common carp , Cyprinus carpio (74%); suckermouth minnow, Phenacobius mirabilis (57%); yellow bullhead, Ameiurus natalis (56%); channel catfish, Ictalurus punctatus (66%); plains killifish (76%); and bluegill (56%). Forty-nine fish species were collected at sites where Arkansas darters also occurred (Table 7).

C. POPULATION SIZES AND ABUNDANCE

Population size and/or abundance are represented by a paucity of literature references. Few data exist reporting density or population values. In states other than Kansas, populations are isolated entities. Robison and Buchanan (1988) and Harris and Smith (1985) found five populations in

Arkansas and estimated 500 – 1,000 individuals for two local populations and less than 100 individuals each in the other three. Densities were not reported.

Many Kansas populations are not as isolated. In southcentral Kansas populations occur nearly the entire length of some streams. Layher (2000) recalls collecting literally hundreds of individuals with a dip net at some vegetated locals. Moss (1981) reported juvenile densities as high as $60/m^2$ in Amber Creek, Barber County, Kansas. Densities on a number/hectare basis for a number of Kansas streams were calculated from data supplied by Mitchell (2000) (Table 8). Undoubtedly, some populations of Arkansas darters are isolated from others, while some populations are much less disjunct. Where they occur, the species is represented by quite numerous individuals in many cases.

D. REPRODUCTION

Ellis and Jaffa (1918) described collecting Arkansas darters in Colorado that were spawning on March 25. Taber et al. (1986) described some spawning information for the Spring River, Missouri. Ova reportedly could be stripped by 23 February. By 16 July resorption was occurring. All females greater than 36 mm spawned by mid March. Females were described as multiple spawners. Spawning was described to occur from February to mid July at temperatures between 9 and 17 C. Fish reach sexual maturity their first year. In fact, they reported Year I fish comprising 96.4% of the population. Maximum age was reported at 3 years. Average ova production for females was 450 (mean length = 46.3 mm). Ova counts ranged from 294 to 492. Spawning discontinues when water temperature exceeds 17-18 C.

Distler (1972) collected a lone female darter in Sedgwick County, Kansas and transferred the specimen along with several males to an aquarium. The female buried in gravel and deposited eggs up to 1 cm into the substrate. This female always spawned in an area of the aquarium devoid of vegetation. Moss (1981) viewed darters in Amber Creek on 28 April with a water temperature of 63 F. He reported spawning to occur in open silty areas. Eggs were retrieved from bottom ooze within 2 cm of the surface. However, Moss (1981) indicated spawning probably did not occur in vegetation, but observations of actual spawning were not made.

During spawning, males segregate from females; males in open areas while females wait in vegetation. Females enter open areas to spawn and are immediately attended by numerous males. After spawning activity ceases and eggs hatch, both adult sexes utilize vegetation if available while juveniles seem to prefer open areas (Moss 1981).

E. FOOD AND FEEDING REQUIREMENTS

Distler (1972) reported that Arkansas darters consumed any live organism placed in aquaria, including cladocerans, copepods, rotifers, brine shrimp, and white worms. Small snails were also eaten in aquaria. Radiographs of wild specimens found snails to represent a large portion of the diet. Taber et al. (1986) found isopods to represent 58% by volume of Arkansas darter diets, with ephemeropterans and chironomids represented by 12 and 8 percent, respectively. Brunson (1992) suggested that Arkansas darters use vegetation to perch in the water column to access prey. Probably any living organism small enough to be ingested constitutes prey with diet differing locally based on potential prey species abundance.

F. Other Pertinent Information and Summary

It would appear that the Arkansas darter inhabits a fairly large area in Kansas (see Figure 2). Analyses of physical and chemical data at collection sites versus sites of nonoccurrence lend little information as to why Arkansas darters occur where they do at first glance. However, darters of this species often occur in clear, cool, small streams. These southcentral to southwestern populations occur primarily in sand substrates. Highest densities occur in vegetated areas, probably due to resting and feeding habitats and food production being increased in a third dimension (vertically).

Habitats such as these are often in headwaters or in large streams that typically do not flash flood. Sandy soils in the Great Bend Prairie Aquifer allow rainwater to percolate rapidly through the soils avoiding heavy overland runoff thereby reducing the scouring effects of stream flow. This condition allows groundwater to provide base flows and encourages plant communities. Less vegetated areas often occur farther downstream and darter populations appear lower in such areas and probably represent recruitment from upstream areas over relatively stable stream flow periods. Unusually large floods probably severely reduce downstream populations.

Dewatering of large streams has probably allowed Arkansas darters to establish populations in such streams, which at least temporarily resemble smaller, headwater streams. Such populations in rivers such as the Arkansas

River undoubtedly are short lived, becoming dislodged by high flow events from potential heavy rainfall such as 100 year flood events.

The preponderance of Arkansas darter populations in Kansas occur in or below the Big Bend Prairie Aquifer. Many streams emanating from this area are characterized as "gaining" streams receiving base flows from groundwater intrusion into streambeds. At least stream margins if not the entire flow in headwater areas contain cool waters. Hubbs (1995) described the species as stenothermal due to its association with springs. Such spring dwellers are not often found outside of the zone of spring influence, however other species enter such zones, especially in droughts. Stream flows in such areas often are not as variable as even 1st order streams. Such a description may identify some Cherokee County occurrences. However in southcentral Kansas the entire stream length may be "spring-fed". As waters move downstream and gradually warm, the zone of groundwater influence probably decreases and the Arkansas darter may be limited to stream margins. An example of such a situation would be the South Fork of the Ninnescah. The Arkansas darter inhabits the entire stream channel in headwater areas but occurs in the stream margins in Kingman County (Layher, pers. communication 2000). As the zone of influence decreases other species become more common and this scenario results in the great number of fishes listed as associated with Arkansas darter occurrence. Hubbs based the conclusion that the Arkansas darter was an example of a fish inhabiting stenothermal habitats on its occurrence represented by eastern Oklahoma populations. Some Kansas populations (adults) appear in quite warm waters and Smith and Fausch (1997) found that the Arkansas darter can withstand higher temperatures than some other darters. This ability may enable adults to emigrate to new areas, as when dislodged downstream during high flows or to move to larger streams when flows are stable for some time. Smith and Fausch (1997) speculate that the eggs of the Arkansas darter may be sensitive to thermal extremes. If so, this in fact may give the darter its stenothermal appearance and be the principle reason that it occurs where it does. Vegetation and silt-free substrate are probably a result of stable flows in such areas with little runoff providing silt, and lack of scouring allowing plant growth. Hence Arkansas darters are found not only in spring habitats but also in streams with major groundwater contributions. Populations are more stable in springs and/or headwaters than those downstream in drainages.

III. OWNERSHIP OF PROPERTIES

Ownership of properties where Arkansas darters occur is primarily in private interests. Lands in the area of Pratt, Comanche, Kiowa, Meade and Seward Counties associated with streams of occurrence are largely in grasslands. The individual ownership of lands has not been listed due to the great number of sites of known occurrence. The probable distribution of the species fully spans some streams between collection points.

One notable area of occurrence of the species is the Kingman Wildlife Area, currently owned by the State of Kansas and managed by the Kansas Department of Wildlife and Parks. The South Fork Ninnescah River flows through this area and Arkansas darters occur along the stream margin as well as in greater densities in spring seeps on the area.

IV. Potential Threats

The occurrence of the species today represents populations in extreme southeastern Kansas with a large area of nonoccurrence between southcentral and southwest Kansas populations. The species seems to be absent form the high plains with the exception of a few isolated populations in eastcentral Colorado.

Ellis and Jaffa (1918) described a population in Colorado some 120 miles distant form the Arkansas River and indicated that only in the spring of the year was the location connected to the Arkansas River. Undoubtedly, numerous such populations existed historically across the high plains in the Arkansas River watershed. Miller (1984) hypothesized that isolation of populations in Colorado may be due in part to climate change but speculated that isolation was further increased through groundwater depletion and surface water diversions. Remaining populations there are threatened by private development and municipal development. Sites shown in Colorado in Cloutman (1980) have now been extirpated. Only a very few populations remain in Colorado.

Blair (1959) noted that populations in Oklahoma might become extinct. Loss of habitat and the species has occurred due to inundation of occupied springs from the U.S. Army Corps of Engineers reservoir construction such as the Grand Lake O' the Cherokees on the Neosho River.

In assessing Kansas' ichthyofaunal history, Cross and Moss (1987) hypothesized that small stream aquatic communities were first affected by agrarian development in the last quarter of the 1800's. Etheostoma species were probably the first to be extirpated due to siltation and spring development. Interestingly, Gould (1901) indicated that streams in the high plains emanated from tertiary springs and provided a “never-ending” supply of water. He recognized this as the final solution to water supply problems for a growing human population and encouraged development of such water sources for domestic use. Cross (1967) and Cloutman (1980) indicates much local extinction has occurred since the 1800’s. Isolated populations became further isolated because of such development and remaining populations in some cases were subject to extirpation from droughts (Cloutman 1970). Repopulation was then impossible at such sites. Platt et al. (1973) listed the Arkansas darter as requiring special attention for continued survival, but did not list the species at that time as threatened or endangered.

The westernmost occurrence of the species in Kansas is the Cimarron River in Seward County. Many authors have cited irrigation development as the primary cause of loss of habitat and range reduction through severe dewatering (Cross 1967, Platte et al. 1973, Cloutman 1980, Schwilling 1981, Moss 1981, Layher 1988, Cross and Collins 1995, Collins et al. 1995).

Other, more local causes, threaten some populations. Cloutman (1970) cited extirpation of darters from Crooked Creek in southern Ford County from runoff from wheat fields and pollution from feedlots. Moss (1981) found that bridge construction and minor stream realignment were not so severe as dewatering. He found darters immediately following construction activities and juvenile darters within realignment areas after construction. Sand substrate streams in southwest Kansas are probably less impacted by such activities than areas in southeast Kansas. Terry and Brunson (1985) postulated Arkansas darter recruitment at bridge construction sites maybe directly related to re-establishment of aquatic vegetation.

Ironically, dewatering has probably resulted in records of the species in larger streams. Stark et al. (1987) found Arkansas darters in the Arkansas River mainstem in Rice and Barton Counties. Ernsting and Eberle (1989) speculated that the partially dewatered river acted as a corridor for dispersal. Eberle and Stark (1998) also reported darters in the mainstem Arkansas and Cimarron Rivers and again speculated that each river could now act as a dispersal corridor. Cross et al. (1985) also hypothesized the same scenario.

Eberle et al. (1996) found only one site in Rattlesnake Creek to contain Arkansas darters. These authors conjectured that considerable irrigation development caused saline water to move into the alluvial system farther upstream than it formerly did. This hypothesis of impact was formulated based on the work of Sophocleous and McCallister (1990).

Schoewe (1951) described the Arkansas River as dispersing underground originally at some points with a porous alluvium. It is now characterized with bluffs to the north and a less discernable valley to the south where it is bordered by sand dunes 1 to 40 miles south of the river. This porosity of soil (sand) probably allows the conductance of water from the river itself into the sandy alluvium to the south, helping to recharge the Big Bend Prairie Aquifer from which many streams and springs occupied by the Arkansas darter emanate.

The Cimarron River to the south lies nearly 500 feet lower in elevation than the Arkansas River bed directly to the north (Schoewe 1951). Between the Cimarron and the Arkansas Rivers many of the streams arise which are currently occupied by Arkansas darters. These streams appear to be relatively stable. Graphs depicting mean annual discharges and mean summer discharges (July-September) were made using the data from the U.S. Geological Survey's stream gauging records. These graphs indicate that the Medicine Lodge River, North Fork Ninnescah River and South Fork Ninnescah River are relatively stable with no obvious trends indicating that dewatering is occurring (Figures 38 - 45). Declines may be occurring in the upper portion of the Big Bend Prairie Aquifer as indicated by similar graphs depicting flows in Rattlesnake Creek (Figures 46– 47). While the mean annual discharge for the last decade is higher generally speaking, than the previous decade, the summer flow values indicate a potential dewatering during this time period. Graphs depicting flows to the west of this aquifer, in Crooked Creek, show an alarming reduction in both mean annual flows and summer discharges since the early 1970's (Figures 48 – 49).

Currently, Arkansas darter populations in the western portion of their range in Kansas, Seward and Meade Counties, are most severely imperiled. Eberle and Stark (1998) reached this same conclusion and found that groundwater declines eliminated seepage into some surface water thus increasing summer water temperatures. They also found some streams had become ephemeral drainages. Eberle and Stark (1998) found that water rights have been overappropriated by the Groundwater Management District #3 and it currently operates under a policy of planned depletion. Such a policy will insure elimination of Arkansas darter habitats in these counties, especially west of the Bear Creek Fault in Meade County. Layher (1989) described dewatering of streams and artesian wells in the Meade State Lake area based on data provided by Joe Lillie (pers. comm. 1989).

Populations in Pratt, Kingman and Reno Counties overlay the Great Bend Prairie Aquifer. This region is managed by the Groundwater Management District

#5, which practices a safe yield policy where withdrawals approximately equal recharge. This policy appears to be working as depicted by examining stream flow records from the region with the exception of Rattlesnake Creek, Stafford County, to the north and also perched the highest in elevation of the Arkansas darter streams of the area. Eberle and Stark (1998) report that irrigated acres and the potential for such have increased in Kiowa, Pratt, Kingman, and Reno Counties. While no indication of dewatering is yet evident, this area is of concern. Lower stream elevations in these areas help ensure flow from the aquifer even if declines occur in Rattlesnake Creek. Streams with darter populations to the east of Bear Creek Fault (eastern Meade County) and to the south of the Ninnescah drainage are perhaps of least concern. With lower elevations, they would appear to be the last ever impacted by irrigation withdrawals from groundwater sources. Additionally, the terrain and water quality combine to decrease irrigation potentials in these counties.

Populations in southeast Kansas are perhaps most in danger of impacts from construction or stream alteration projects due to the geology of the area. However, they are in the least danger from dewatering. Larger human populations in the area may pose isolated threats from illegal dumping or polluting activities.

V. Protective Laws

A. Federal

A number of federal laws may apply to the protection of Arkansas darters and their habitats. Most notably the U.S. Army Corps of Engineers administers a permit program under Section 404 of the Clean Water Act. This governs fill placed into streams and stream realignment projects. Section 401 of the Clean Water Act provides for state review of water quality impacts from such activities and, while authorized by federal law, is administered by the Kansas Department of Health and Environment. The National Pollution Discharge Elimination System (NPDES) permits awarded under section 402 of the same act are also permitted by KDHE. The U.S. Fish and Wildlife Coordination Act provides for the review and comment of both state and federal agencies concerning fish and wildlife impacts for any federal or nonfederal project which is approved by a federal agency that serves to impound, deepen the channel of, or otherwise control, pollute, or modify waters of the U.S. for any purpose whatsoever. Other federal laws may be relevant in specific instances. For a review of applicable major federal laws affecting Kansas Fish and Wildlife, see Layher (1985).

B. STATE

1. Permitting Requirements

Several state statutes, regulations and procedures may be invoked related to habitat alteration associated with Arkansas darters. Some of these require permits to be acquired.

Foremost, K.A.R. 115 - 15 - 1 and 115 - 15 - 2 lists species declared to be threatened or endangered. K.A.R. 115 - 15 - 3 provides for a permit system including review of habitat alterations. The permit program and review system is administered by the Kansas Department of Wildlife and Parks. This allows the critical review of projects potentially affecting Arkansas darter habitats and the project described in applications may be accepted, modified or revoked.

A host of other actions may trigger various permit requirements of other agencies, especially actions allowing for discharge, dam construction, stream alteration or flood plain development. Most significant of agencies involved is the Division of Water Resources of the State Board of Agriculture. Permit applications through this office are sent out to be reviewed by KDWP as a result of the Water Projects Coordination Act, which was designed to simplify the state overall permitting systems and allow fish and wildlife interest review. Projects identified as potentially impacting a threatened or endangered species would require appropriate permits as well from KDWP.

The KDWP has several MOU's with other agencies, notably the Kansas Department of Transportation, which aids in the identification of road and bridge projects in areas with threatened or endangered species. This MOU has been in force for years and was recently revised February 2000.

Many other permit systems may be activated through a variety of agencies. For a comprehensive review see Monda et al. (1992) and Layher (1985).

2. Critical Habitat Designation

The Kansas Department of Wildlife and Parks has designated the following locations as critical habitat for the Arkansas darter (regarding item 4, refer to appropriate county maps for known population locations):

a. The main stem of the North Fork Ninnescah River on the Stafford/Reno County line (Sec. 31-T24S-R10W) to its confluence with South Fork Ninnescah River in Sedgwick County (Sec. 36-T28S-R4W).

b. The main stem of the South Fork Ninnescah River on the Sedgwick/Kingman County line (Sec. 19-T28S-R4W) to the confluence with the North Fork Ninnescah River (Sec. 36-T34S-R4W) in Sedgwick County.
c. That reach of the main stem of the Spring River from the Kansas-Missouri border in Cherokee County (Sec. 1-T33S-R25E) to where it crosses SE Lostine Road (Sec. 3-T34S-R25E).
d. Numerous perennial spring-fed reaches of named and unnamed streams south of the Arkansas River within Barber, Clark, Comanche, Cowley, Harper, Kingman, Kiowa, Meade, Pratt, Reno, Rice, Sedgwick, Seward, and Stafford counties.

VI. Recovery

A. Objectives

Monitoring, evaluation, recovery and/or downlisting of the Arkansas darter should be addressed on a statewide basis unless genetic analyses reveal that the species actually consists of identifiable subpopulations. If identifiable subpopulations are determined, we recommend treating groups as defined in Section VII as separate entities with subpopulation downlisting criteria for each group. If genetic analyses do not identify distinct subpopulations then downlisting the species should only occur when all tasks for all management groups have been completed with delisting following the timetable for the last of the management group recommendations to be implemented. Hence genetic analyses using organisms from all four management groups should be the first task performed (see Section VII., 2.3.5.).

B. Recovery Criteria

1. Group 1

Group 1 should be downlisted from threatened to SINC (Species In Need of Conservation) only if items VII.: 2.1.1., 2.1.2., 2.1.3., 2.1.5. and 2.1.6. are accomplished and item 2.1.4. reflects habitat and population stability for a period of ten consecutive years. Due to the extreme vulnerability of these populations, removal from the SINC category should occur only after an additional ten year monitoring program indicates no habitat/population/occurrence declines. Hence, total delisting would only occur twenty years after implementation of all items identified for this group have been fully implemented. Delisting should occur no earlier than year 2020.

2. Group 2

Group 2 is perhaps the most stable of currently existing Arkansas darter populations. Based on currently available flow data, it would appear that these populations dependent on flows from the mid to lower portion of the Big Bend Prairie aquifer are not declining. We would recommend that items VII: 2.2.1., 2.2.3., 2.2.6., and 2.2.7. be initiated immediately (year 2001).

If analysis, after a five year period indicates no decline in populations, habitats, or occurrences, this Group 2 could be downlisted to SINC (year 2006). An additional five years of evaluation indicating no declines would provide evidence for delisting in year 2011. Items 2.2.4., 2.2.5., 2.2.8., and 2.2.9., should be ongoing to promote sound conservation practices to afford stream protection.

3. Group 3

Group 3 represents the Rattlesnake Creek population which may be in as much, if not more immediate jeopardy than Group 1. We would recommend following the plan identified in Section VII., 2.3.2., to implement recovery (see also Appendix B). Only after successful implementation and plan monitoring, perhaps over a period of fifteen to twenty years to fully implement, should this population be downlisted to SINC (year 2020). If fully developed, an additional ten years of flow evaluation, habitat and population assessment should be conducted revealing no declines before delisting should be considered (year 2030).

4. Group 4

Group 4 populations are not perceived to be in immediate jeopardy. Perhaps this group is represented less in available literature, however, than any of the other groups. If after all items listed in Section VII., 2.4., are conducted, and populations appear stable, this group could be downlisted to SINC by year 2005. If areas of concern are identified, corrective measures should be implemented as identified in item 2.4.5.. After a five year period from either the initial evaluation if populations appear stable or after corrective measures are taken if necessary, there is no decline in localities or habitats; the Group 4 could be delisted in year 2010.

VII. NARRATIVE OUTLINE

1. Additional species information needs – Biology-life history

While many literature citations exist referring to the Arkansas darter, few provide quantitative information on habitat occupied, life history requisites, or even spawning activity. To better understand the organism, items 1.1, 1.2 and 1.3 should be investigated. Knowledge of habitat needs/requisites, spawning requirements, and factors influencing successful reproduction would aid in overall plans to protect viable populations.

1.1. Define habitat variables in relation to density of species.

1.2. Examine thermal tolerance and egg viability over a temperature and salinity gradient.

1.3. Characterize spawning activity in the field. These items are represented by a paucity of information.

2. Management activities for maintaining species populations and for species recovery

The currently existing populations of Arkansas darters can be divided into four groups with regard to potential threats, existing status, and management options. Historical data indicates that Arkansas darter habitats have declined little in the past 40 years with one major exception. We define group one as those populations occurring in Seward and Meade Counties. These populations are severely threatened from dewatering of springs and streams in the area. Group two includes populations of Arkansas darters in southcentral Kansas with the exception of Group 1 and the Rattlesnake Creek population, which we will define as Group 3. Group 2 populations appear to have declined little and perhaps even appear to be dispersing into larger river systems, albeit due to potential dewatering of the large rivers such as the Arkansas River. Group four is represented by the southeast Kansas population known only from Cherokee County. Management strategies will be listed by the above-defined groups.

2.1 Group 1 Recommendations: Seward and Meade Counties

2.1.1. Establish stream gauges at more upstream points and monitor flow data for Crooked Creek in Meade County. Establish a minimum flow for points along the stream.

2.1.2. Conduct geological/hydrological research to define flows in Crooked Creek

2.1.3. Establish an Intensive Groundwater Use Control Area (IGUCA) or take similar administrative actions to preserve some level of flow in Crooked Creek working in cooperation with GMD #3 and the Kansas Water Office as well as the Division of Water Resources.

2.1.4. Frequently monitor habitat and Arkansas darter populations in select locations in Meade and Seward Counties, perhaps as often as annually to forewarn of further habitat decline. Sites selected should include several sites on the edge of the current distribution (upstream populations).

2.1.5. Utilize existing avenues and resources, along with item 2.1.2. to designate a stream corridor zone of influence with regard to water withdrawals from groundwater sources. While the overall stream flow is a result of water levels in the Ogallala aquifer, reducing cone-of-depression influence will increase stream longevity to some degree. This may only be prolonging the inevitable if Ogallala depletion continues.

2.1.6. Work with GMD #3 to maximize water conservation measures by irrigators, assist to maximum extent possible implementation of water plan conservation measures and support state policy decisions in such areas.

2.1.7. After review of flow records, if it appears that cessation of flows is imminent, augmentation of stream flow with groundwater pumping to maintain a viable population of Arkansas darters, should be considered. Water rights would have to obtained through a trade with a landowner to irrigate a site perhaps away from the stream or through a water banking program.

2.2 Group 2 Recommendations:

2.2.1. Evaluate existing data for streams that drain tributaries containing Arkansas darter populations with established minimum flow levels to evaluate whether such levels have been met. Evaluate administration of enforcement of minimum desirable steam flows in cases where flows dropped below those established by K.S.A. 82a-7o3c.

2.2.2. Request enforcement of water right use restrictions if flows drop below those minimum desirable stream flows established for rivers which receive flows from tributaries containing Arkansas darters. Rivers include Arkansas River, Rattlesnake Creek, N.F. Ninnescah, S.F. Ninnescah, Medicine Lodge, and Chikaskia.

2.2.3. Establish a monitoring program to evaluate range and distribution of Arkansas darters. As with 2.1.4. select some sites on periphery of range (especially upstream sites) to quickly determine declining habitats or population losses.

2.2.4. Encourage landowners to participate in water conservation measures.

2.2.5. Coordinate with County Conservation District office to promote and enroll landowners in CRP, WRP, EQIP and other water quality and habitat programs by establishing up-to-date conservation plans for all farms possible. Promote buffer strip programs such as continuous CRP signups (CP 21) to reduce water needs for crops and protect water quality. Promote establishment of out-of-stream watering for livestock. Conduct inventories using aerial photography or other techniques to identify problem areas such as no buffer, gully erosion, failed banks, etc.

2.2.6. Evaluate stream and water table data in cooperation with GMD #5 to gather information concerning area groundwater trends (declines and/or increases). The GMD #5 currently monitors data (base flow nodes) along some stream courses.

2.2.7. Monitor locations and new irrigation well development to become alerted to possible stream flow alteration. Request additional node placement on select stream areas if warranted.

2.2.8. Establish communications with GMD #5 to develop procedures/plans to limit well development along stream corridors.

2.2.9. Promote water conservation programs throughout the area.

2.3. Group 3 Recommendations:

2.3.1. Conduct a longitudinal survey of Rattlesnake Creek for its entire length to document locations and densities of Arkansas darters in 2001 to be used as baseline information.

2.3.2. Assist GMD #5, the U.S. Fish and Wildlife Service and the Kansas Department of Agriculture, Division of Water Resources in implementing and promoting the "Rattlesnake Creek Management Program Proposal" by the Rattlesnake Creek/Quivira Partnership.

2.3.3. Assess Arkansas darter populations along Rattlesnake Creek every four years to coincide with the evaluation of program in item 2.3.2.

2.3.4. Evaluate Arkansas darter distribution and populations in relation to trend data collected by GMD #5.

2.3.5. Re-establish Arkansas darters to areas within Rattlesnake Creek if conditions improve, i.e. increased stream flow and reduced salinity, if populations within the stream declined prior to habitat improvements and were incapable of providing recruitment up or downstream naturally. Examination of genetics (loci) may be necessary to compare populations to other sources.

2.3.6. If monitoring of flows in Rattlesnake Creek indicate that cessation of flows is imminent, stream flows should be augmented with groundwater pumping, perhaps using formerly retired water rights programs referred to in the "Rattlesnake Creek Management Program Proposal."

2.4. Group 4 Recommendations:

2.4.1. Assess current locations of Arkansas darter populations along the Spring River in Cherokee County and Shoal Creek.

2.4.2. Assess potential of sites for disturbance, development, etc.

2.4.3. Compare occurrences to historical data and collections to indicate if declines have occurred or habitat has been reduced.

2.4.4. Determine location of spring areas and small backwaters to be avoided by developers, transportation projects, etc.

2.4.5. Evaluate occurrences for potential impacts. If disturbances such as cattle watering, riparian removal, etc, appear to be encroaching on spring seepages, work with District Conservationists, NRCS, and landowners to develop conservation plans to implement protective measures for springs and seeps using EQIP, CRP, buffer initiatives and other federal programs. CRP practices such as CP 21, CP 3A, CP 2 and CP 4B may apply in given situations.

VIII. Costs of Recovery Plan Implementation

Additional life history studies would require $10,000 - $15,000 to complete. Due to the separation of the populations into management groups included in the review, costs of implementing the recovery plan will be addressed following the group designation in section VII. 2. for each group and item. The costs required to implement this recovery plan can only be estimated.

For Group 1:

Item 2.1.1. Stream gauge establishment is estimated at $10,000 per gauge. Establishment of minimum flows could be evaluated in-house or contracted for evaluation for approximately $5,000.

Item 2.1.2. An instream flow assessment could be accomplished as in Item 2.1.1. and evaluated in relation to current groundwater level/streamflow information as related to historical records. This analysis could be accomplished for $8,000 - $10,000.

Item 2.1.3. Establishment of an IGUCA could be accomplished with existing personnel from agencies and entities involved.

Item 2.1.4. Arkansas darter populations could be monitored and/or evaluated annually at a cost of $3,000 or perhaps with current KDWP personnel as part of ongoing duties.

Item 2.1.5. It is envisioned that this task might be accomplished with existing data and personnel from Kansas Geological Survey and other appropriate agencies.

Item 2.1.6. This task should be ongoing with existing personnel of the GMD#3 and all involved state and local agencies.

For Group 2:

Item 2.2.1. This task could use existing flow records and be performed with in-house personnel as part of ongoing duties. Such an evaluation could be performed under contract for approximately $5,000.

Item 2.2.2. Enforcement of minimum streamflows in Kansas should be an ongoing activity currently within the Division of Water Resources budgets.

Item 2.2.3. Monitoring of Arkansas darters within the area addressed could be performed annually for $6,000 - $10,000 or perhaps, utilizing existing KDWP personnel.

Item 2.2.4. Encouraging landowners to participate in water conservation measures should require no new funds and be a goal of all entities associated with current and future water usage.

Item 2.2.5 Most counties and NRCS offices contain personnel to conduct and develop farm plans for landowners participating in government, especially USDA programs. Encouragement of enrollment by landowners in conservation programs could be accomplished through existing KDWP personnel by coordinating with county conservation district employees.

Item 2.2.6. Evaluation of stream data and groundwater levels can be accomplished by coordination between KDWP and GMD employees.

Item 2.2.7. As in item 2.2.6., a periodic review of new well applications and potential stream impacts could be conducted by coordination and cooperation between staffs of agencies collecting such data and KDWP staffs.

Item 2.2.8. This activity closely relates to the previous item and should be an outcome of that activity.

Item 2.2.9. Promoting water conservation needs to be a priority of all water users and regulators in the affected area.

For Group 3:

Item 2.3.1. A survey of Rattlesnake Creek for its entire length to document locations of Arkansas darters could be conducted for about $5,000.

Item 2.3.2. One should refer to the document "Rattlesnake Creek Management Program Proposal" for costs of this initiative. KDWP's involvement and promotion of the partnership should not result in the need for additional funds.

Item 2.3.3. After Arkansas darter populations are identified as in Item 2.3.1., future year assessments at specific sites could be accomplished using KDWP personnel or contracted for less than $2,000 per annum, once each four year period.

Item 2.3.4. These data could be analyzed in-house at no additional costs to the agency.

Item 2.3.5. This activity may never be needed if flows continue in Rattlesnake Creek. Despite whether or not flows cease, the genetics of Arkansas darters in the stream should be examined and compared to select populations in the other groups. A DNA analysis for the four groups is estimated to cost $10,000.

Item 2.3.6. Costs for well development, continued pumping and maintenance are not estimated, but could undoubtedly be estimated by GMD personnel.

For Group 4:

Item 2.4.1. An intensive assessment of Arkansas darter populations in southeast Kansas could be accomplished for $5,000 - $8,000.

Item 2.4.2. A review of sites for potential disturbance would be most easily performed in conjunction with the survey under Item 2.4.1., and in such a case it would not require additional funds.

Item 2.4.3. This comparison could be made, if the survey in Item 2.4.1. were completed by existing KDWP personnel at no additional costs.

Item 2.4.4. The identification of areas needing protection could also be a product of the survey under Item 2.4.1.

Item 2.4.5. Coordination between KDWP and the Cherokee County District Conservationist would ensure that these tasks are addressed as part of ongoing activities.

Table 1. Mean density of Arkansas darters in southcentral Kansas streams related to increments of physical and chemical variables (Mitchell 2000). See also figures 3 – 19.

Habitat variable and range (<=x<)	N	Mean Density (#/ha)	Habitat variable and range (<=x<)	N	Mean Density (#/ha)
Phosphorus (mg/L)			Alkalinity		
0 – 0.25	25	98.53	0 – 50	3	30.63
0.25 – 0.50	5	74.20	50 – 100	4	21.92
0.50 – 0.75	0	0.00	100 – 150	4	2.10
0.75 – 1.00	1	25.64	150 – 200	12	80.10
1.00 – 1.25	0	0.00	200 – 250	8	204.91
1.25 – 1.50	1	45.22	250 – 300	2	58.54
1.50 – 1.75	0	0.00			
1.75 – 2.00	1	0.50	PH		
			7.00 – 7.25	1	34.12
Nitrates (mg/L)			7.25 – 7.50	3	83.77
0 – 1	14	58.91	7.50 – 7.75	0	0.00
1 – 2	9	154.56	7.75 – 8.00	54	144.80
2 – 3	1	41.26	8.00 – 8.25	7	78.45
3 – 4	3	29.48	8.25 – 8.50	5	293.42
4 – 5	2	125.87	8.50 – 8.75	8	44.04
5 – 6	1	250.00	8.75 – 9.00	5	3.38
6 – 7	2	12.05	9.00 – 9.25	2	23.83
35 – 36	1	34.12			
			Dissolved oxygen (mg/L)		
Ammonia (mg/L)			2.00 – 4.00	2	9.65
.00 – 0.05	9	141.30	4.00 – 6.00	8	42.84
.05 – 0.10	7	63.37	6.00 – 8.00	21	134.03
0.10 – 0.15	6	63.20	8.00 – 10.00	7	46.86
0.15 – 0.20	5	74.58	10.00 – 12.00	1	2.56
0.20 – 0.25	0	0.00			
0.25 – 0.30	1	307.12	TDS (mg/L)		
0.30 – 0.35	1	8.66	0 – 300	16	65.02
0.35 – 0.40	0	0.00	300 – 600	8	208.67
0.40 – 0.45	2	19.23	600 – 900	9	46.24
			900 – 1200	0	0.00
Chlorides (mg/L)			1200 – 1500	0	0.00
0 – 250	25	112.98	1500 – 1800	0	0.00
250 – 500	5	11.79	1800 – 2100	3	43.74
500 – 750	0	0.00	2100 – 2400	2	125.11
750 – 1000	1	9.71	2400 – 2700	0	0.00
1000 – 1250	0	0.00	2700 – 3000	1	6.80
1250 – 1500	1	5.57			
1500 – 1750	1	6.80	H_2O Temperature (°C)		
			15 – 20	7	76.39
			20 – 25	9	44.21
			25 – 30	9	44.21

Table 1. Continued.

Habitat variable and range (<=x<)	N	Mean Density (#/ha)	Habitat variable and range (<=x<)	N	Mean Density (#/ha)
Turbidity NTU			Depth (cm)		
0 – 50	27	112.33	0 – 5	1	307.12
50 – 100	8	47.70	5 – 10	11	46.17
100 – 150	3	21.79	10 – 15	5	54.92
150 – 200	0	0.00	15 – 20	10	200.56
200 – 250	0	0	20 – 25	7	46.36
250 – 300	0	0.00	25 – 30	2	21.98
300 – 350	0	0.00	30 – 35	0	0.00
350 – 400	1	34.12	35 – 40	0	0.00
			40 – 45	0	0.00
Conductivity (uS)			45 – 50	1	2.69
0 – 500	11	149.54			
500 – 1000	10	67.50	Macrophytes (%)		
1000 – 1500 4	8	158.99	0	16	440.49
1500 – 2000	4	95.68	<10	15	122.49
2000 – 2500	0	0.00	10 – 40	6	126.70
2500 – 3000	0	0.00	40 – 75	0	0.00
3000 – 3500	0	0.00	>75	1	1.00
3500 – 4000	3	43.74			
4000 – 4500	1	5.57	Filamentous Algae (%)		
4500 – 5000	1	244.65	0	32	52.98
5000 – 5500	1	6.80	<10	5	297.48
			10 – 40	2	165.65
Discharge (cfs)			40 – 75	0	0.00
0 – 20	17	177.10	>75	0	0.00
20 – 40	10	38.89			
40 – 60	2	3.04			
60 – 80	2	22.09			
80 – 100	3	13.07			
100 – 120	0	0.00			
120 – 140	0	0.00			
140 – 160	3	2.22			
Width (m)					
0 – 10	18	161.45			
10 – 20	11	38.84			
20 – 30	4	14.81			
30 – 40	2	56.87			
40 – 50	0	0.00			
50 – 60	2	3.43			
60 – 80	2	0.50			

Table 2. Variables at sites of occurrence and nonoccurrence of Arkansas darters in south-central Kansas (Mitchell 2000).

	Present				Absent			
	Mean	Standard Deviation	Range	N	Mean	Standard Deviation	Range	N
Channel Width	17.02	17.03	3.13 – 66.40	39	14.40	12.88	2.50 – 63.77	68
Depth	15.78	8.14	1.91 – 45.70	39	25.52	13.68	5.67 – 67.73	68
Discharge	36.84	40.86	2.16 – 146.04	37	42.71	72.83	0.00 – 480.66	61
H_2O Temp.	22.06	2.68	15.80 – 27.00	39	23.41	2.44	17.40 – 29.00	68
Conductance	1359.54	1370.80	140.00 – 5480.00	39	1195.19	1113.50	233.00 - 6100.00	68
Turbidity	48.15	58.91	3.00 – 352.00	39	68.24	95.18	8.00 – 596.00	68
TDS	676.54	709.30	67.00 – 2890.00	39	555.24	511.83	49.00 – 3050.0	68
Oxygen	6.88	1.60	3.30 – 11.30	39	7.07	4.05	3.20 – 37.00	67
PH	7.79	1.84	1.40 – 9.00	39	7.55	1.92	1.10 – 9.00	68
Alkalinity	161.02	66.36	16.00 – 271.00	33	188.96	74.99	31.00 – 447.00	56
Chlorides	190.82	359.41	1.80 – 1501.00	33	251.12	719.97	0.30 – 5000.00	55
Ammonia	0.12	0.11	0.00 – 0.43	31	0.10	0.13	0.00 – 0.55	55
Nitrates	2.84	6.18	0.10 – 35.80	33	3.41	6.84	0.00 – 35.80	54
Phosphorus	0.23	0.39	0.02 – 1.87	33	0.21	0.31	0.01 – 1.76	56

Table 3. Vegetation estimate (Mitchell 2000) at sites where Arkansas Darters were found (see text).
(0 = 0%; 1 = <10%; 2 = 10 – 40%; 3 = 40 – 75%; 4 = >75%)

Site	Mean Macrophytes	Mean Filamentous Algae
001-LARB-99	3.09	2
001-STWD-96	1.73	2
002-STWD-96	0.91	0
003-LARB-99	1.00	1
005-LARB-99	0.00	0
007-LARB-99	0.00	0
009-LARB-99	0.00	0
013-STWD-96	0.00	0
017-LARB-99	0.91	0
018-LARB-99	0.00	0
019-LARB-99	0.73	0
020-LARB-99	0.00	0
021-STWD-96	1.36	0
022-LARB-99	0.00	0
022-STWD-96	0.00	0
023-STWD-96	0.82	0
024-GEMO-99	1.00	0
026-GEMO-99	0.09	0
032-GEMO-99	0.00	0
033-LARB-99	0.00	0
035-LARB-99	0.00	0
036-LARB-99	0.09	1
039-LARB-99	0.00	0
040-STWD-97	0.00	0
041-STWD-97	0.00	0
042-GEMO-99	0.82	0
044-LARAB-99	0.00	0
09452	1.00	0
09491	0.82	0
09625	0.00	0
09643	0.55	0
004-GEMO-99	1.45	1
005-GEMO-99	1.00	0
010-STWD-97	0.82	0
014-STWD-97	1.09	1
017-STWD-97	0.18	0
018-STWD-97	1.00	0
09453	1.55	1
09498	1.36	0
Total Mean	0.60	0.23

Table 4. Vegetation estimates (Mitchell 2000) at sites of nonoccurrence in southcentral Kansas.
(0 = 0%; 1 = <10%; 2 = 10 – 40%; 3 = 40 – 75%; 4 = >75%)

Site	Mean Macrophytes	Mean Filamentous Algae
001-GEMO-99	0.09	0
002-GEMO-99	1.82	1
002-LARB-99	1.36	1
003-GEMO-99	1.73	0
004-LARB-99	0.09	0
006-LARB-99	3.27	2
007-GEMO-99	0.18	1
008-GEMO-99	0.00	0
009-LARB-99	1.18	0
010-LARB-99	0.00	0
011-LARB-99	0.00	0
012-LARB-99	0.00	0
012-STWD-96	0.09	0
012-STWD-97	1.09	0
013-LARB-99	0.00	0
013-STWD-97	0.82	1
014-LARB-99	0.00	0
014-STWD-96	0.55	1
015-LARB-99	0.00	0
015-STWD-96	0.00	0
016-LARB-99	0.18	0
016-STWD-96	0.00	0
019-STWD-97	1.09	0
021-LARB-99	0.00	0
023-GEMO-99	0.00	0
023-LARB-99	0.00	0
024-LARB-99	0.00	0
025-GEMO-99	0.00	0
025-LARB-99	1.36	0
026-LARB-99	0.64	0
027-LARB-99	1.45	0
028-LARB-99	1.64	0
029-GEMO-99	0.00	0
029-LARB-99	0.00	0
030-LARB-99	0.36	0
031-GEMO-99	0.00	0
031-LARB-99	0.09	0
032-LARB-99	0.18	0
034-LARB-99	0.36	0
037-LARB-99	0.09	0
037-STWD-97	0.00	1
038-LARB-99	0.00	0

Table 4. Continued.

Site	Mean Macrophytes	Mean Filamentous Algae
040-LARB-99	0.00	0
041-GEMO-99	0.00	0
041-LARB-99	0.00	0
042-LARB-99	0.00	0
042-STWD-97	2.27	1
043-LARB-99	0.00	0
043-STWD-96	0.45	1
043-STWD-97	0.00	0
045-LARB-99	1.00	0
09451	0.91	0
09464	0.91	0
09468	1.73	0
09469	0.18	0
09484	1.00	0
09490	1.09	0
09495	1.18	1
09624	0.00	0
09630	0.00	0
09633	0.00	0
09646	0.00	0
KBC-05	0.00	0
006-GEMO-99	1.73	1
009-STWD-97	1.73	0
011-STWD-97	1.09	0
015-STWD-97	1.00	1
016-STWD-97	1.00	0
Total Mean	0.54	0.19

Table 5. Substrate at various sites sampled (Mitchell 2000).

Substrate Type	% of Substrate at Capture Sites	% of Substrate at All Sites
Bedrock (smooth)	0.0	1.0
Bedrock (rough)	0.7	2.4
Boulder	0.4	1.3
Cobble	0.1	2.8
Course Gravel	0.6	5.2
Fine Gravel	4.1	6.0
Sand	85.9	59.7
Silt/Clay	7.7	21.4
Wood	0.4	0.4
Other	0.0	1.5

Table 6. Percent of sites sampled and frequency of occurrence of various substrates (Mitchell 2000).

Substrate Type	% of Substrate at Capture Sites	% of Substrate at All Sites
Bedrock (smooth)	0.0	1.0
Bedrock (Rough)	0.7	2.4
Boulder	0.4	1.3
Cobble	0.1	2.8
Course Gravel	0.6	5.2
Fine Gravel	4.1	6.0
Sand	85.9	59.7
Silt/Clay	7.7	21.4
Wood	0.4	0.4
Other	0.0	1.5

Table 7. Percent of sites (Mitchell 2000) where Arkansas darters and various fishes were captured (species association).

Species	Number of Sites	% Association
Longnose gar	2	5.13
Gizzard shad	10	25.64
Central stoneroller	31	79.49
Sand shiner	38	97.44
Southern redbelly dace	2	5.13
Fathead minnow	27	69.23
Red shiner	38	97.44
Bluntnose minnow	7	17.95
Bullhead minnow	10	25.64
Common carp	29	74.36
Suckermouth minnow	20	51.28
Plains minnow	7	17.95
Emerald shiner	6	15.38
Goldfish	6	15.38
Unidentified minnow	2	5.13
Speckled chub	3	7.69
Bluntface shiner	2	5.13
Golden shiner	2	5.13
Red river shiner	2	5.13
Golden redhorse	3	7.69
River carpsucker	9	23.08
Shorthead redhorse	1	2.56
Smallmouth buffalo	3	7.69
Black buffalo	2	5.13
Quillback	1	2.56
Black bullhead	18	46.15
Yellow bullhead	22	56.41
Flathead catfish	8	20.51
Channel catfish	26	66.67
Freckled Madtom	1	2.56
Plains killifish	30	76.92
Western mosquitofish	35	89.74
Brook silverside	2	5.13
White bass	3	7.69
Wiper	1	2.56
White perch	2	5.13
Bluegill	22	56.41
Green sunfish	35	89.74
Largemouth bass	25	64.10
Longear sunfish	10	25.64
Orangespotted sunfish	10	25.64
Bluegill x green sunfish	1	2.56
Warmouth	1	2.56

Table 7. Continued.

Species	Number of Sites	% Association
White crappie	3	7.69
Orangethroat darter	13	33.33
Sauger	1	2.56
Walleye	2	5.13
Slenderhead darter	2	5.13
Freshwater drum	4.	10.26

Table 8. Arkansas darter densities for sites of occurrence (Mitchell 2000).

Site #	Stream	#Arkansas darters present	Arkansas darter density (#ha)
001-LARB-99	Turkey Creek	66	250.00
001-STWD-96	Turkey Creek	20	81.30
002-STWD-96	Smoots Creek	1	2.56
003-LARB-99	North Fork Ninnescah River	56	1192.76
005-LARB-99	Nescatunga Creek	13	98.66
007-LARB-99	Thompson Creek	4	68.08
008-LARB-99	Salt Fork Arkansas River	1	2.43
013-STWD-96	Elm Creek	6	11.49
017-LARB-99	Goose Creek	13	249.04
018-LARB-99	Peace Creek	1	6.80
019-LARB-99	South Fork Ninnescah River	1	4.33
020-LARB-99	Rattlesnake Creek	7	41.26
021-STWD-96	Painter Creek	21	283.94
022-LARB-99	Rattlesnake Creek	9	5.57
022-STWD-96	Silver Creek	82	307.12
023-STWD-96	South Fork Ninnescah River	30	43.29
024-GEMO-99	Goose Creek	3	45.22
026-GEMO-99	Silver Creek	8	25.64
032-GEMO-99	South Fork Ninnescah River	1	0.50
033-LARB-99	South Fork Ninnescah River	4	4.57
035-LARB-99	Chikaskia River	2	1.28
036-LARB-99	Sand Creek	7	12.53
039-LARB-99	South Fork Ninnescah River	1	0.50
040-STWD-97	South Fork Ninnescah River	13	34.12
041-STWD-97	Chikaskia River	2	2.69
042-GEMO-99	Rattlesnake Creek	6	43.09
044-LARB-99	Medicine Lodge River	1	0.88
09452	Mule Creek	8	25.16
09491	North Fork Ninnescah River	2	3.97
09625	North Fork Ninnescah River	34	61.93
09643	Rattlesnake Creek	16	160.00
004-GEMO-99	Crooked Creek	1	9.71
005-GEMO-99	Cimarron River	6	8.66
010-STWD-97	Cavalry Creek	1	18.42
014-stwd-97	Big Sandy Creek	3	27.74
017-STWD-97	Bluff Creek	1	2.69
018-STWD-97	Crooked Creek	1	18.52
09453	Crooked Creek	80	244.65
09498	Cimarron River	108	112.85
	Mean	16.41	90.1
	Standard Deviation	26.12	201.35
	Range	1 – 108	0.50 – 1192.26
	N	39	39

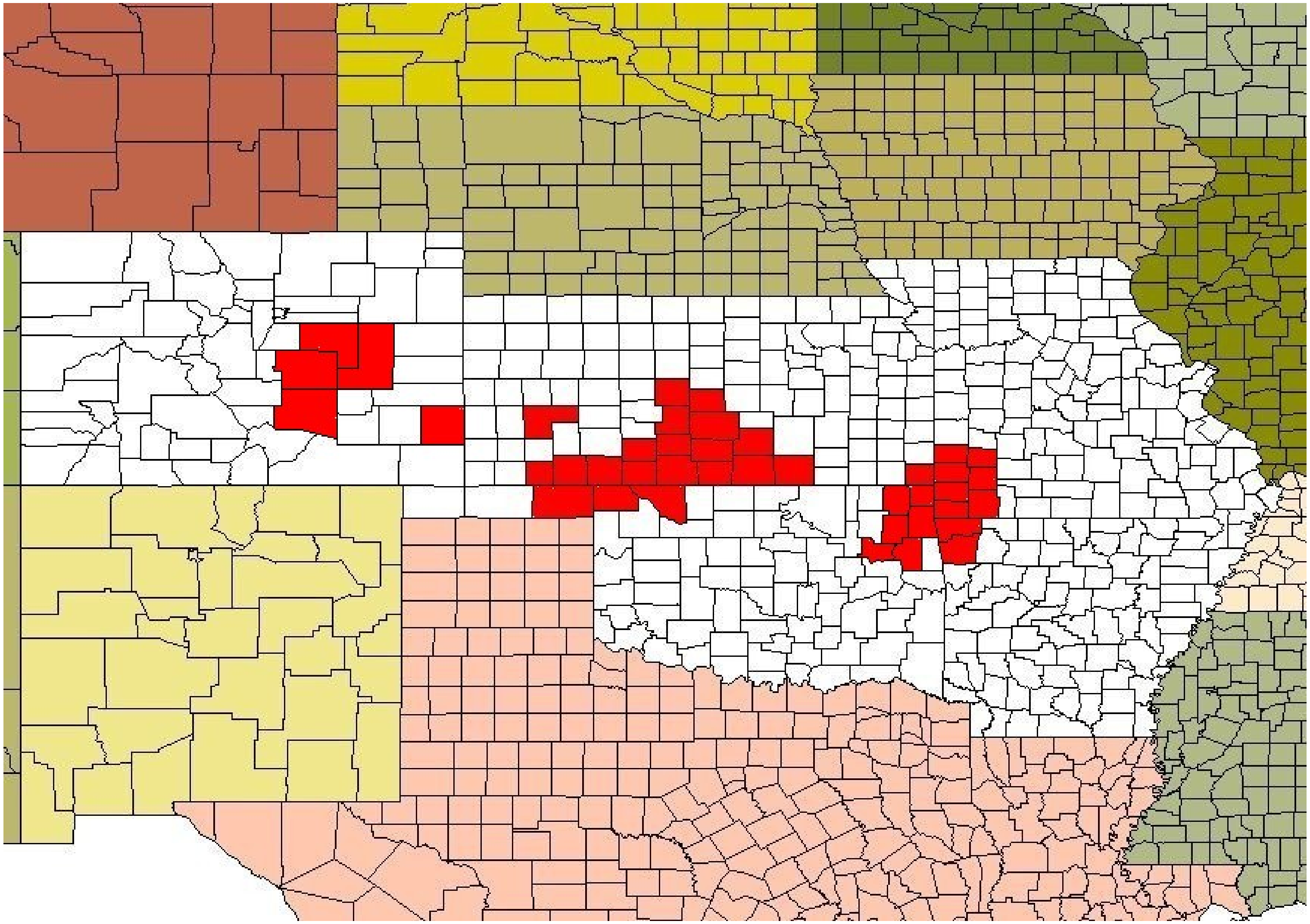

Figure 1. Historical distribution of Arkansas darters based on known collection records (red).

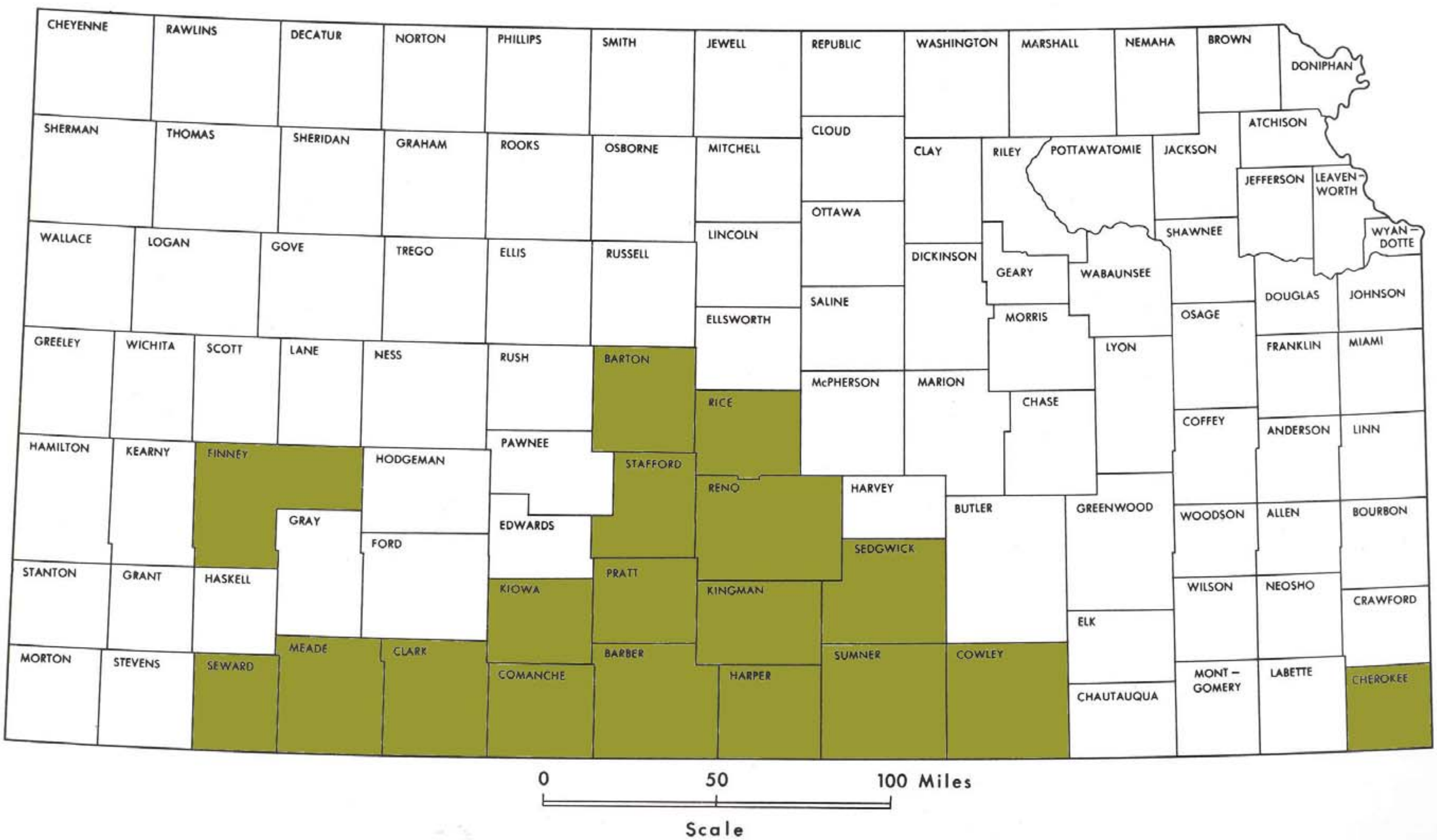

Figure 2. Distribution of the Arkansas Darter in Kansas.

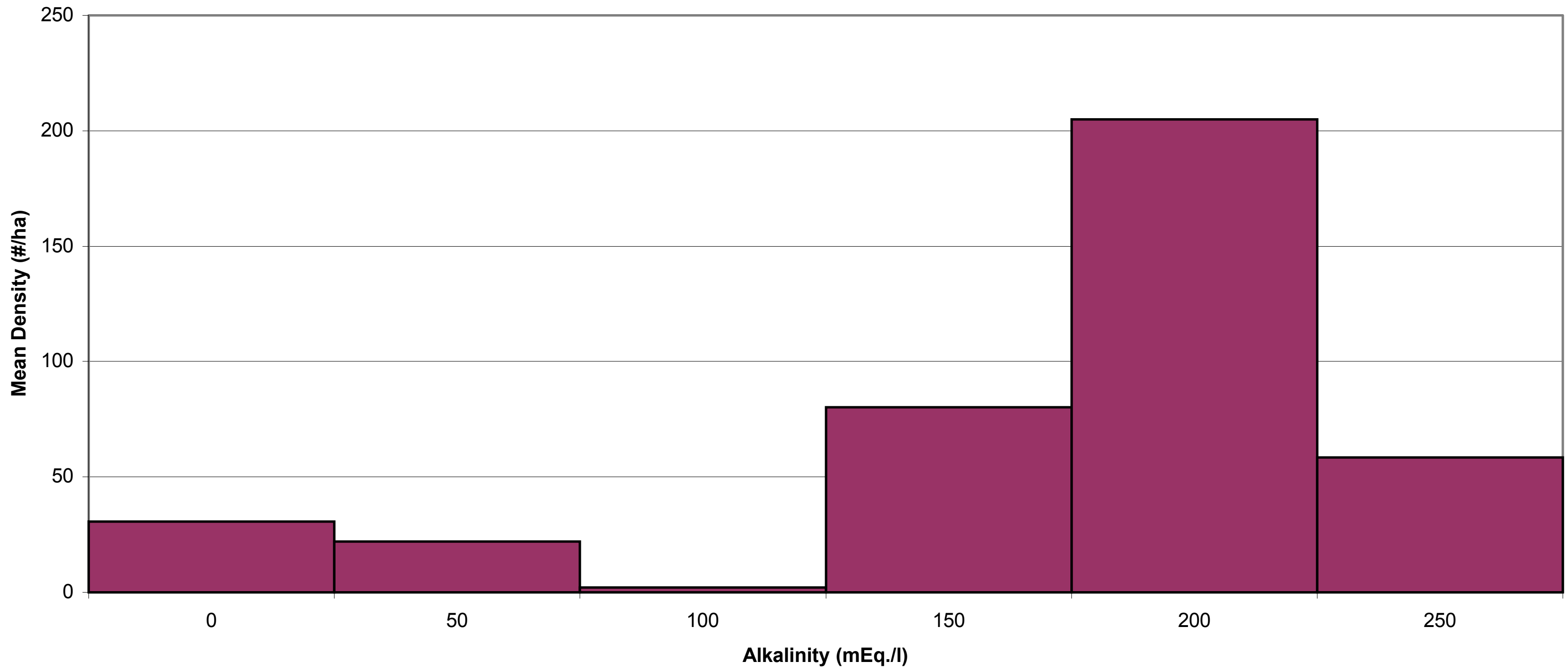

Figure 3. Relationship between Arkansas darter density and alkalinity .

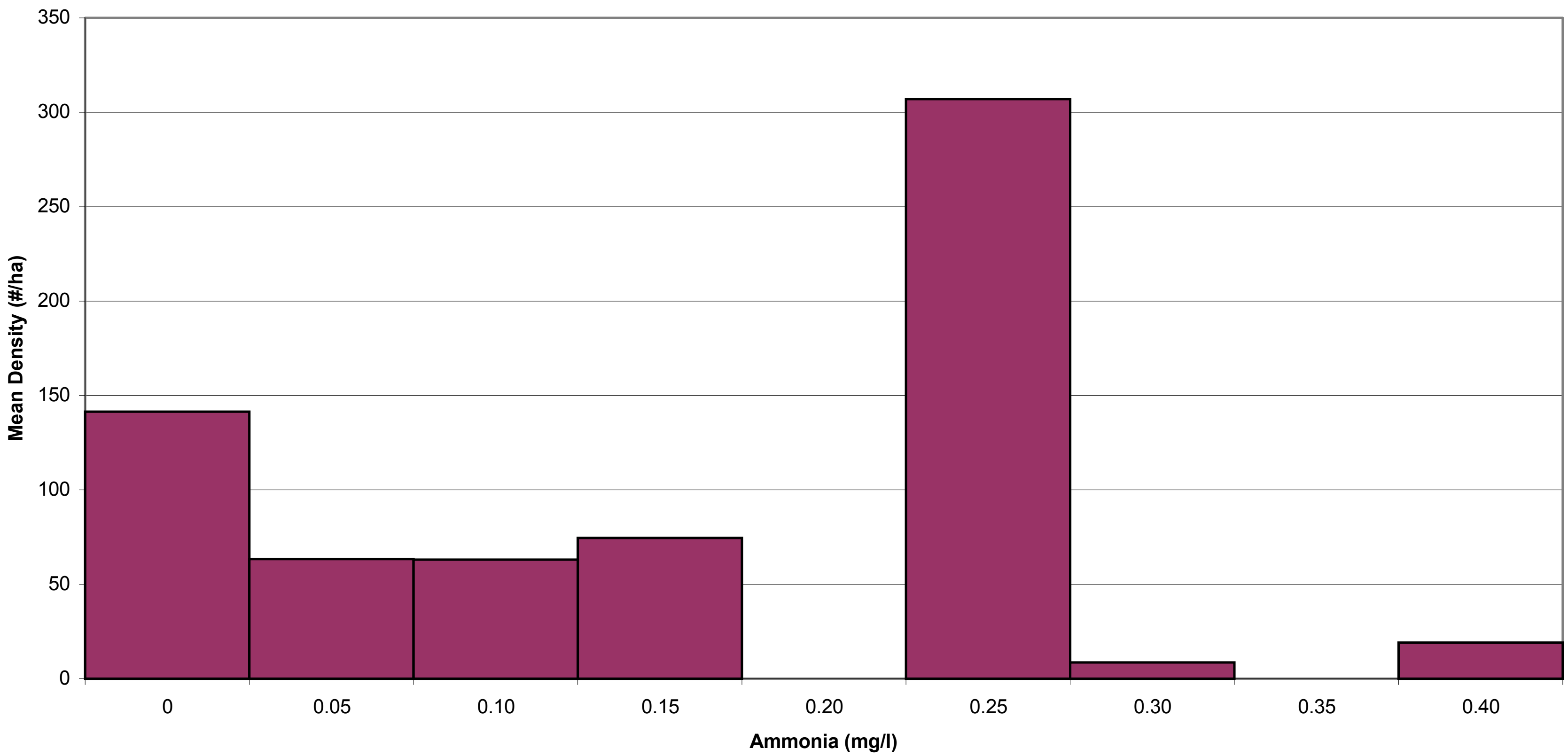

Figure 4. Relationship between Arkansas darter density and ammonia.

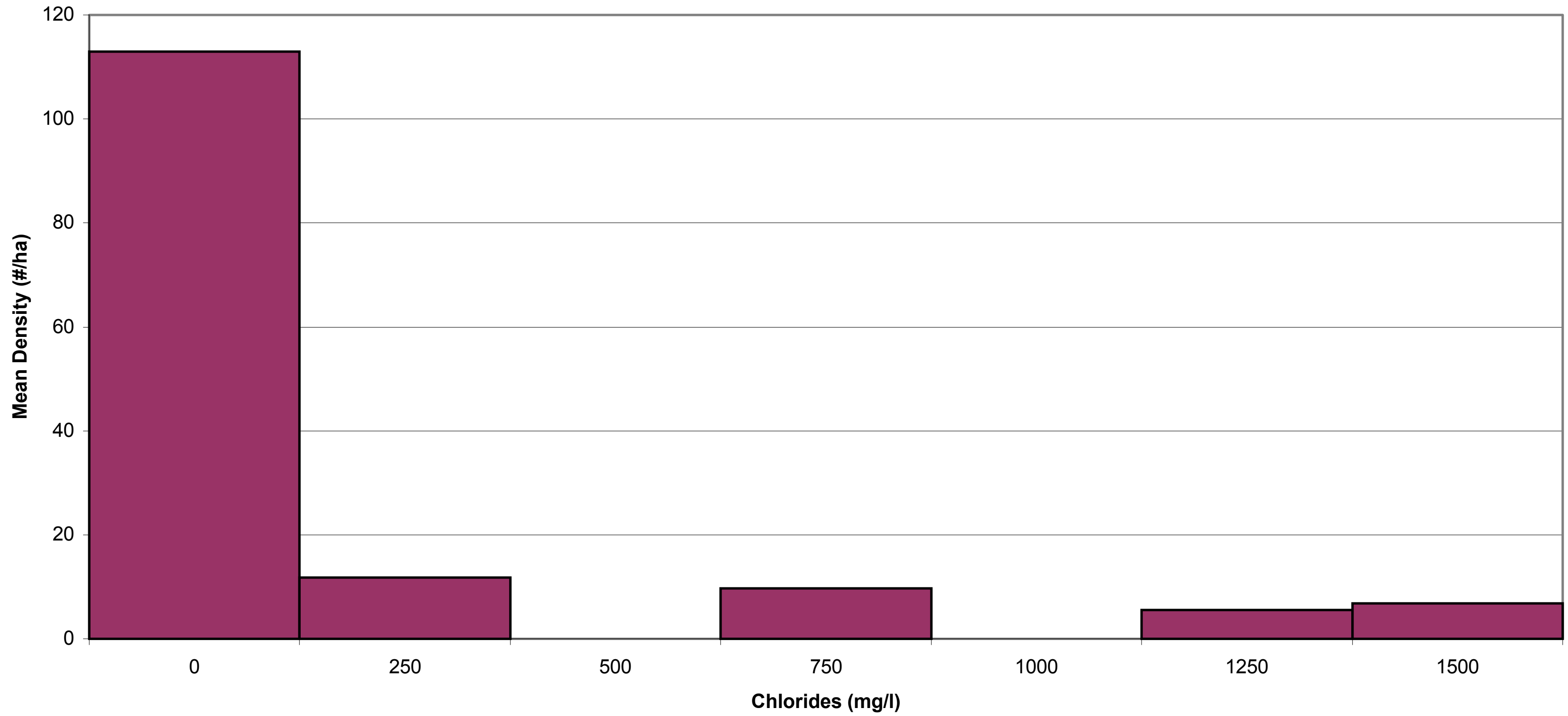

Figure 5. Relationship between Arkansas darter density and chlorides.

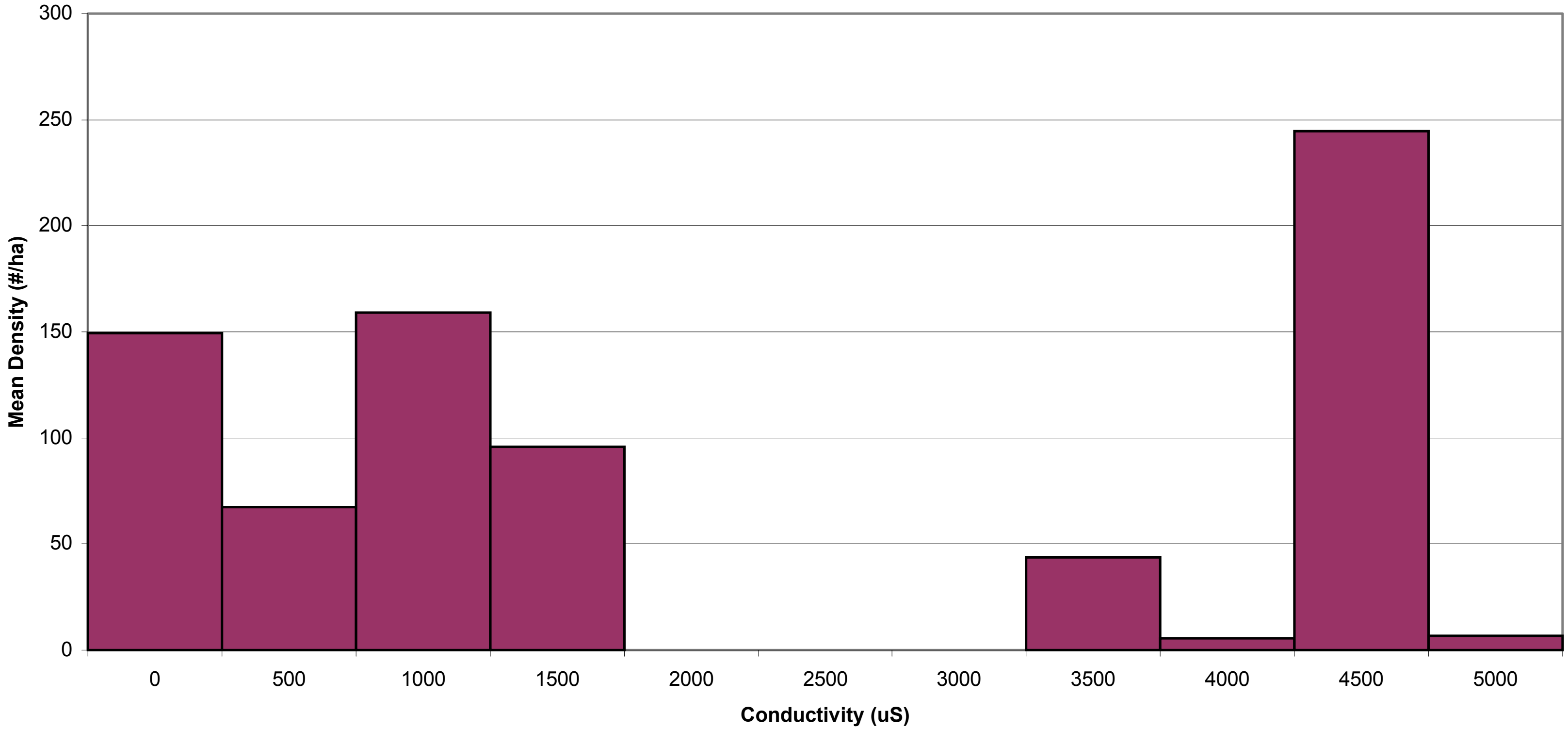

Figure 6. Relationship between Arkansas darter density and conductivity.

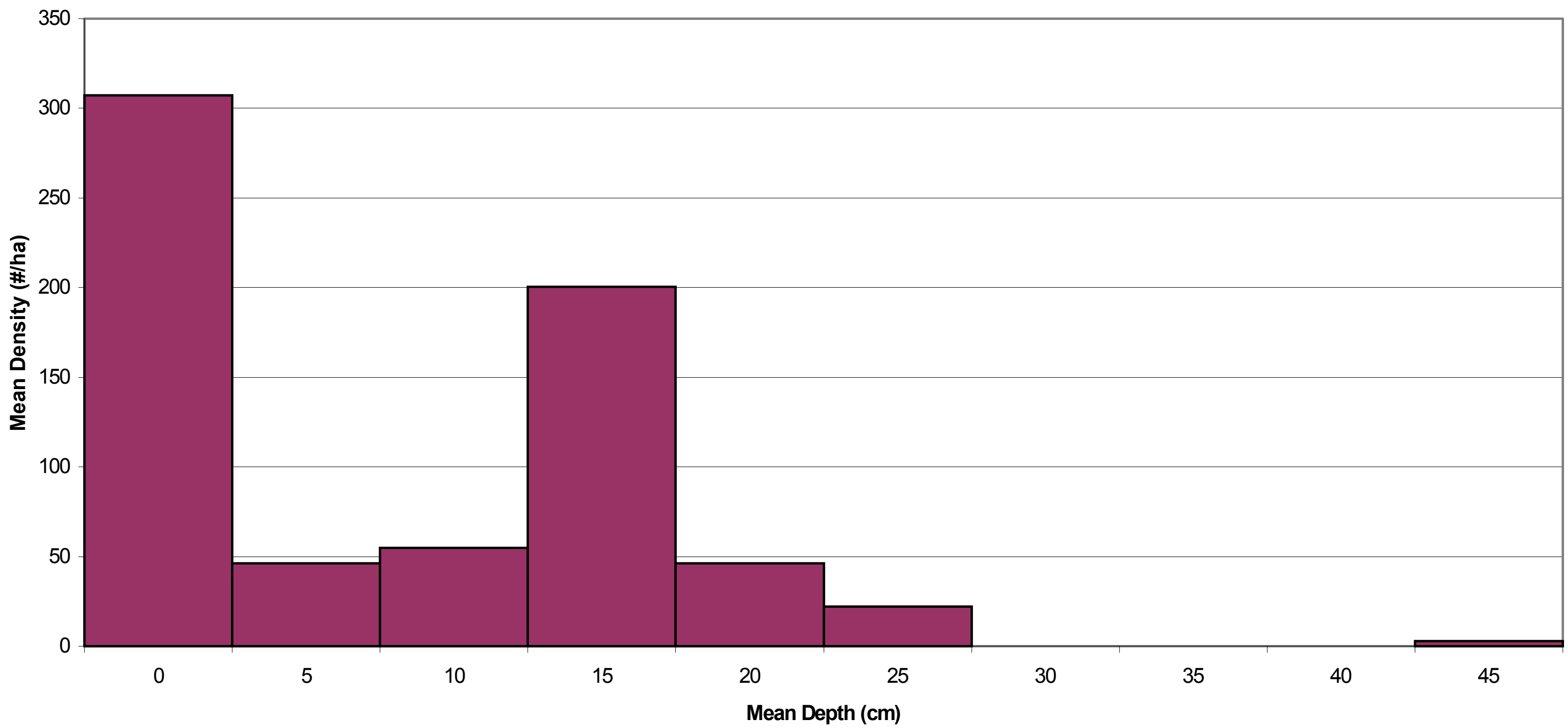

Figure 7. Relationship between Arkansas darter density and mean stream depth.

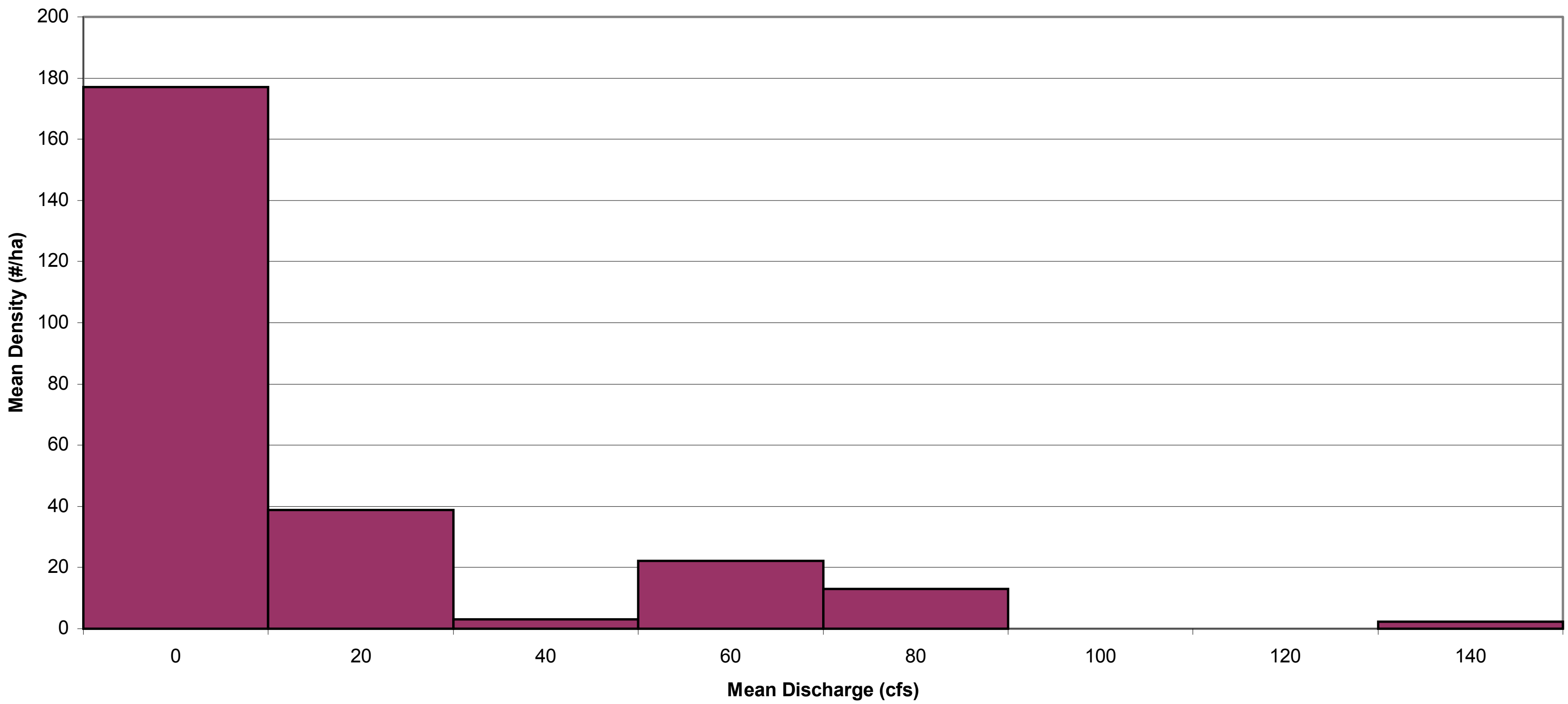

Figure 8. Relationship between Arkansas darter density and mean stream discharge.

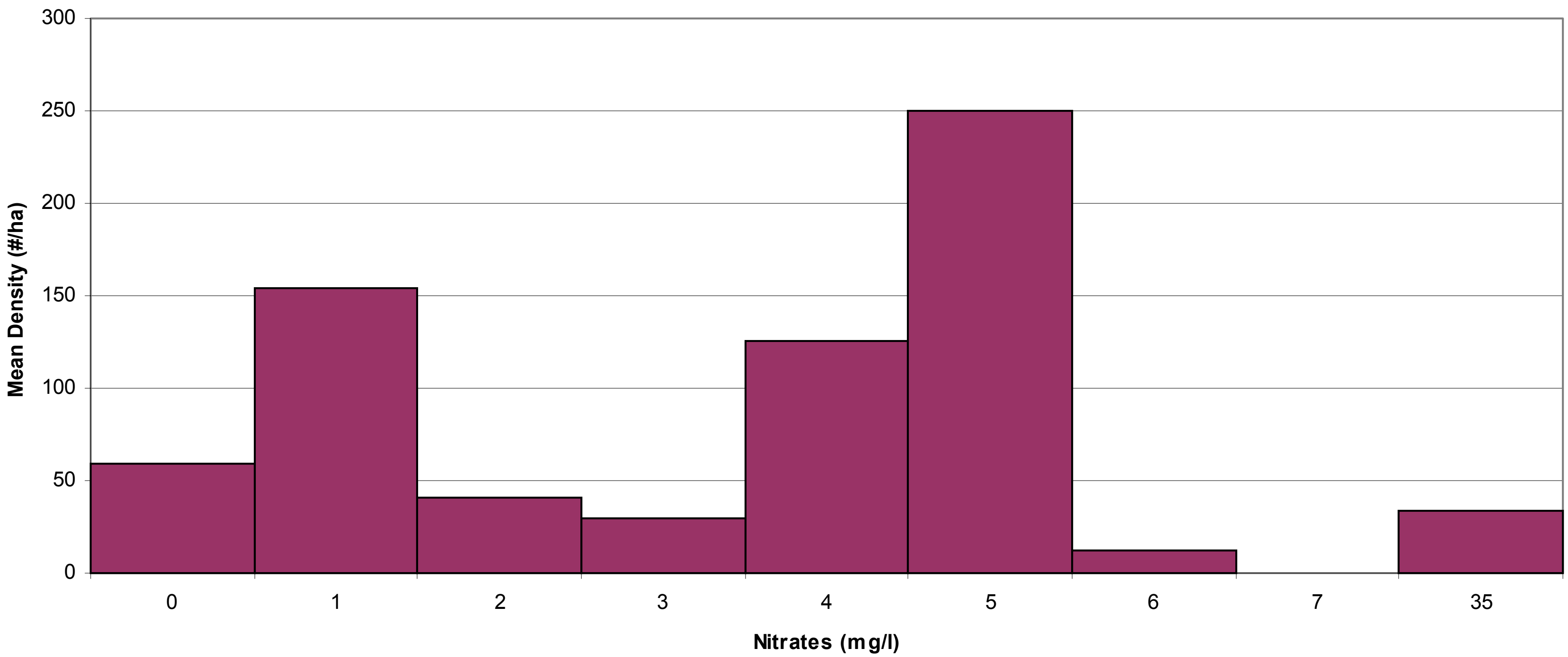

Figure 9. Relationship between Arkansas darter densities and nitrates.

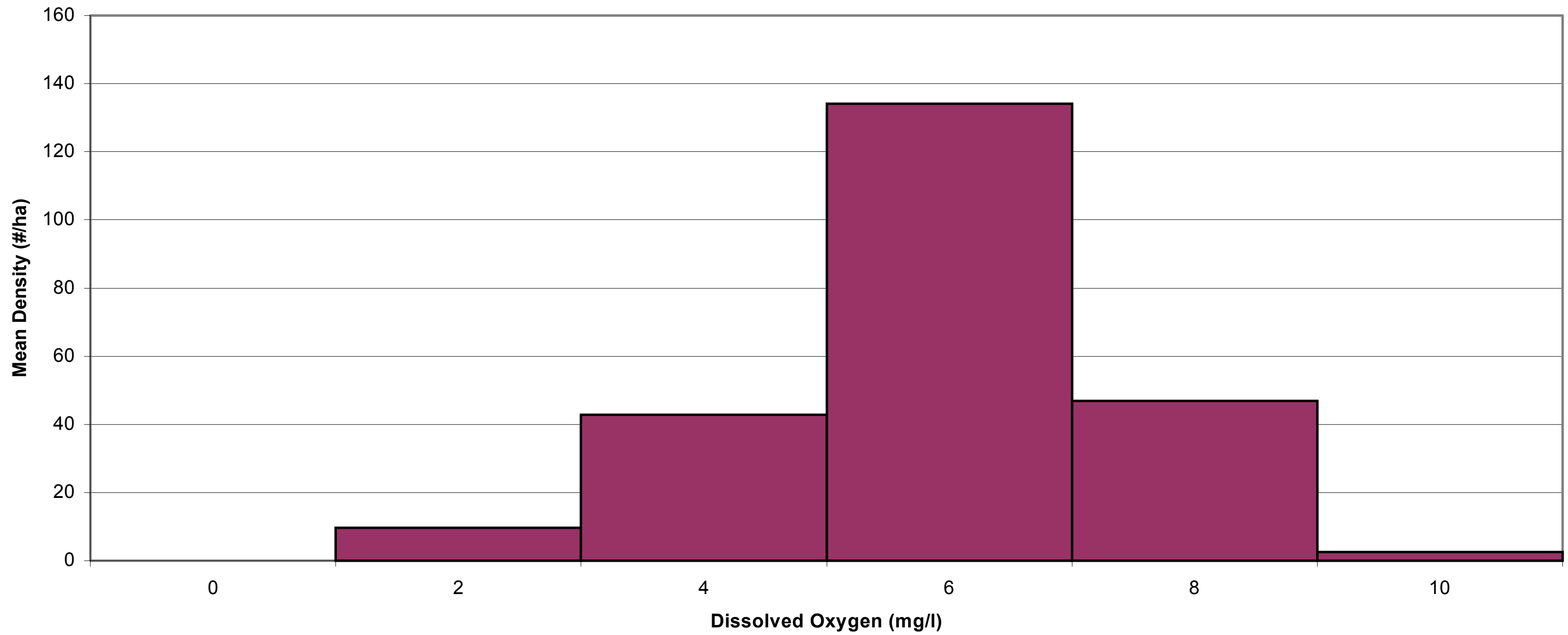

Figure 10. Relationship between Arkansas darter density and disolved oxygen.

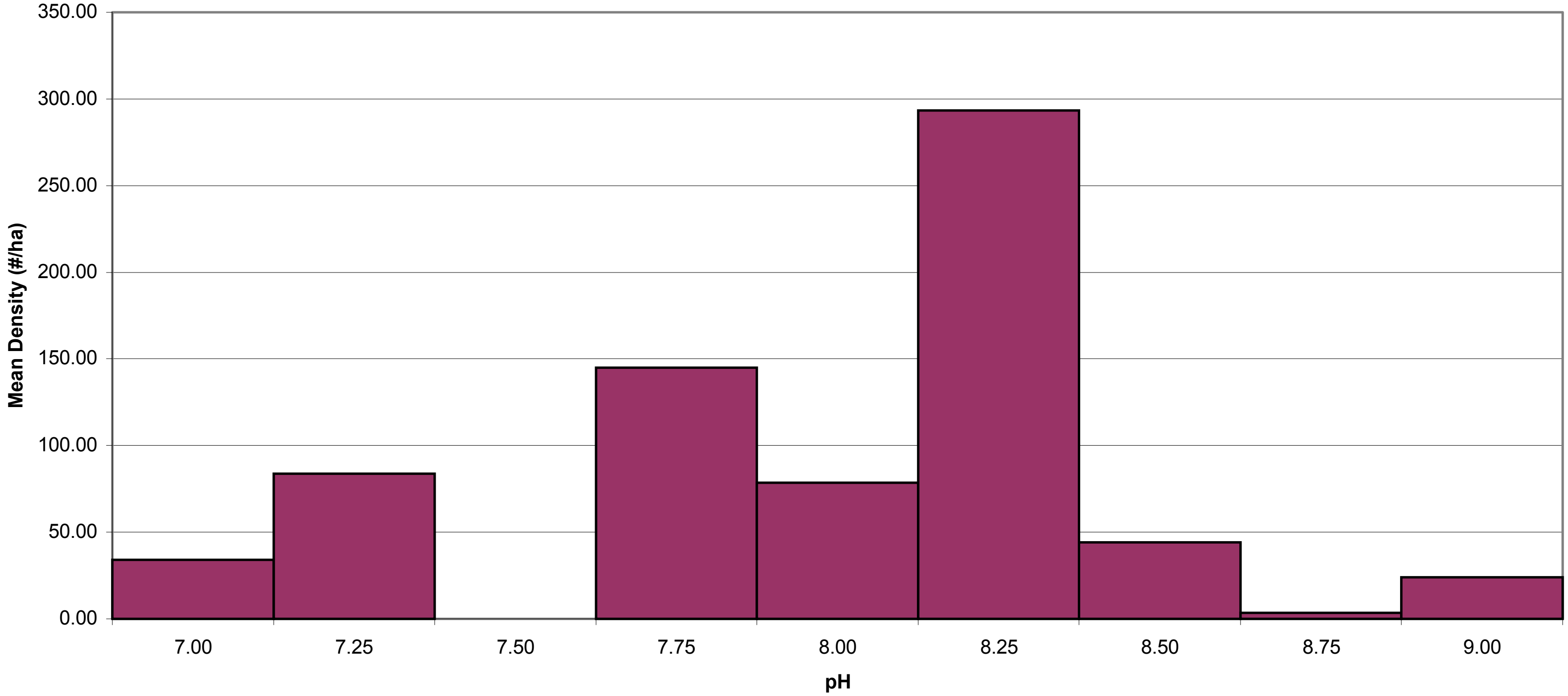

Figure 11. Relationship between Arkansas darter density and pH.

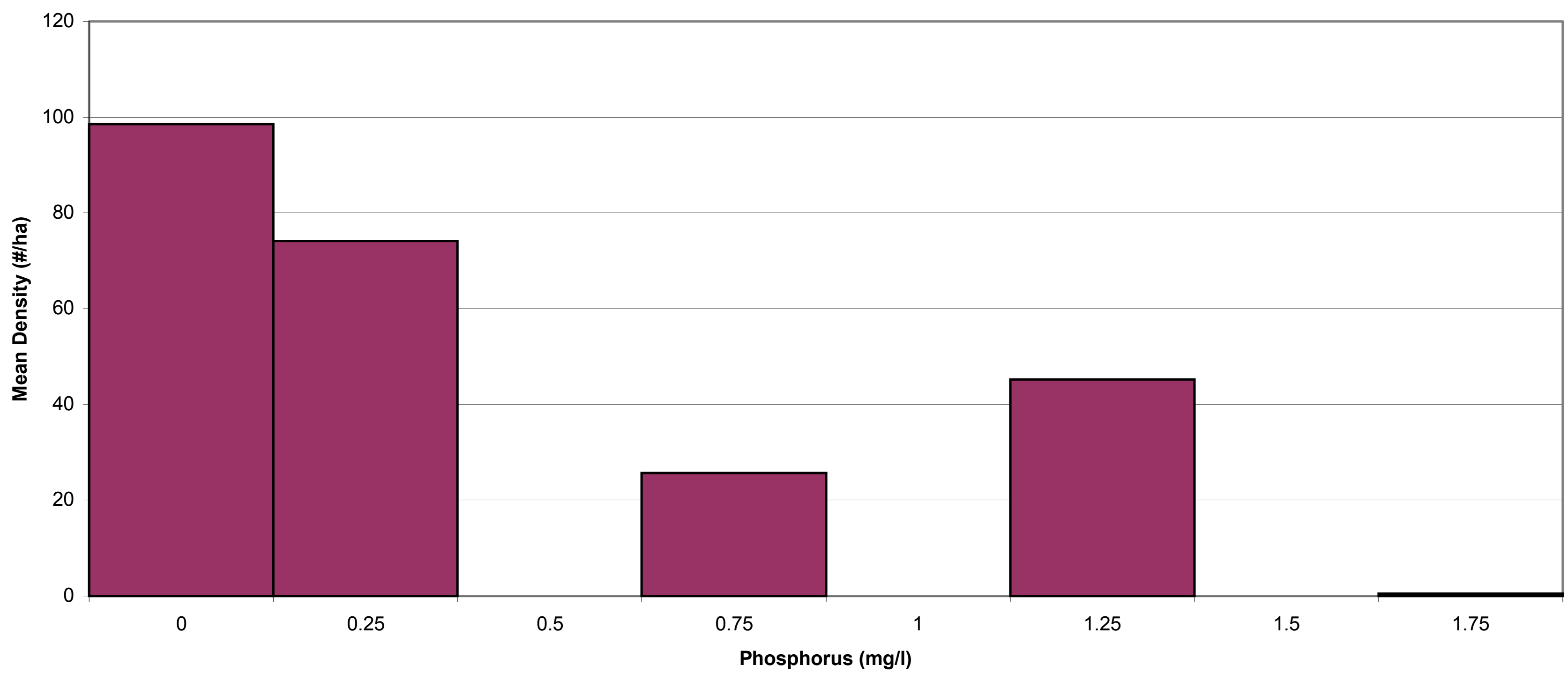

Figure 12. Relationship between Arkansas darter density and phosphorus.

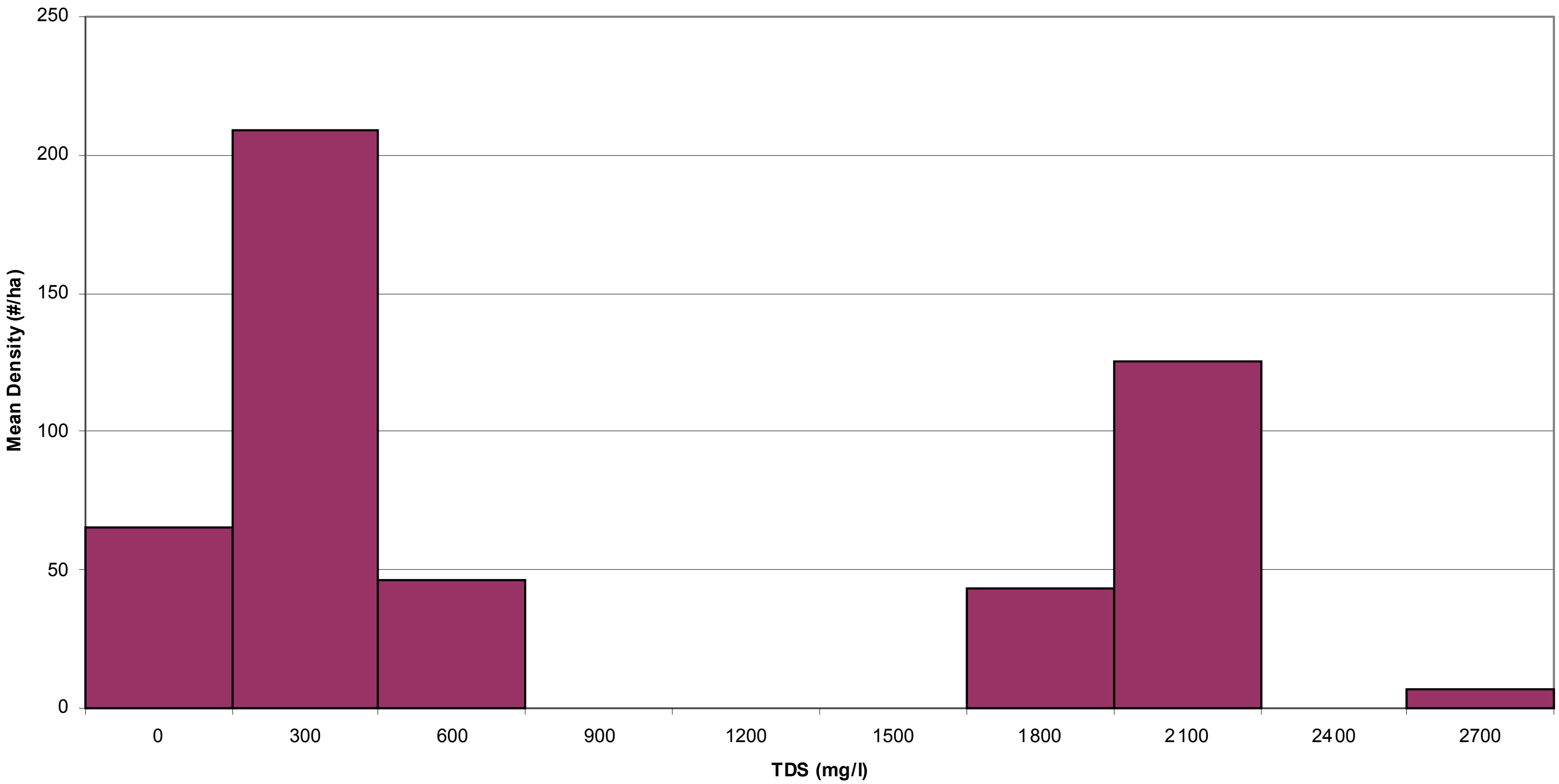

Figure 13. Relationship between Arkansas darter density and TDS

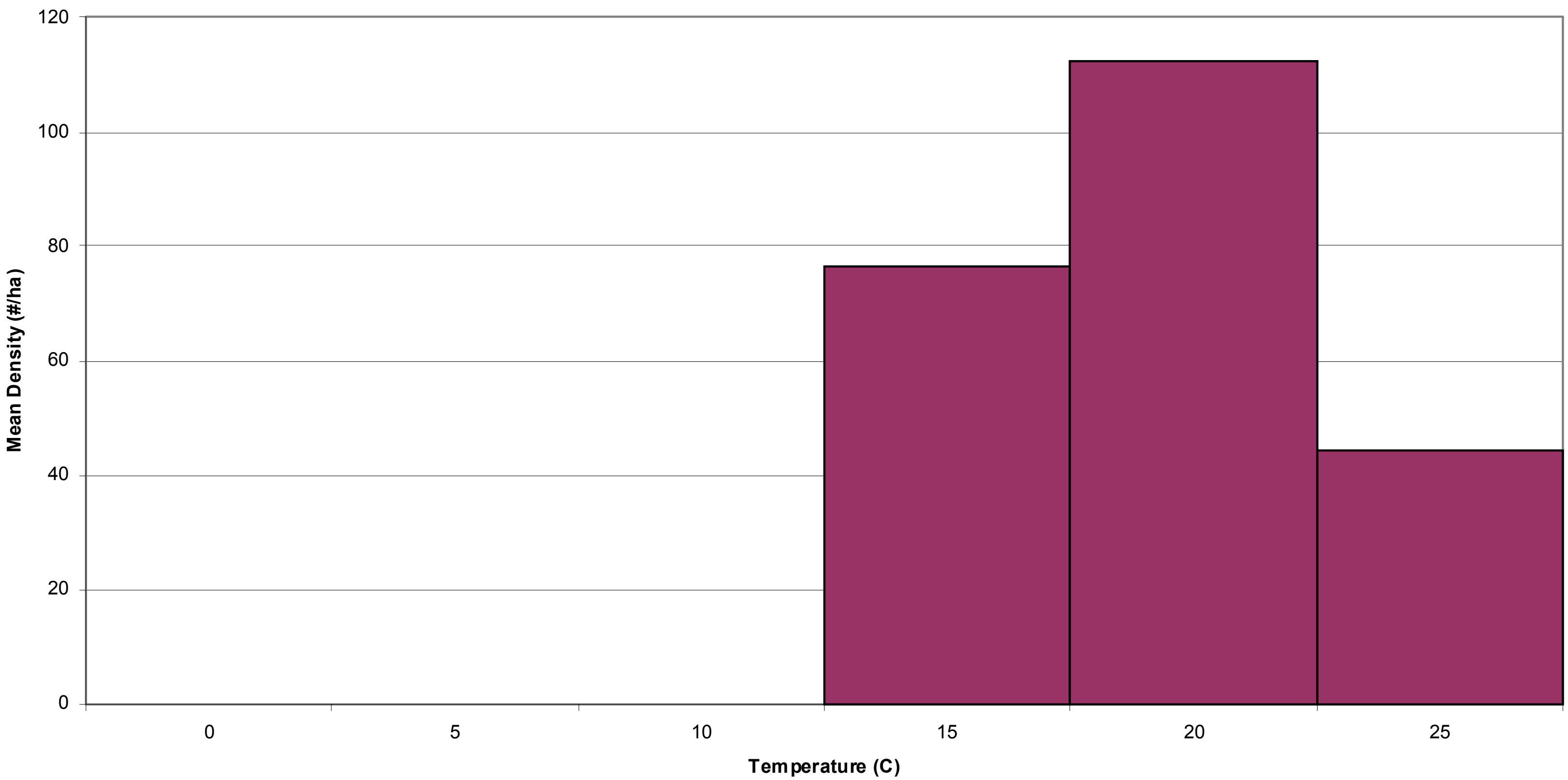

Figure 14. Relationship between Arkansas darter density and water temperature.

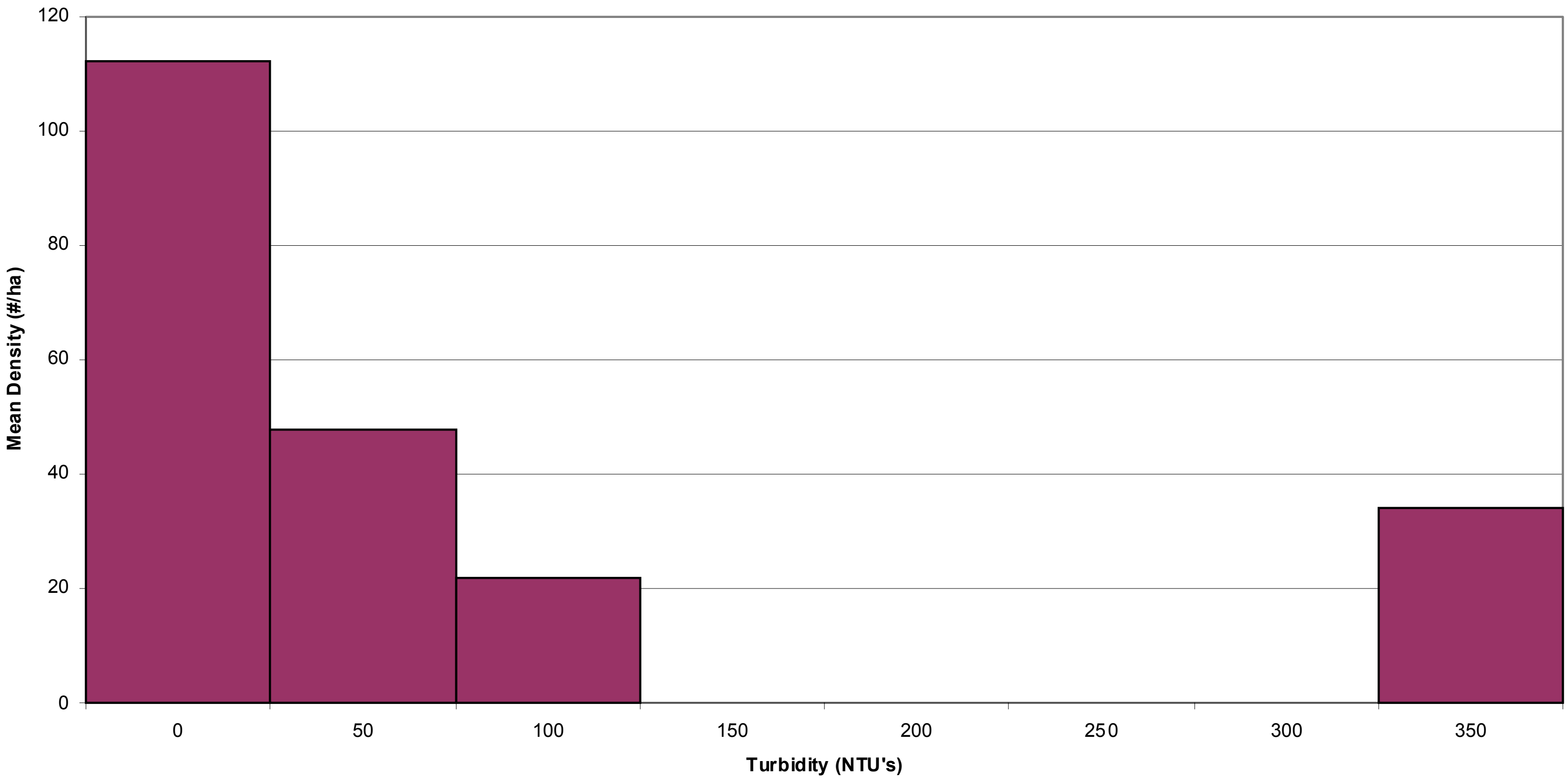

Figure 15. Relationship between Arkansas darter density and turbidity.

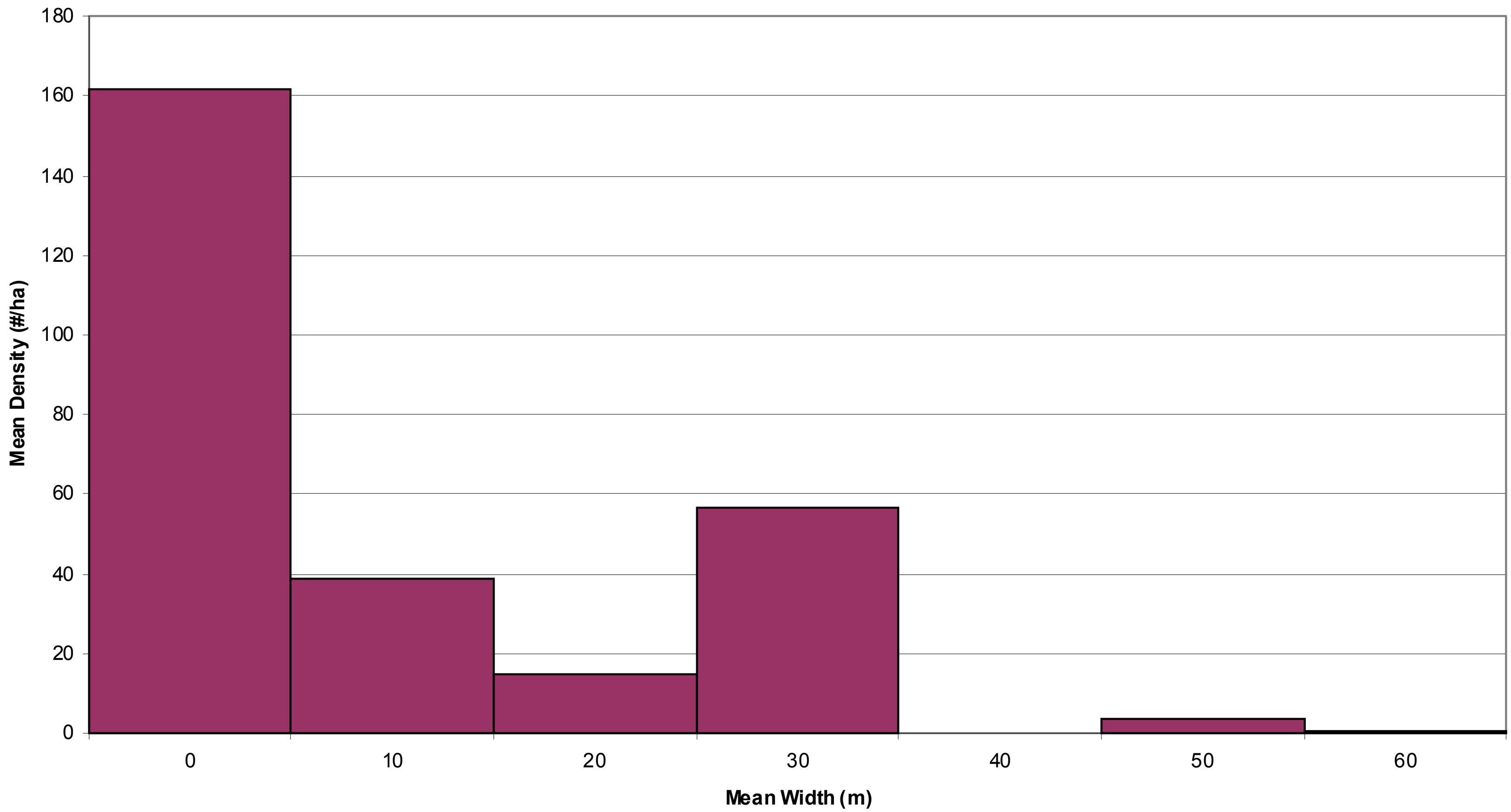

Figure 16. Relationship between Arkansas darter density and mean stream width.

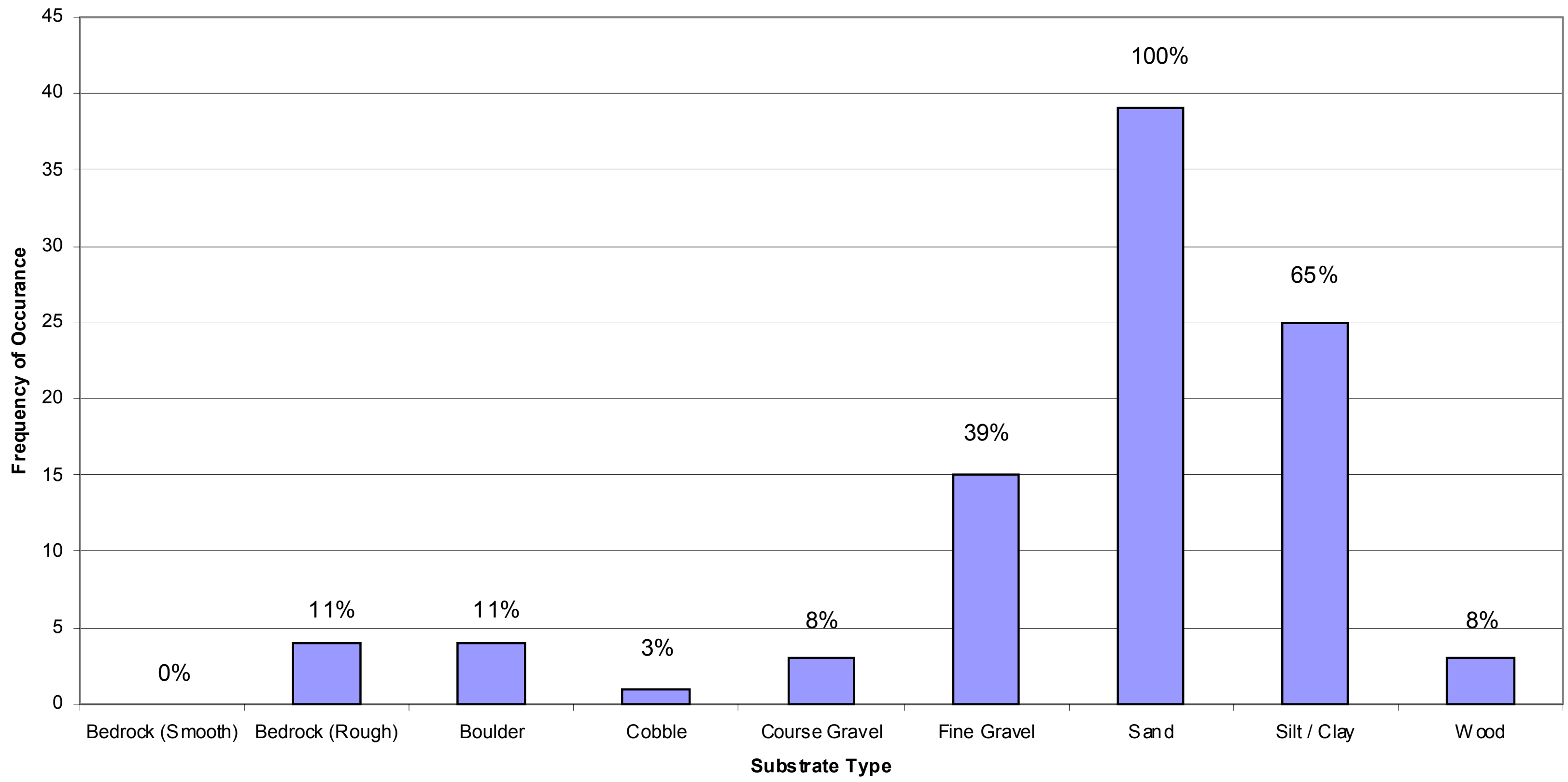

Figure 17. Relationship between the presence of various substrates and Arkansas darter occurance.

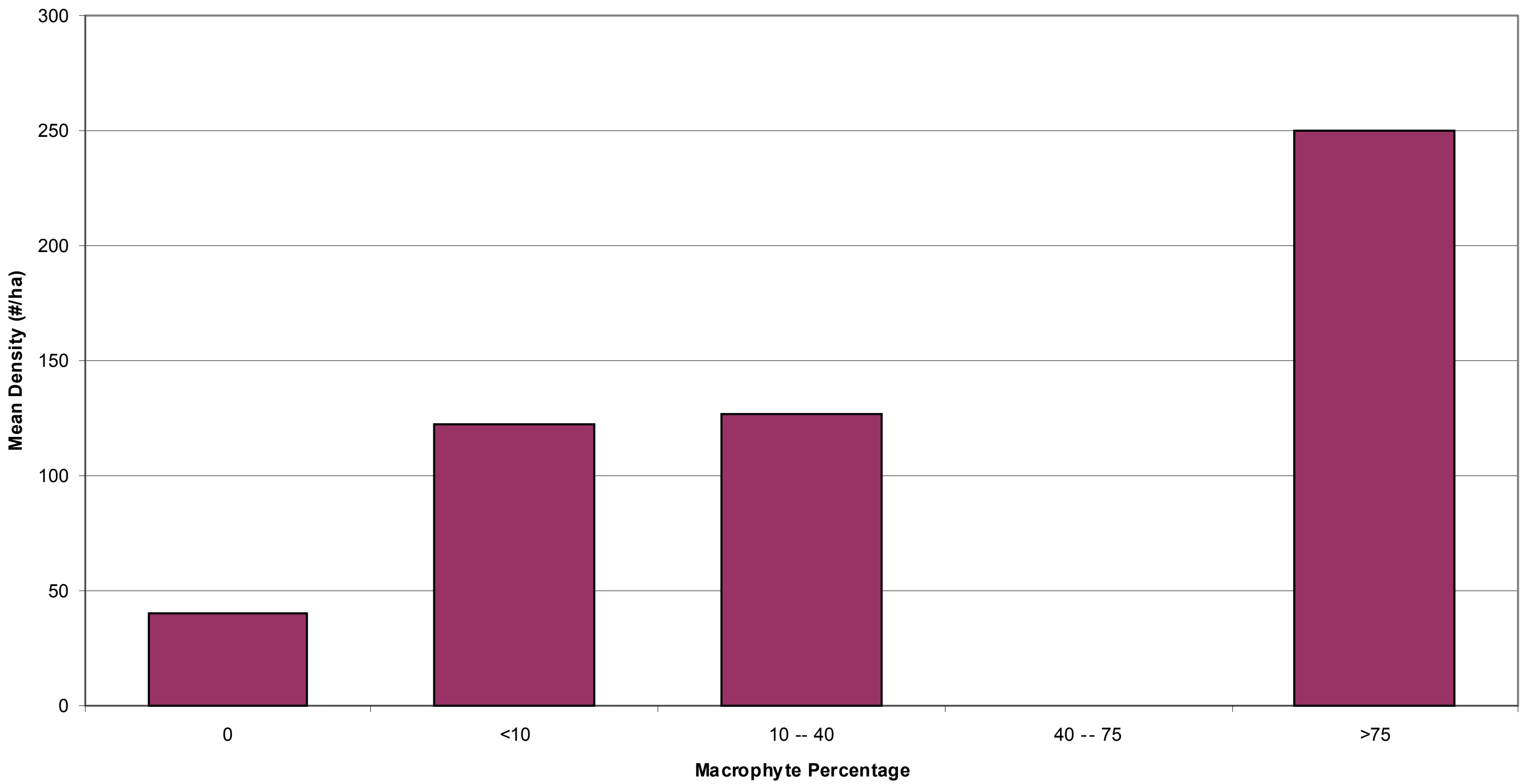

Figure 18. Relationship between Arkansas darter density and macrophyte abundance.

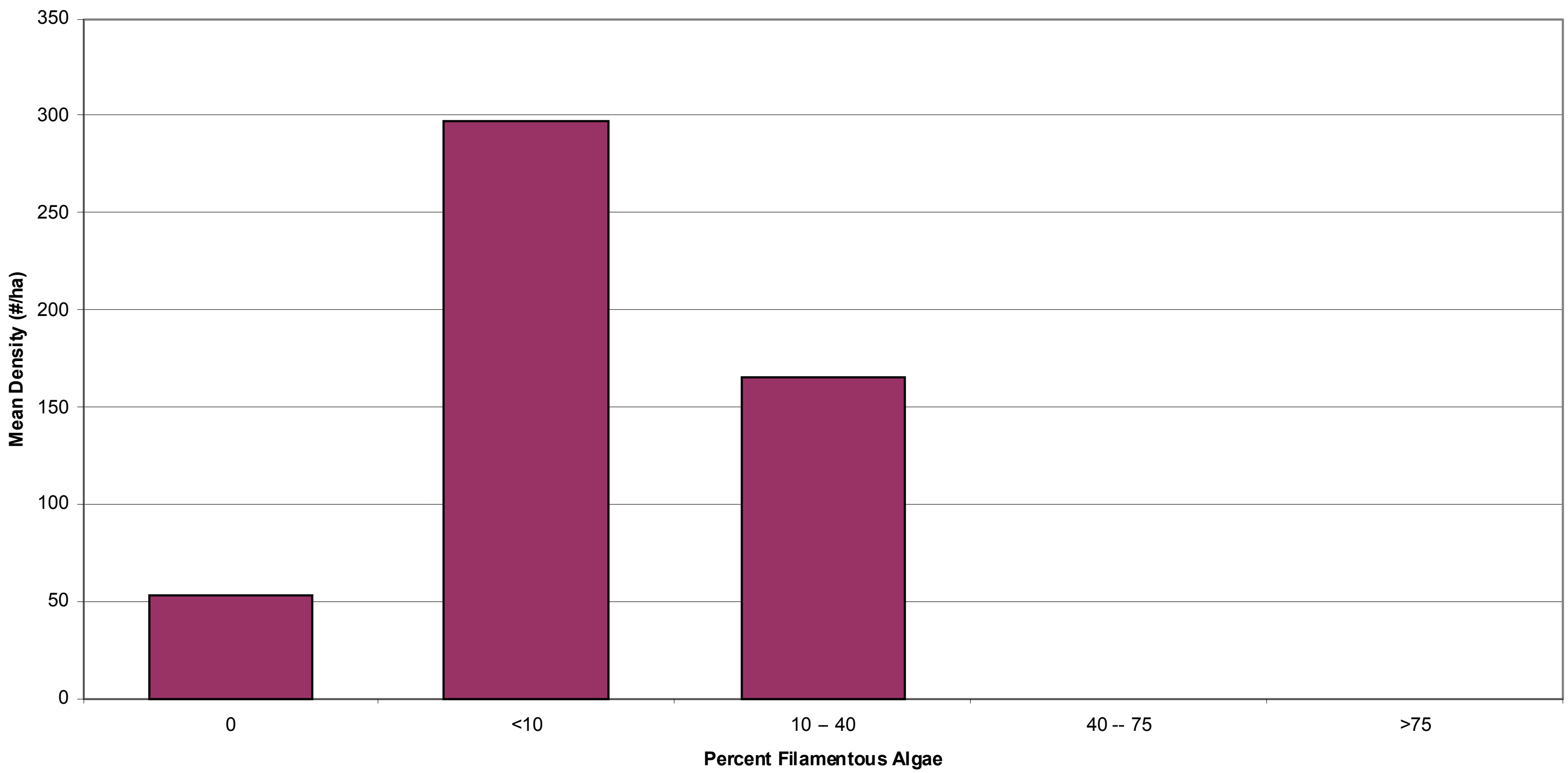

Figure 19. Relationship between Arkansas darter density and filimentous algae abundance.

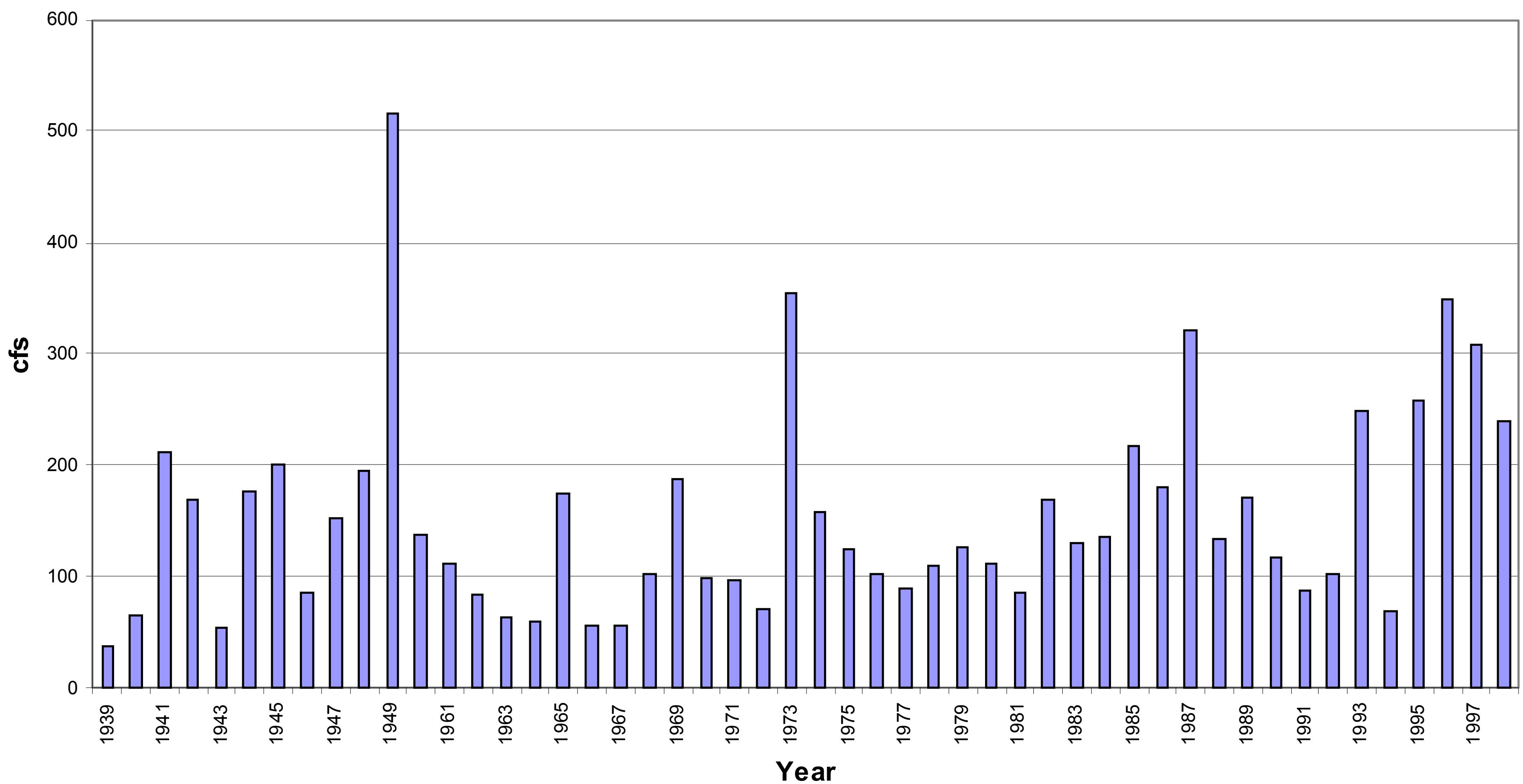

Figure 38. Mean annual discharge in the Medicine Lodge River.

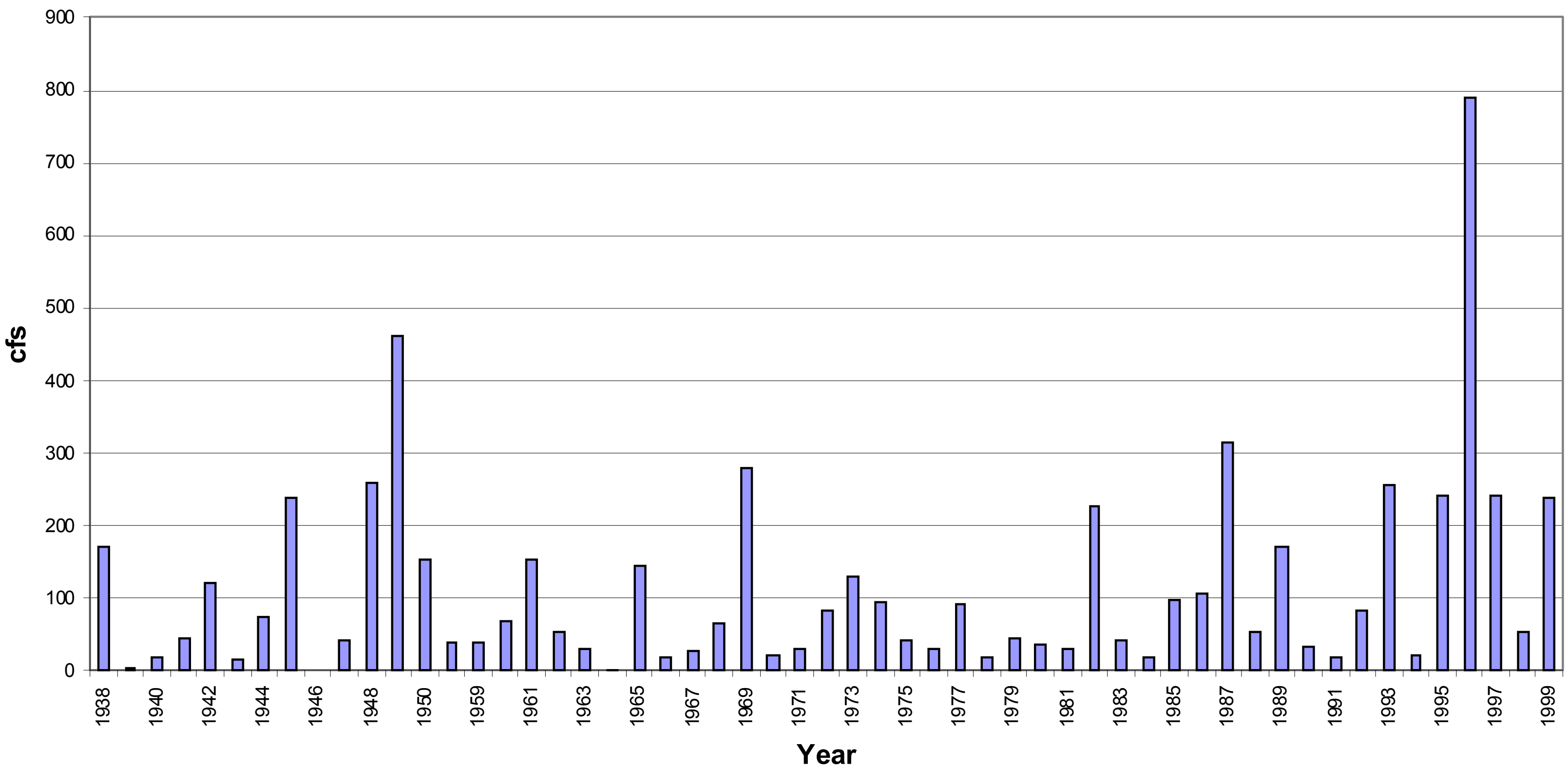

Figure 39. Mean summer (Jul-Sept) discharge in the Medicine Lodge River.

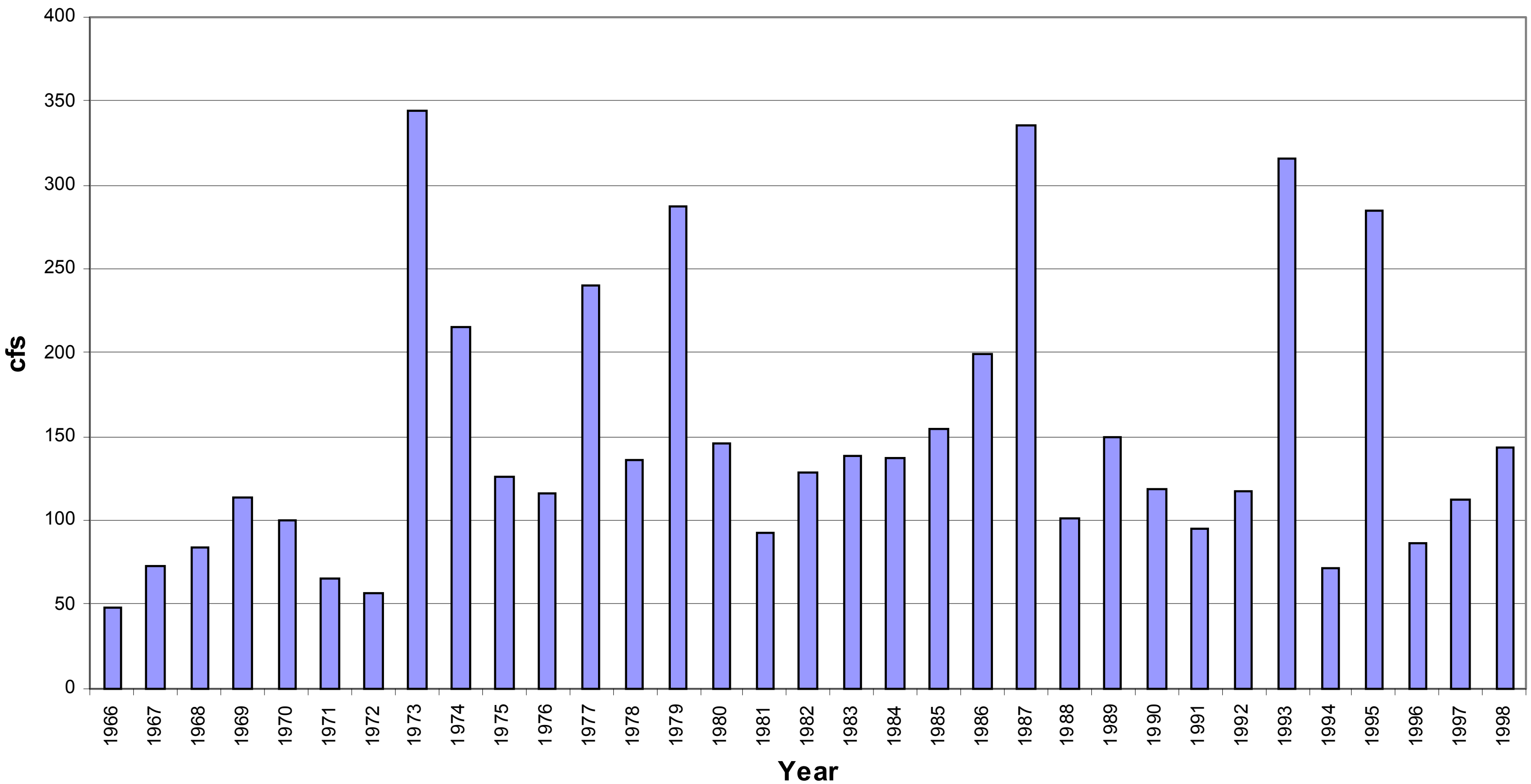

Figure 41. Mean annual dischage in the N. Fork of the Ninnescah River.

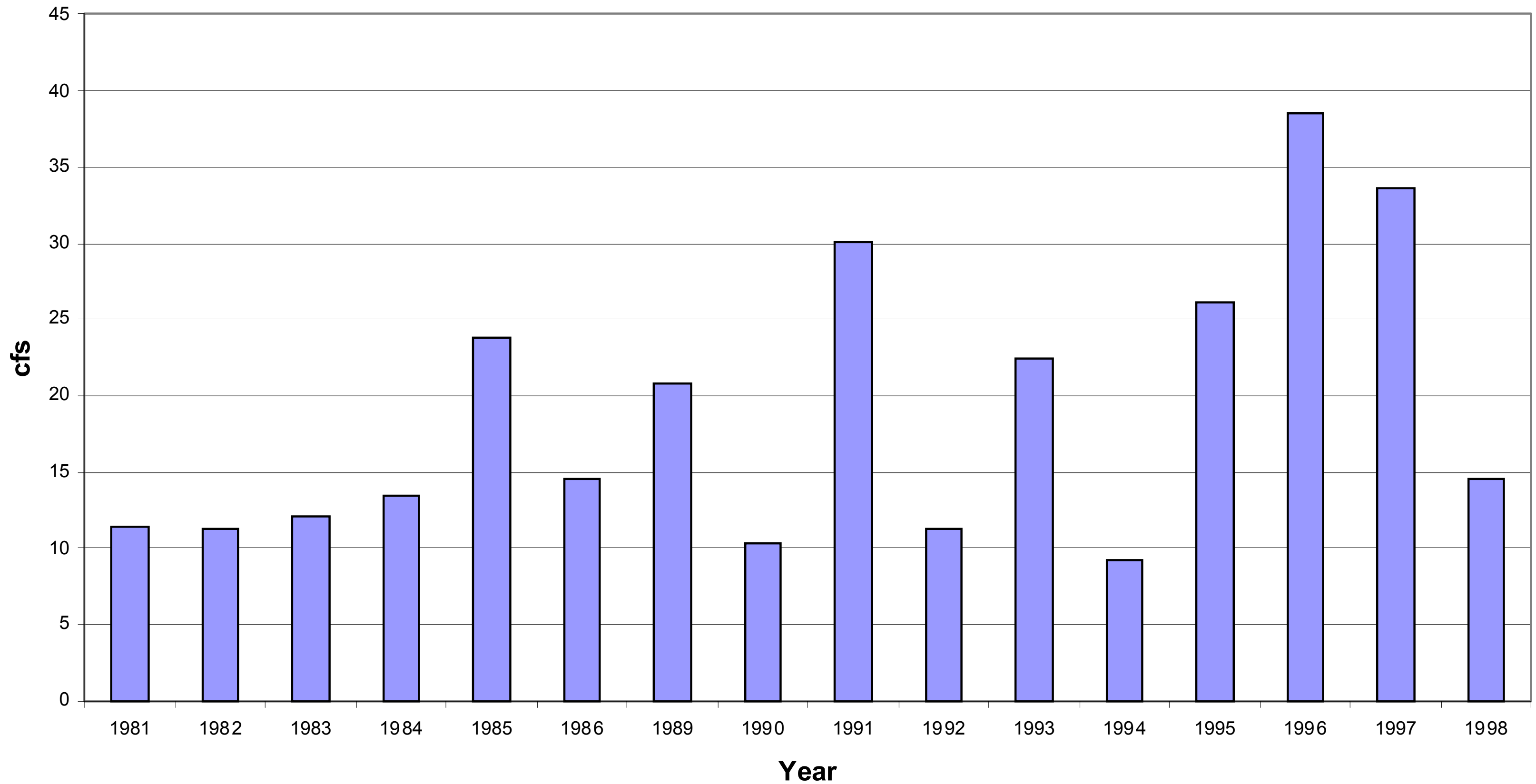

Figure 42. Mean annual discharge in the S. Fork of the Ninnescah River near Pratt.

Figure 43. Mean summer (Jul-Sept) discharge in the S. Fork of the Ninnescah River near Pratt.

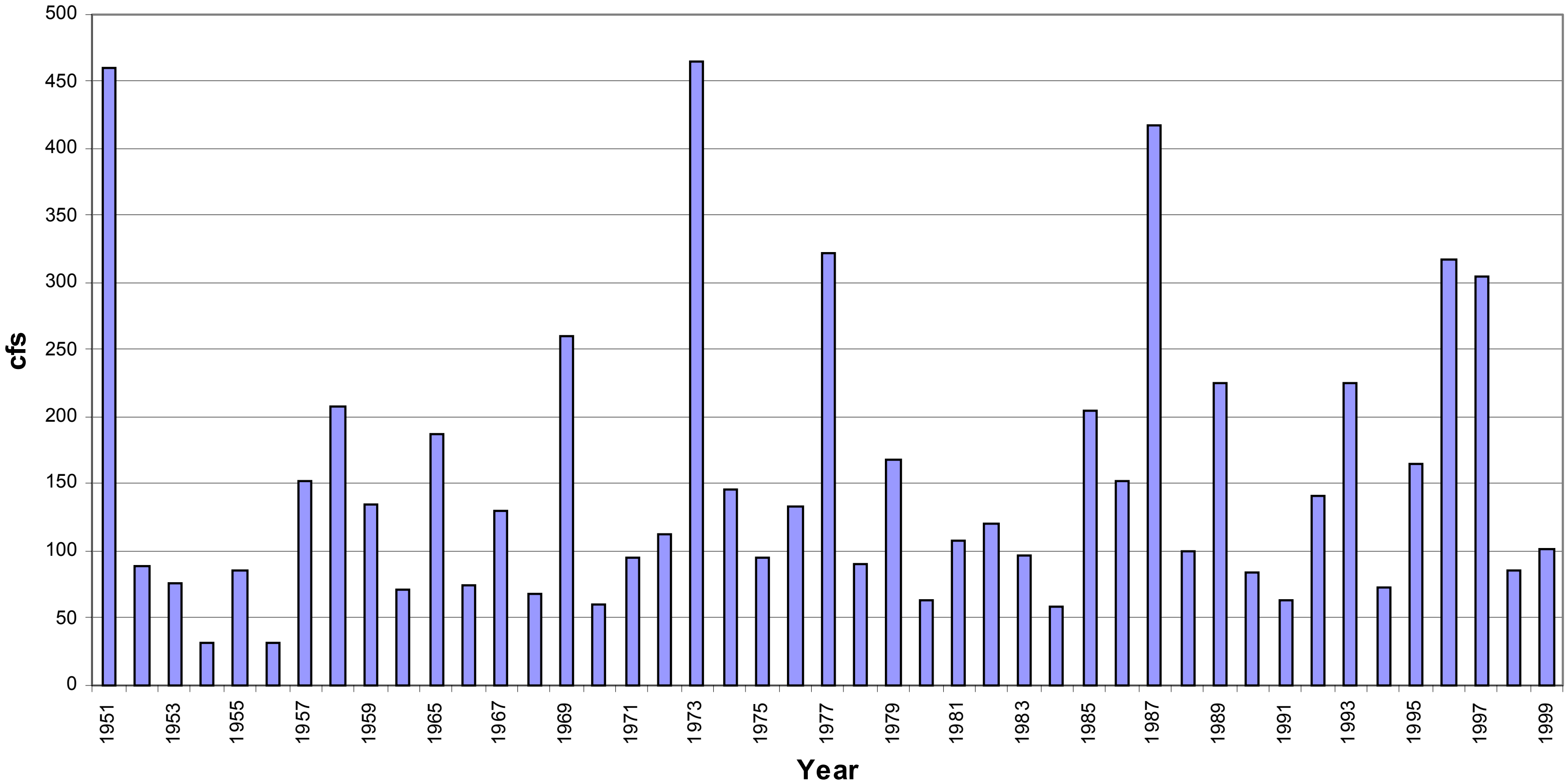

Figure 44. Mean summer (Jul-Sept) discharge in the S. Fork of the Ninnescah River near Murdock.

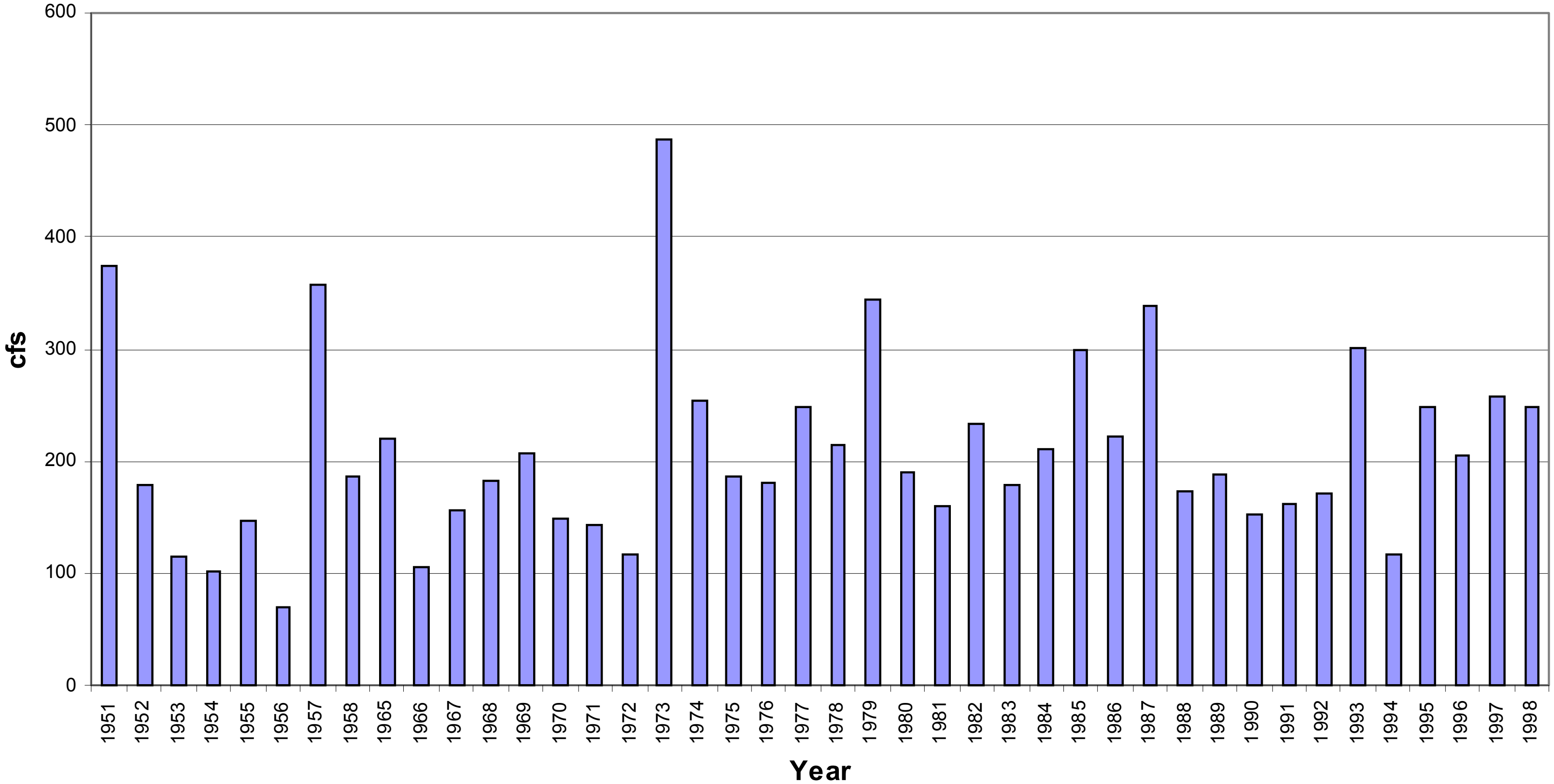

Figure 45. Mean annual discharge in the S. Fork of the Ninnescah River near Murdock.

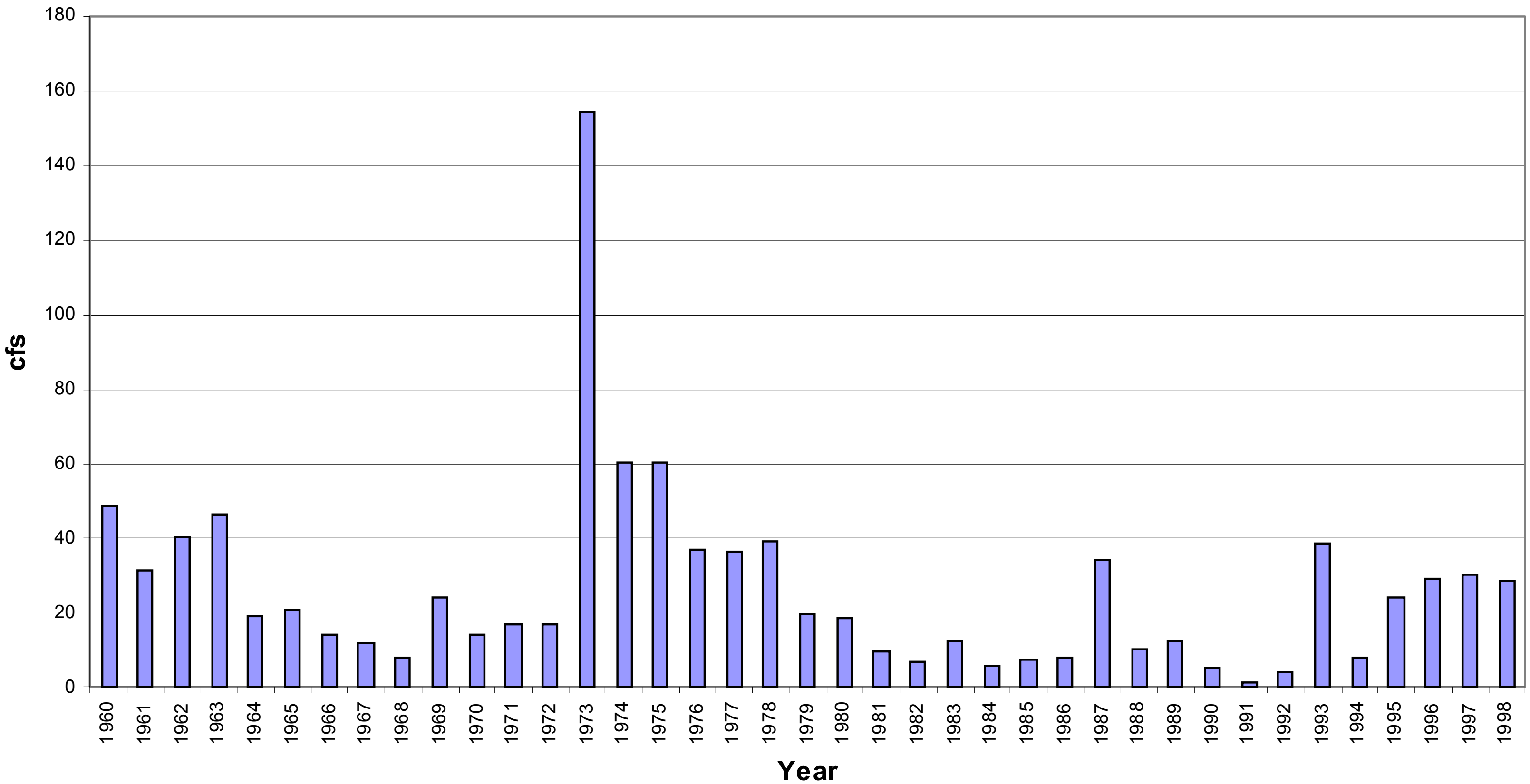

Figure 46. Mean annual discharge in Rattlesnake Creek.

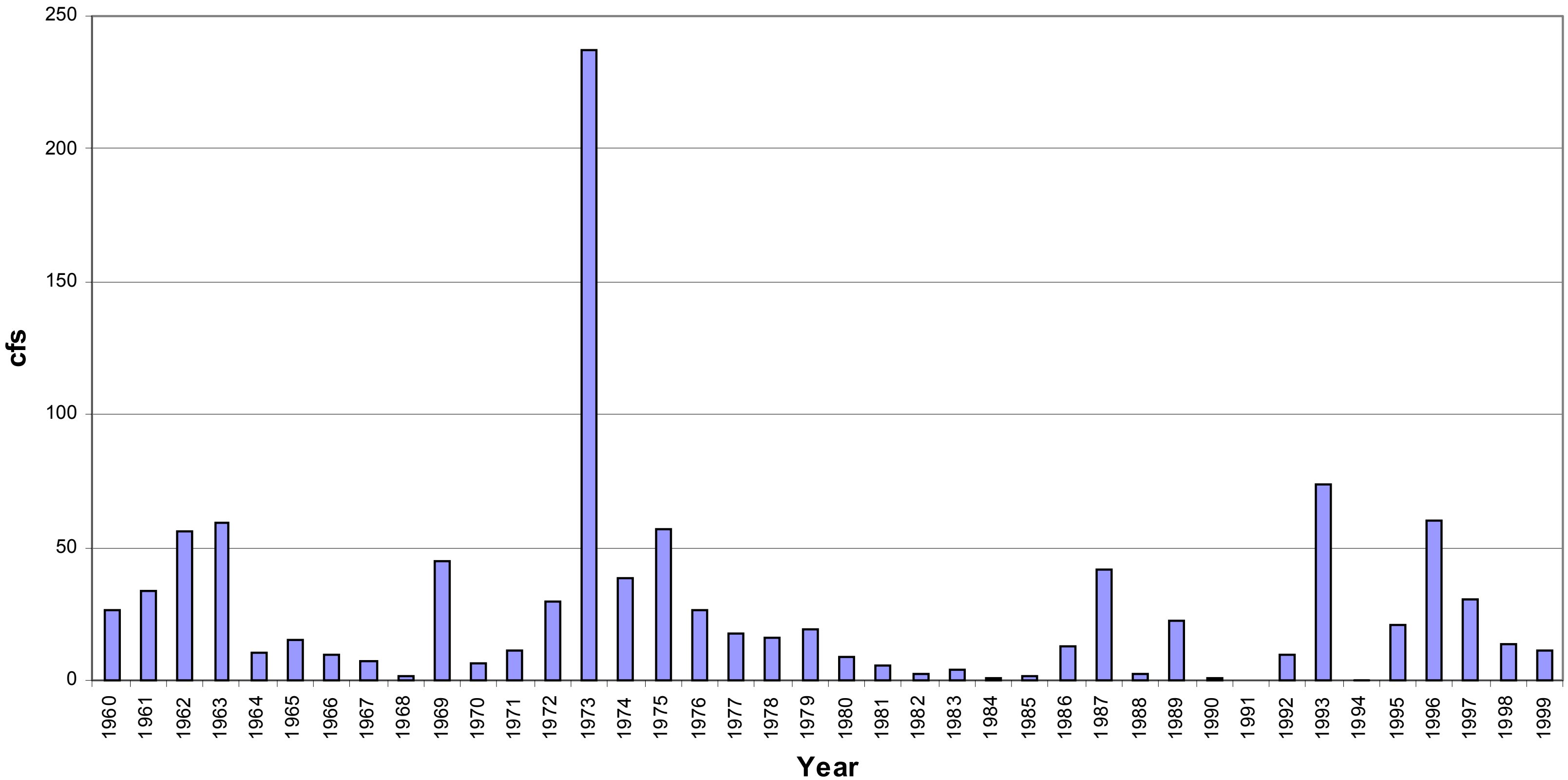

Figure 47. Mean Summer (Jul-Sept) Discharge in Rattlesnake Creek.

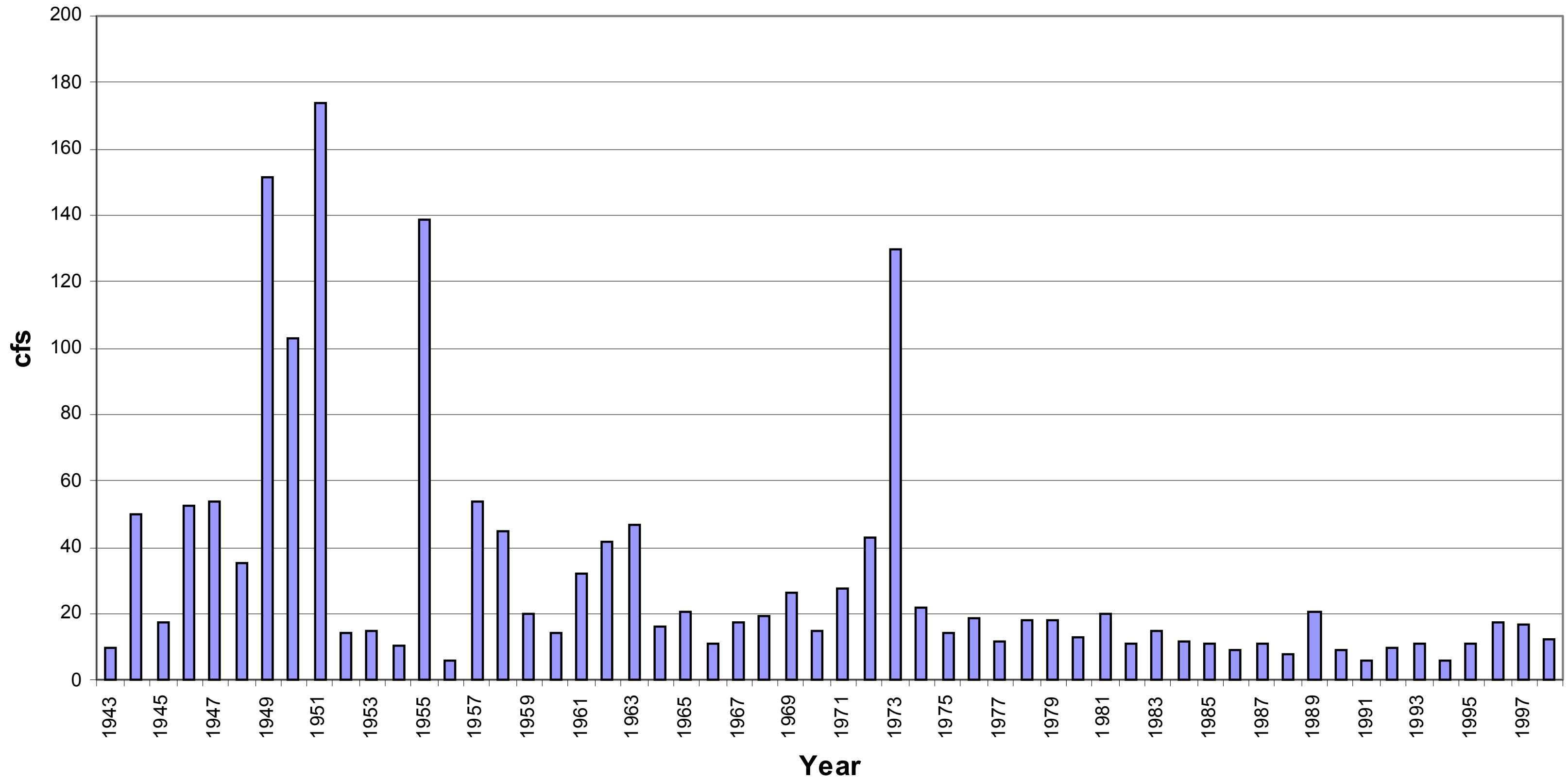

Figure 48. Mean annual discharge in Crooked Creek.

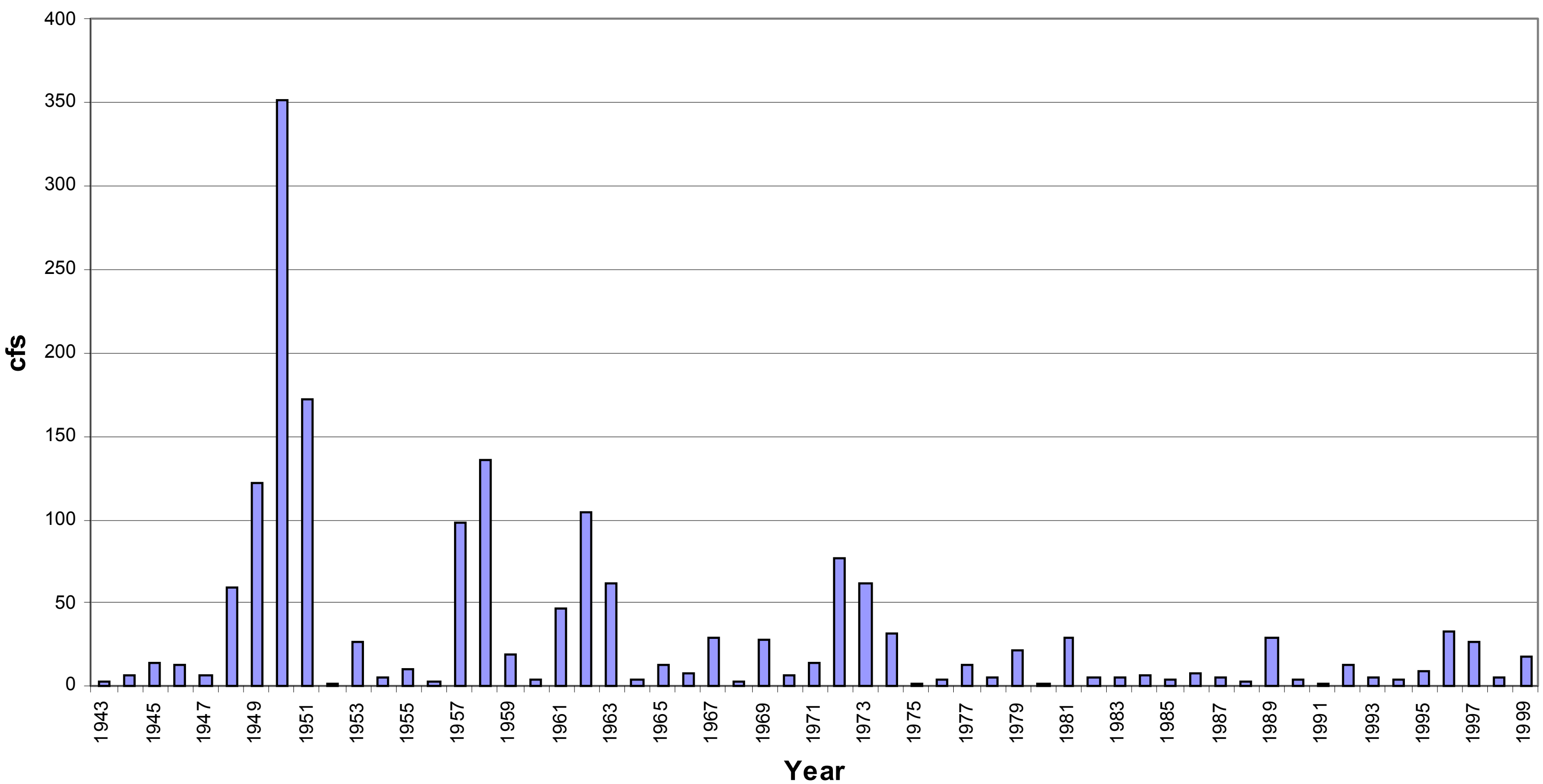

Figure 49. Mean summer (Jul-Sept.) discharge in Crooked Creek.

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