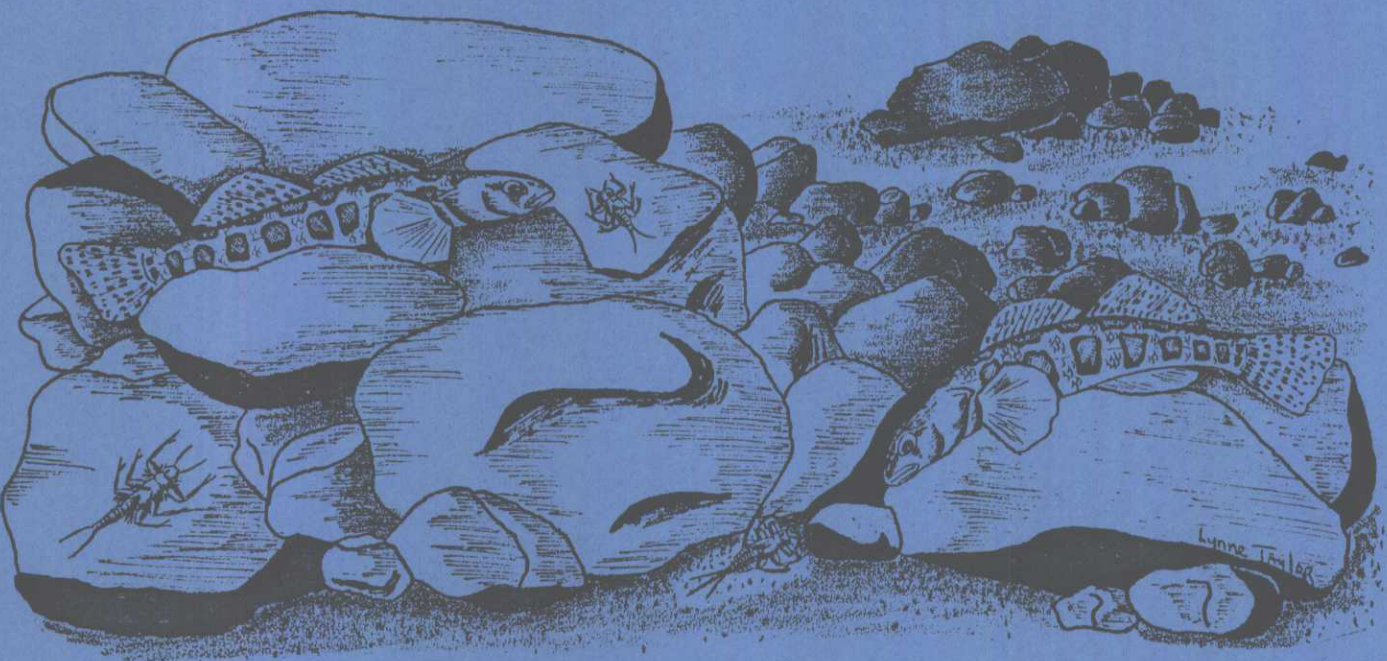


85-06-12-001

A RECOVERY PLAN FOR THE NIANGUA DARTER

Etheostoma nianguae

FILE COPY



A RECOVERY PLAN

for the

NIANGUA DARTER

(Etheostoma nianguae)

Prepared by W. L. Pflieger
Missouri Department of Conservation
Columbia, Missouri

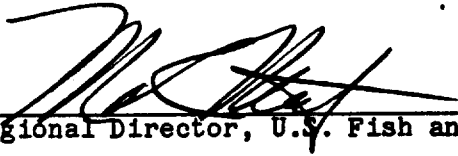
For

U.S. Fish and Wildlife Service

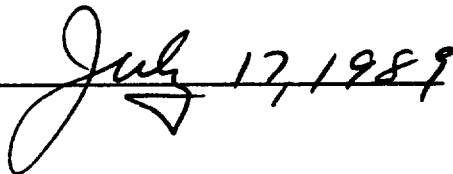
Region 3, Twin Cities, MN

Approved:

Acting


Regional Director, U.S. Fish and Wildlife Service

Date:


July 17, 1989

DISCLAIMER

This is the completed Niangua Darter Recovery Plan. It has been approved by the U.S. Fish and Wildlife Service. It does not necessarily represent official positions or approvals of cooperating agencies and does not necessarily represent the views of all individuals who played a role in preparing this plan. This plan is subject to modification as dictated by new findings, changes in species status, and completion of tasks described in the plan. Goals and objectives will be attained and funds expended contingent upon appropriations, priorities, and other constraints.

Acknowledgments should read as follows:

The Niangua Darter Recovery Plan, dated July 17, 1989, prepared by the U.S. Fish and Wildlife Service under contract with the Missouri Department of Conservation.

Literature Citations should read as follows:

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Additional copies may be purchased from:

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EXECUTIVE SUMMARY

Current Status: The Niangua darter, a threatened species, is currently composed of eight known populations which occupy 138 stream miles in the Ozark Region of west-central Missouri.

Goal: The recovery plan goal is to improve the status of the species to the point that it no longer needs to be listed as a threatened species.

Recovery Criteria: Two criteria must be satisfied to ensure the species no longer needs the protection of the Endangered Species Act. 1) The eight known populations must be made secure by reducing existing and potential threats to the greatest extent possible and population size is stable or increasing. 2) Viable populations have been discovered or established in four additional stream drainages.

Actions Needed: Surveys of occupied and suitable streams must be done. If no additional populations are located, they will be established. All populations and their habitats will be monitored to detect changes. Stream habitat occupied by the species will be protected by review and modification of actions potentially adversely affecting these areas, by purchase or lease of important habitat, by habitat improvement actions, and by public education.

Date of Recovery: An expected date of recovery has not been selected. The probable need to establish additional viable populations, likely involving artificial propagation (an untried technique for this species), makes any recovery projection purely speculative.

Cost of Recovery: Recovery costs for the first three years of the recovery program are estimated at \$562,000, with \$370,000 of this being spent for habitat protection via purchase or easement. This three year estimate does not include any costs for establishing new populations.

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PART I. INTRODUCTION

Background

The Niangua darter, Etheostoma nianguae, Gilbert and Meek, is a percid fish with a highly localized distribution in the Osage River Basin of the Ozark Region in west-central Missouri (Fig. 1). Its only near relative is the arrow darter, Etheostoma sagitta (Jordan and Swain), which is similarly localized in the Cumberland and Kentucky stream systems of eastern Kentucky and northern Tennessee. These two darters are the sole members of the subgenus Litocara, as first proposed by Bailey (1948).

In a study conducted by the Missouri Department of Conservation under a contract with the U.S. Fish and Wildlife Service, Pflieger (1978) concluded that the Niangua darter was rare, localized in occurrence, and vulnerable to extinction. He defined reservoir construction, general deterioration of stream habitat, and introduction of non-native species as important threats to the survival of E. nianguae. In a final rule making published in the Federal Register on June 12, 1985, the Fish and Wildlife Service determined the Niangua darter to be a nationally threatened species and designated critical habitat under the authority contained in the Endangered Species Act of 1973, as amended.

Description

Etheostoma nianguae is a large, slender darter with a long head that tapers into a slender, pointed snout (Fig. 2). The background coloration is yellowish-olive, with eight prominent saddle bars along the back, and orange

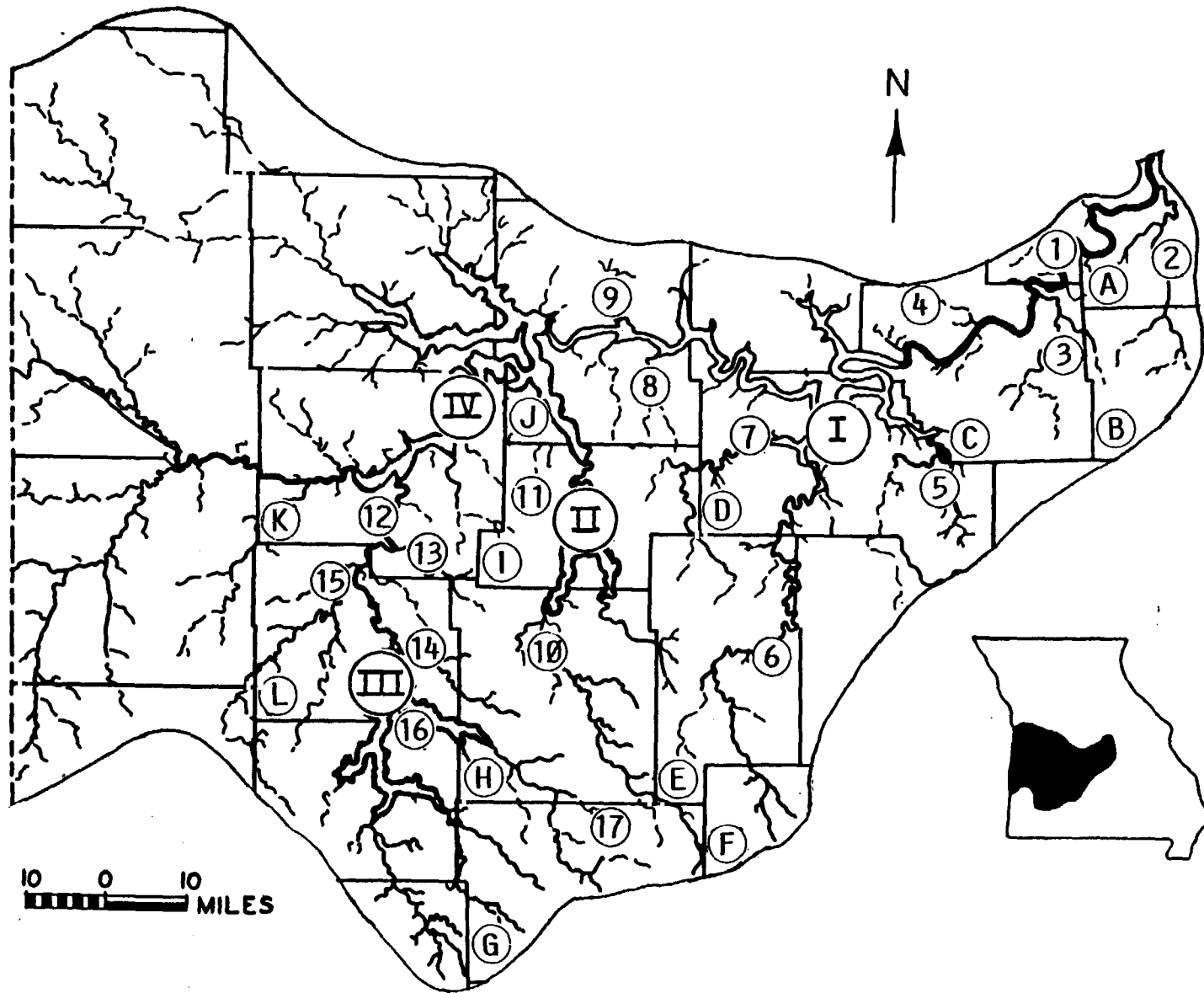


Figure 1. Geographic features of the Osage River Basin mentioned in this report. **Streams:** 1) Osage R, 2) Maries R, 3) Big Tavern Cr, 4) Big Saline Cr, 5) Grand Auglaize Cr, 6) Niangua R, 7) Little Niangua R, 8) Deer Cr, 9) Cole Camp Cr, 10) Pomme de Terre R, 11) L Pomme de Terre R, 12) Sac R, 13) Brush Cr, 14) Bear Cr, 15) Cedar Cr, 16) Maze (Arbell) Cr, 17) North Dry Sac; **Counties:** A) Osage, B) Maries, C) Miller, D) Camden, E) Dallas, F) Webster, G) Greene, H) Polk, I) Hickory, J) Benton, K) St. Clair, L) Cedar; **Reservoirs:** I) Lake Ozark, II) Pomme de Terre Res, III) Stockton Res, IV) Truman Res.

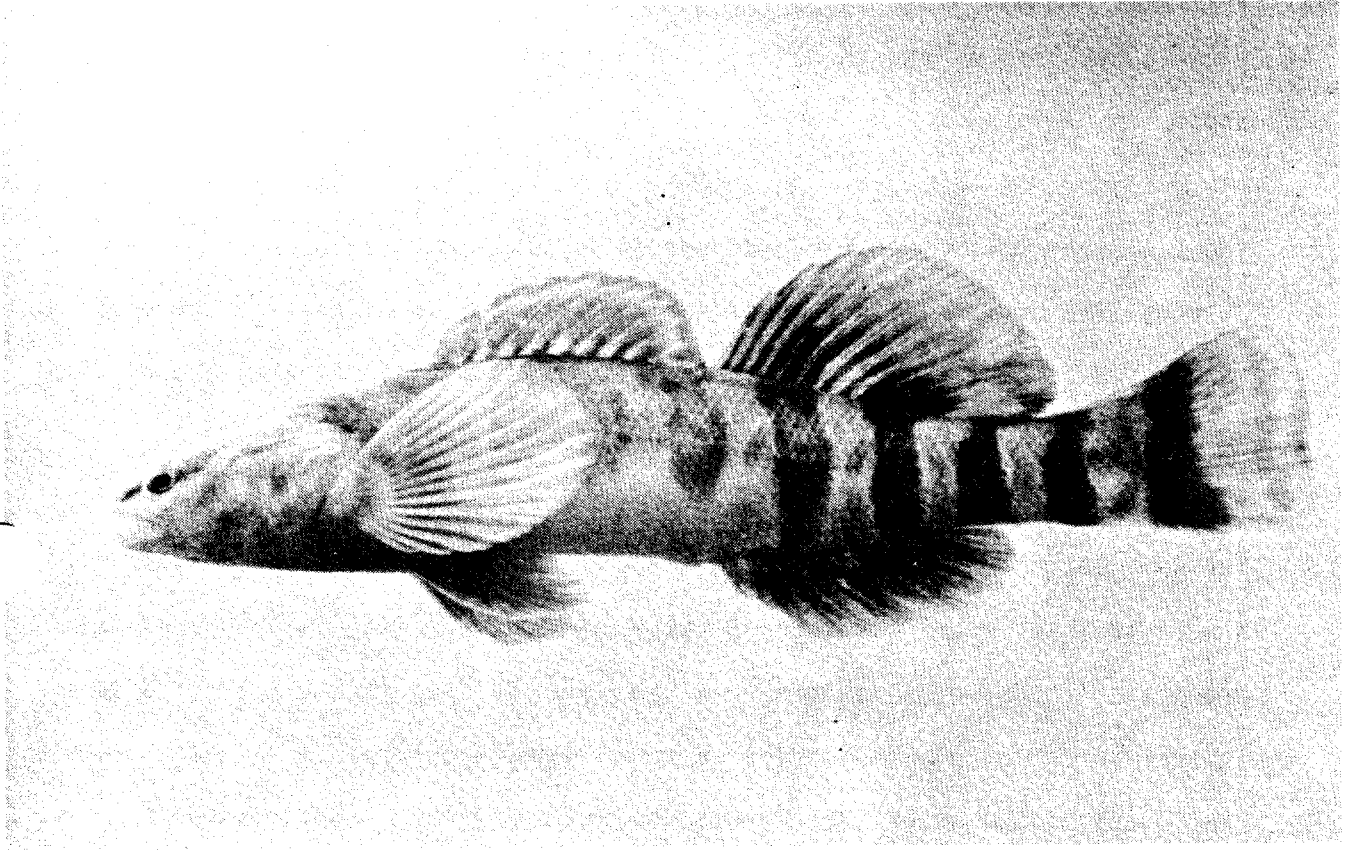


Figure 2. The Niangua darter, Etheostoma nianguae. A breeding male, 81.2 mm S.L. collected from Big Tavern Creek, Miller County, Missouri, 6 April 1972.

spots scattered over the upper sides. A series of U-shaped greenish blotches alternate with narrow orange bars along the mid-side. Two small, jet-black spots are present at the base of the caudal fin. Breeding males are more brilliantly colored than other individuals, and have an orange-red belly and a series of iridescent blue-green bars along the sides. One of these bars crosses the base of the caudal fin, obscuring the two jet-black spots noted above.

The head length of the Niangua darter is a little more than 1/4 the standard length. The lateral line is complete and contains 72-81 scales. The anal fin has 2 stiff spines and 11 or 12 rays. The maximum total length is about 4.5 in (115 mm).

The two discrete jet-black spots evident at the base of the caudal fin in all except breeding males distinguish the Niangua darter from all other darter species. It most closely resembles the arrow darter, from which it differs further in having smaller scales, a more complete lateral line, and a more completely scaled cheek (see Kuehne and Bailey 1961 for comparisons).

Distribution

The Niangua darter was described by Gilbert and Meek (In Gilbert, 1888) from specimens they collected from the Niangua River near Marshfield, Missouri in the summer of 1884. Nothing further was learned of its distribution until the early 1940's, when a survey of Missouri fishes by Mr. George V. Harry revealed the presence of Niangua darter populations in the Maries River, Big Tavern Creek, and the Niangua River. A specimen was collected from the headwaters o.

the Pomme de Terre River in 1960, and four were collected from Arbell (Maze) Creek, a tributary of the Sac River in 1971 (Taber and Wilkinson, 1973).

Collections made by Pflieger (1978) throughout the Osage Basin during the period 1974-1977 revealed the presence of the Niangua darter at 24 of 168 stations (Fig. 3). Eight populations of this species were found: (1) The Maries River population in the Maries River and lower Maries Creek, Osage County; (2) the Big Tavern Creek population in Big Tavern Creek and upper Little Tavern Creek, Barren Fork, and Brushy Fork, Miller County; (3) the Niangua River population in the Niangua River and Greasy Creek, Dallas County; (4) the Little Niangua River population in the Little Niangua River, Starks Creek, Thomas Creek, and Cahoonie Creek, Hickory and Dallas counties; (5) the Little Pomme de Terre River population, Benton County; (6) the Pomme de Terre River population, Greene and Webster counties; (7) the Brush Creek population, St. Clair County; and (8) the North Dry Sac population, Polk County.

These observations confirmed and extended the known distribution of the Niangua darter in all the streams from which it was previously recorded except Maze (Arbell) Creek, and revealed the existence of three populations not previously known. Niangua darters were found in 128 miles of stream.

Since 1978, the Niangua darter has been collected in Bear Creek, a tributary of the Sac River in Cedar County, and Panther Creek, a tributary of Brush Creek (Charles A. Taber, personal communication). These records add about 14 stream miles and one additional population (Bear Creek) to the known range of E. nianguae. However, recent repeated efforts to collect this species in the Little Pomme de Terre River have been unsuccessful, suggesting that the

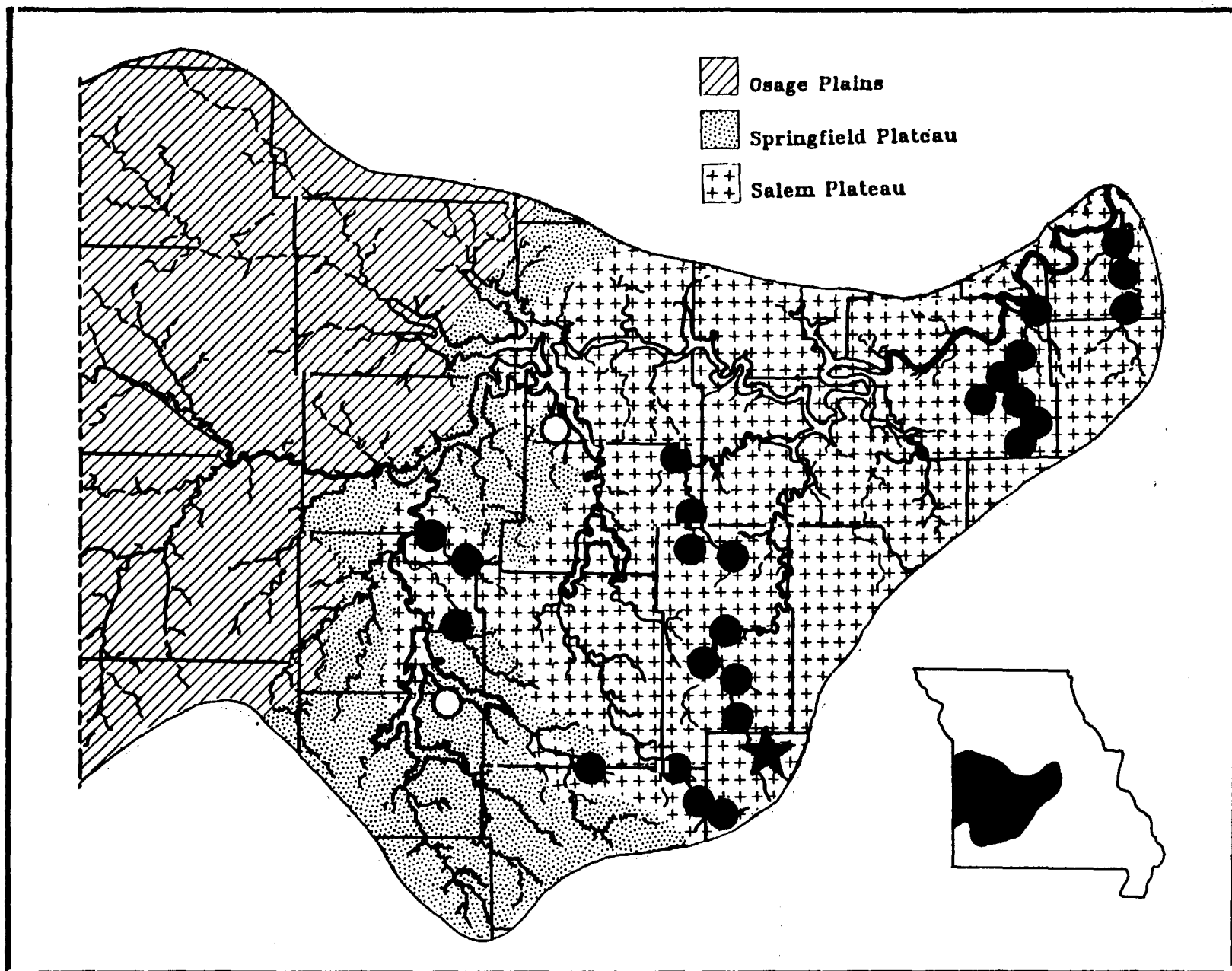


Figure 3. Localities where Niangua darters have been collected. The type locality is indicated by a star. White circles indicate populations extirpated since 1971.

Niangua darter has been extirpated from that stream. As a result of these additions and deletions, the present range of the Niangua darter is thought to encompass approximately 138 miles of stream (Table 1).

Table 1. Stream reaches presently known to be inhabited by the Niangua darter.

Stream Name	Stream reach known to be inhabited (miles above stream mouth)	Total miles of stream known to be inhabited
Maries River	13-29	17
Little Maries Creek	1	1
Big Tavern Creek	7-36	30
Barren Fork	0-3	3
Brushy Fork	0-1	1
Little Tavern Creek	0-1	1
Niangua River	83-113	31
Greasy Creek	0-5	5
Little Niangua River	41-53	13
Starks Creek	0-1	1
Thomas Creek	0-1	1
Cahoochie Creek	0-1	1
Pomme de Terre River	114-123	10
Brush Creek	3-11	9
Panther Creek	0-1	1
Bear Creek	9-18	10
North Dry Sac River	0-3	3
Total Miles		138

Status

A rough estimate of the total number of Niangua darters in all populations combined was obtained by Pflieger (1978). He computed this estimate using visual counts, a faunal index of Niangua darter habitat, and estimates of the miles of habitable stream. These computations suggested that the total number of Niangua darters was probably between 2,300 and 27,000 individuals.

Historical data are insufficient to determine long-term trends in distribution and abundance. The Niangua darter no longer occurs in the Niangua River near Marshfield, suggesting that its distribution in that stream has been reduced since the time of its original discovery. Populations of the Niangua darter in Maze (Arbell) Creek and Little Pomme de Terre River have apparently been extirpated since 1970. Others were probably extirpated before the distribution of the species was adequately documented.

Life History

The Niangua darter rests on the bottom in typical darter fashion unless it is actively swimming. When alarmed it rests with head up and caudal fin bent to one side, and escapes by dashing rapidly off with quick sweeps of its caudal fin (Pflieger 1978). E. nianguae was occasionally observed entering or emerging from spaces beneath stones, and may have used these for escape or resting cover. This species exhibits a clumped or non-random distribution, suggesting that it is somewhat gregarious or is restricted to certain stream pools by habitat scarcity.

Individual Niangua darters were observed in the same general area over a period of days or weeks. No data are available on movements or migrations, but other darters are known to move upstream in early spring.

Nymphs of stoneflies and mayflies gleaned from crevices of the stream bottom comprise most of the diet of the Niangua darter. Some benthic insects (larvae of caddisflies and blackflies; certain stonefly nymphs) are rarely eaten even though they are common components of the biota, indicating selectivity in feeding habits.

Four age-groups (0-IV) were found in a sample of 54 Niangua darters (Pflieger, 1978:Table 12). None of the three age-groups in which both sexes were represented exhibited a significant departure from a 1 to 1 sex ratio. Few individuals had lived more than 2 years. About 50% of the maximum adult length is achieved during the first growth period. The largest specimen examined was a female 111 mm (4.4 inches) total length. Males grow more rapidly than females, at least in early life.

Spawning occurs on swift, gravel riffles in mid-April, as daily maximum temperatures reach 65°F. The female burrows into gravel substrate and the male takes a position above her as the eggs are deposited and fertilized. The number of mature ova averaged 189.8 for four females of age-group I, 387.5 for two females of age-group II. A female of age-group IV had 748 mature eggs. Both sexes achieve sexual maturity at 1 year of age.

The incidence of parasites in the intestine of Niangua darters was 22.0% for trematodes and 9.8% for acanthocephalans.

Habitat Requirements

All known populations of the Niangua darter are in streams of the Salem Plateau, of order 3, 4, and 5, having gradients of 3 to 21 feet/mile. In these streams the Niangua darter occurs no closer to the ultimate headwater divide than 8 miles, or farther from the headwater divide than 49 stream miles. Most collections are from localities where the local relief is between 150 and 250 feet and the elevation of the stream bed is between 550 and 1,050 feet.

Streams in which the Niangua darter occurs may be characterized as medium sized, moderately clear upland creeks draining hilly topography underlain by bedrocks consisting principally of chert-bearing dolomites. Except when spawning, Niangua darters are most often found in shallow pools or "runs" having slight to moderate current and clean, gravelly or rocky bottoms. Occasionally, Niangua darters are found in riffles as early as mid-March, and by mid-April when spawning occurs most adults are in or near that habitat. By mid-May spawning is completed and Niangua darters are again found in pools. Throughout the year the Niangua darter exhibits a preference for silt-free substrates. The substrate is generally gravel with scattered rubble and occasional boulders or bedrock.

Limiting Factors and Potential Causes of Decline

Reservoir construction appears to be the principal threat to survival of the Niangua darter. Four major reservoirs (Lake of the Ozarks, Pomme de Terre Reservoir, Stockton Reservoir, and Truman Reservoir), are within the range of this species (Fig. 1). These reservoirs have adversely affected Niangua darter populations through inundation of stream habitat, range fragmentation, and the influx of fish species favored by the reservoirs into tributary streams. The full extent of these impacts on the Niangua darter is not known, since most of the reservoirs were completed before the distribution of this species had been adequately documented.

Taber and Wilkinson (1973) reported the collection of Niangua darters in Maze (Arbell) Creek, 50 yards upstream from the rising waters of Stockton Reservoir, at a locality subsequently covered by 15 feet of water. These specimens likely were upstream migrants retreating ahead of the lake as it

filled. Only 6 miles of Maze Creek are not inundated by Stockton Reservoir, and available evidence indicates that this stream no longer supports a population of E. nianguae.

A substantial population of the Niangua darter was present in the Little Pomme de Terre River until Truman Reservoir began to fill in 1979 (Pflieger 1978). Nearly all habitat for the Niangua darter in this stream is within the flood pool of Truman Reservoir and is subject to inundation during periods of heavy precipitation. Attempts to collect the Niangua darter in this stream in 1982 and 1983 were unsuccessful, and it is likely that this population has been extirpated.

Reservoir construction could be detrimental to the Niangua darter in ways other than the physical destruction or degradation of habitat. The influx of species favored by the reservoir into tributary streams may increase competition or predation. The log perch, a potential competitor with the Niangua darter, is often favored by reservoir construction. The largemouth bass and the spotted bass are favored by reservoirs and are potential predators. Reservoir construction creates insurmountable barriers to the dispersal of the Niangua darter between suitable habitats. Such movements are essential for maintaining populations in streams where local extirpation occurs as a result of environmental extremes or other factors. Movements may also be important in maintaining gene flow and genetic diversity. Studies of insular biogeography have indicated that repeated local extinction, followed by dispersal and recolonization from other inhabited areas, is characteristic of all species that occur in discontinuous habitats (MacArthur 1972).

The general deterioration of stream habitats in the Osage Basin resulting from a variety of factors is less obvious but no less important than reservoir construction in determining the prospects for survival of the Niangua darter. The accelerated conversion of woodlands to pasture in recent years is one factor. Increased sedimentation and nutrient enrichment are likely results of this activity. Stream channelization is not as extensive within the range of the Niangua darter as it is in some areas of Missouri, but is still a factor in habitat destruction. It has been common practice to channelize streams for a short distance above and below new road bridges. Landowners also channelize streams to control local flooding. Another common practice detrimental to stream habitat is the removal of willows and other woody vegetation from the stream channel, on the assumption that this increases water carrying capacity and reduces bank erosion. This results in greater instability of the substrate. There is little doubt that all of the factors discussed above contribute to a general reduction of the quality of stream habitat. A comment heard from long-time residents throughout the Ozarks and specifically from along some streams inhabited by the Niangua darter is that the streams are "graveling in." By this these observers mean that the channel is becoming choked with deposits of unstable gravel. This eliminates pools, and reduces surface flow across riffles.

The introduction of fishes not native to the Osage Basin is another change that could be detrimental to the Niangua darter. The spotted bass Micropterus punctulatus, the rock bass (Ambloplites rupestris), and Ozark bass (Ambloplites constellatus) were introduced by 1940, and are now widely distributed in streams where Niangua darters occur. All are to some extent piscivorous and thus are potential predators of the Niangua darter.

The Niangua darter has persisted in spite of these changes, but it cannot be assumed that it will continue to do so indefinitely. The general deterioration of habitat and other factors may be exerting stresses on existing Niangua darter populations so that recruitment fails to completely compensate for mortality. This increases the likelihood of local extirpation of populations, and once eliminated, these populations will not be reestablished naturally because the reservoirs which isolate them are barriers to dispersal. This could lead the species slowly and almost imperceptibly to extinction.

Recovery Actions Already Accomplished

The final rulemaking for the Niangua darter included the designation of 90 of the 138 miles of stream currently known to be occupied by the species, plus a 50-foot riparian zone along each side of these streams, as critical habitat (Table 2). These streams were selected because they are the best remaining examples of Niangua darter habitat and support the largest populations known to exist. The 50-foot riparian zone along each side of these streams will help to maintain habitat quality by reducing siltation and helping to stabilize the stream channel. Federal agencies involved in constructing, authorizing, or funding projects within the designated critical habitat are required to consult with the U.S. Fish and Wildlife Service before any such action is taken.

The final rule making also includes a provision allowing take of the Niangua darter for conservation purposes if a valid state collecting permit is first obtained and all other state laws and regulations are followed. This special

rule will allow for more efficient management of the species, thereby facilitating its conservation.

Table 2. Stream reaches designated as critical habitat for the Niangua darter, Etheostoma nianguae.

Name	Reach (miles above mouth)	Reach Description	Counties	Total Miles	Comments
Big Tavern Creek	7-36	From Hwy 52 upstream to Highway 17	Miller	32	No documented sources of pollution in the watershed. No dams. Stream habitat relatively unaffected by man.
Niangua R.	83-113	From County Road "K" upstream to one (1) mile beyond County Road M	Dallas	31	Proposed by Heritage Conservation and Recreation Service for inclusion in National Wild and Scenic River System.
L. Niangua River	41-53	From one (1) mile below Hwy 54 upstream to one (1) mile above County road E (Dallas County)	Camden, Dallas, Hickory	13	No documented sources of pollution in the watershed. Stream relatively unaffected by man.
Pomme de Terre R.	114-123	From Hwy 65 upstream to Webster County Line	Greene	10	
Brush Creek	3-8	From 1,000 feet upstream of County Road J upstream to the boundary of Sections 34 and 35, Township 36N, Range 25W	St. Clair, 8 Cedar		Large population of <u>E. nianguae</u> . Three state rare and endangered species. About 1.7 mi of critical habitat in state ownership.

The Federal Insecticide, Fungicide, and Rodenticide Act authorizes the U.S. Environmental Protection Agency to ban the use of certain pesticides in areas inhabited by nationally endangered or threatened species. A proposal is under review that would restrict the use of designated pesticides within a buffer zone (20 yards for ground application and 100 yards for aerial application) along approximately 140 miles of stream in 11 Missouri counties for protection of the Niangua darter.

Three towns within the range of the Niangua darter (Humansville, Fair Grove, and Strafford) are upgrading facilities for the treatment of sewage effluent discharged into streams inhabited by the Niangua darter. These improvements should enhance water quality in the impacted streams.

The Missouri Department of Conservation has purchased approximately 5.5 miles of frontage along four streams that support the Niangua darter (Table 3). Most of these frontages are quite small, but provide some opportunity for habitat protection and enhancement. The most significant of these acquisitions is the Birdsong Wildlife Area on Brush Creek, which supports a substantial population of the Niangua darter.

Table 3. Ownership by the Missouri Department of Conservation on streams where Niangua darters occur.

Area Name	Stream Reach (miles above mouth)	Stream Name	Miles of stream in ownership
Camden County			
Fiery Fork State Forest	14-15	Little Niangua River	1.1
Dallas County			
Big John Access	94	Niangua River	0.1
Charity Access	113	Niangua River	0.3
Moon Valley Access	71	Niangua River	0.2

Table 3. (continued). Ownership by the Missouri Department of Conservation on streams where Niangua darters occur.

Area Name	Stream Reach (miles above Mouth)	Stream Name	Miles of stream in ownership
Miller County			
Boeckman Bridge Access	14	Big Tavern Creek	0.6
Brays Access	33	Big Tavern Creek	0.2
Madden Ford Access	41	Big Tavern Creek	0.5
Wilson Camp Access	24	Big Tavern Creek	0.8
St. Clair County			
Birdsong Wildlife Area	3-4	Brush Creek	1.7
Total Miles			5.5

PART II: RECOVERY

A. Recovery Objective

Objective: To improve the status of the Niangua darter to the point that it will no longer be a threatened species. This will have been accomplished when: (1) the eight known populations have been made more secure through habitat protection and enhancement, and (2) viable populations have been discovered or established in four additional stream drainages. Known populations will have been made more secure when existing and potential threats to their survival have been reduced to the greatest extent possible, and population size is stable or increasing. A viable population is one in which recruitment is sufficient to maintain or increase population size.

B. Step-down Outline

1) Survey streams to establish the present status of Niangua darter populations.

1.1 Survey streams where Niangua darters were previously reported.

1.2 Survey streams that may have undocumented Niangua darter populations.

2) Develop a strategy for establishing additional Niangua darter populations.

- 2.1 Select streams suitable for introducing populations.
- 2.2 Develop techniques for establishing populations.
- 3) Protect and enhance habitat for existing and introduced Niangua darter populations.
 - 3.1 Review proposals for actions having the potential for adversely affecting Niangua darter habitat.
 - 3.2 Protect additional areas of critical habitat through purchase or lease.
 - 3.3 Develop and maintain public support for protection of the Niangua darter.
 - 3.4 Enhance habitat on publicly controlled lands.
- 4) Develop and implement a program for monitoring Niangua darter populations and habitat.
 - 4.1 Monitor trends in existing populations.
 - 4.2 Monitor trends in introduced populations.
 - 4.3 Monitor habitat protection/enhancement efforts.

C. Recovery Outline Narrative

Additional populations of the Niangua darter should be established to minimize chances of extinction through incremental extirpation of existing populations. The species can also be made more secure by protecting and enhancing the quality of Niangua darter habitat.

- 1) The only comprehensive survey of the status of Niangua darter populations was conducted more than 10 years ago, and more current information is needed to develop and evaluate recovery efforts.

1.1 Survey streams where Niangua darters were previously reported.

All streams listed in Table 1 should be sampled with sufficient intensity to document the distribution and abundance of the Niangua darter, as an indication of present status and to provide a basis for selecting streams from which stock can be obtained for establishing new populations.

The communities of fish and benthic invertebrates in Niangua darter streams will be sampled, using techniques applied in previous surveys (Pflieger, 1978; Duchrow, 1984). The length and sex of Niangua darters will be obtained, and scale samples will be taken as needed to determine age structure and recruitment. Physical parameters, including substrate type, stream dimensions and discharge, turbidity, and temperature; and chemical parameters, including dissolved oxygen, pH, specific conductance, nitrate nitrogen, ammonia nitrogen, total organic nitrogen, total

phosphorous, and orthophosphorous, will be taken. Streams receiving effluent from sewage treatment plants using chlorination processes will be tested for residual chlorine. Historical information, including patterns of land use, pesticide application practices, potential sources of heavy metals from industry or mining, and fish kills will determine the need to scan fish flesh for pesticides and heavy metals. If scanning is conducted, a surrogate species rather than the Niangua darter will be used. This baseline data will facilitate an evaluation of environmental quality in streams now supporting Niangua darter populations, and the selection of streams in which to establish additional Niangua darter populations.

1.2 Survey streams that may have undocumented Niangua darter populations. Cluster analysis and species composition analysis of fish and benthic invertebrate communities as outlined by Pflieger et al. (1981) and principal components analysis of the physical and chemical parameters of Niangua darter streams will be used as a guide in selecting streams that are likely to have undocumented Niangua darter populations.

2) Develop a strategy for establishing additional Niangua darter populations. Establishment of additional Niangua darter populations would provide direct and immediate benefits to the Niangua darter by lessening the potential for extinction through the incremental extirpation of existing populations. Any additional populations that

are established could serve as sources of brood stock for reestablishment of other populations that may become extinct, or for establishment of new populations to meet Recovery Plan goals.

2.1 Select streams suitable for introducing populations. Tributaries of the Osage River will be given priority in selecting streams for establishing additional populations of the Niangua darter. Stream drainages tentatively proposed for study as potential introduction sites are: Grand Auglaize Creek, Camden County; Cole Camp Creek, Benton County; Cedar Creek, Cedar County; Sac River, Dade, Lawrence and Green counties; Deer Creek, Benton County; and Big Saline Creek, Miller County. These streams are all within the historic range of the Niangua darter, and are similar physically and biologically to streams supporting Niangua darter populations (Pflieger 1978). Additional streams are likely to be added to this list as a result of surveys conducted in Part I of the Recovery Outline Narrative.

The principal threat to continued survival of the Niangua darter is the presence of four large reservoirs in the Osage Basin. These reservoirs have reduced habitat, isolated populations, and favored increased abundance of potential competitors and predators. Populations within the historic range of the Niangua darter will be affected by these reservoirs for the foreseeable future. If only streams within the historic range are considered for introductions, we will, in large part, be merely establishing additional isolated populations subject to the same threats as

existing populations. The fact that these streams do not already support populations, although the Niangua darter presumably had access to them in the recent past, does not provide optimism for the long-term survival of any populations introduced into streams within the historic range. Therefore, consideration should be given to possible introduction of the Niangua darter into streams outside the historic range where threats from reservoirs do not exist. Such introductions would be made only after thorough study and review, with due consideration given for potential impacts on other species. Guidelines for introductions of threatened and endangered fishes proposed for adoption by the American Fisheries Society (Williams, et al. 1988 and Appendix I of this plan) will be followed in conducting this review.

Streams tributary to the Gasconade River offer the greatest potential for successful extralimital introductions, and it is highly improbable that streams in any other drainage would need to be considered. The Gasconade River drainage is contiguous with the Osage River drainage and both are tributary to the Missouri River (Fig. 4). Their mouths are only 26 miles apart, and their fish faunas are very similar, suggesting frequent biotic exchanges in the past. The Gasconade River is in the same physiographic region (Salem Plateau) as the Osage River, with similar topography, geology, and soils. No large reservoirs are present in or proposed for the Gasconade River drainage.

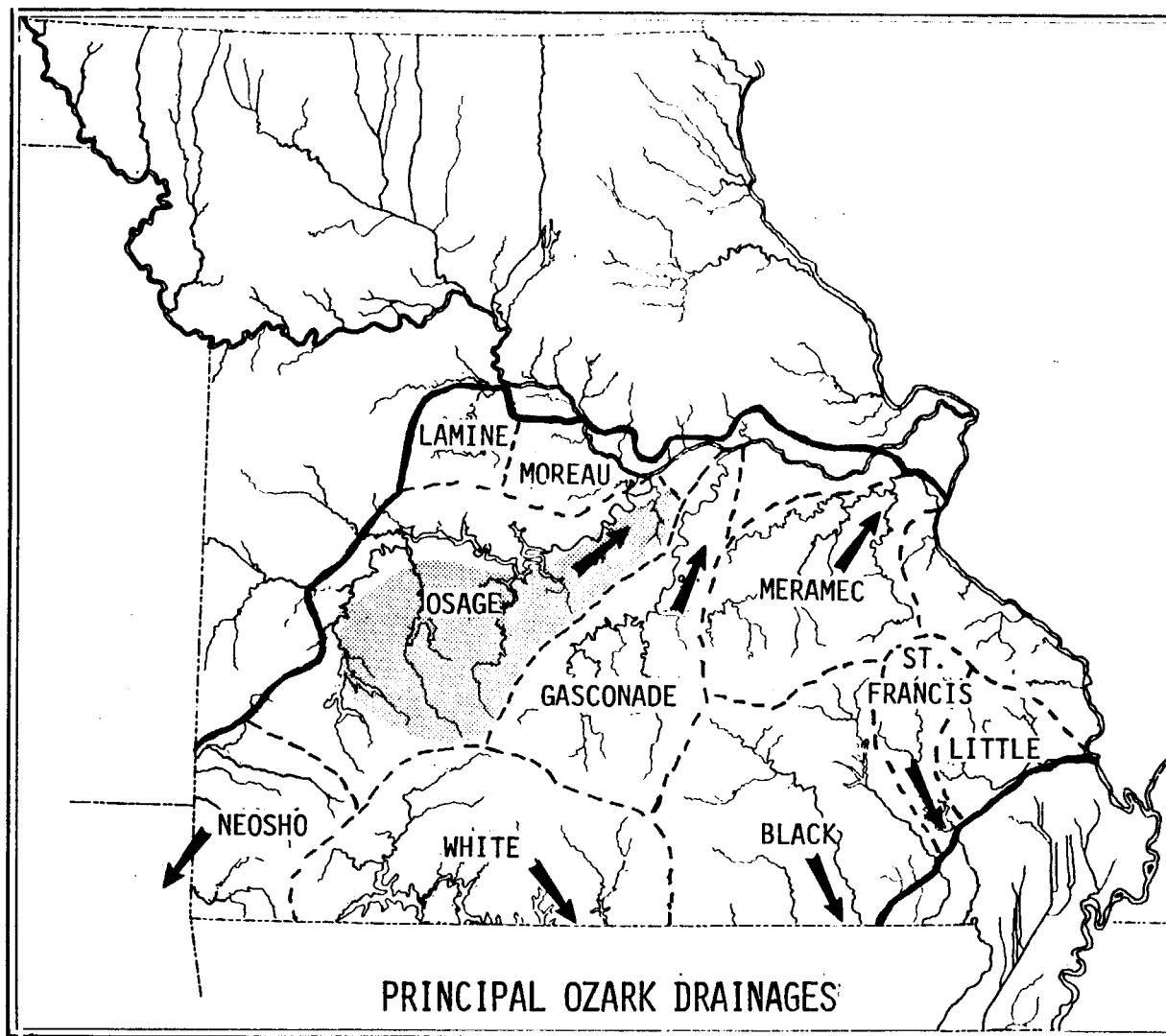


Figure. 4. Principal drainages of the Ozark Region in Missouri. The shaded area encompasses all localities where the Niangua darter has been recorded.

The faunal composition and physical and chemical characteristics of streams supporting existing Niangua darter populations will be used as a guide in selecting streams for establishing new populations. Other criteria to be considered in selecting these streams will include the amount and quality of available habitat, the presence of existing or potential threats to habitat quality, the distance and isolation of selected streams from those having established populations, the abundance of potential competitors or predators, and the amount of stream frontage owned by public or private conservation organizations dedicated to stream habitat protection.

2.2 Develop techniques for establishing populations. Stock for introductions should be obtained from several established populations to minimize impacts and increase genetic diversity of introduced populations. Transplantation attempts will likely involve artificial propagation of eggs obtained and fertilized at natural spawning sites. Since brood stock will be immediately returned to the water, effects on established populations will be minimal.

3) Protect and enhance habitat for existing and introduced populations. Long-term survival of the Niangua darter depends ultimately on the quality of its habitat.

3.1 Review proposals for actions having the potential to adversely affect Niangua darter habitat. These actions would include such

things as reservoir construction, the introduction of potential predators or competitors, stream channelization, the construction of waste treatment facilities, and the placement of sanitary land fills. Actions that would jeopardize Niangua darter populations will be identified, and alternatives to lessen or eliminate impacts will be proposed and encouraged.

3.2 Protect additional areas of critical habitat through purchase or lease. Stream reaches designated as critical habitat, and information resulting from the surveys conducted under Part C(1) above, will provide the basis for establishing priorities in purchasing or leasing Niangua darter habitat. Areas that include substantial frontage along both banks of the stream are preferred, since they provide better opportunities for habitat protection and management.

3.3 Develop and maintain public support for protection of the Niangua darter and enhancement of its habitat. The watersheds in which the Niangua darter occurs are largely in private ownership, and it is unlikely that sufficient land in these watersheds will ever be acquired to adequately protect the Niangua darter. Therefore, the cooperation of landowners and other private citizens is essential for maintaining and improving habitat quality. The public at large should be made aware of the values and plight of the Niangua darter and endangered and threatened species generally. This can be accomplished through the development of pamphlets, the publication of articles in

newspapers and magazines, and direct contacts. Landowners along streams supporting Niangua darter populations in particular should be informed of actions they can voluntarily take to protect and enhance streams habitat. Examples of such actions include the protection or restoration of natural vegetation on gravel bars and banks, and farming practices that minimize the influx of pesticides, silt, or excessive nutrients into streams.

3.4 Enhance habitat on publicly controlled lands. Areas purchased or leased as Niangua darter habitat provide opportunities to revegetate streambanks and gravel bars, stabilize eroding banks, and develop instream cover. Technical assistance will be provided to the Missouri Highway Department, county courts, and other governmental bodies controlling easements or owning stream frontages to assure that their activities will protect and enhance Niangua darter habitat. Biologists recently hired by the Missouri Department of Conservation as part of an expanded stream management program will assist in these activities.

4) Develop and implement a program for monitoring populations and habitat protection/enhancement activities.

4.1 Monitor trends in existing populations. Present population trends are not known. Knowledge of these trends is essential to evaluate status and the response of populations to recovery efforts.

Visual counts of Niangua darters obtained with face mask and snorkel, and catch per unit of seining effort as outlined by Pflieger (1978) can provide indices for measuring trends in abundance between time periods and streams. A census of all existing populations will be conducted every 10 years, and selected populations will be censused at intervals of 3-5 years. Abrupt changes in darter abundance or habitat may determine a need for more frequent monitoring.

4.2 Monitor trends in introduced populations. Knowledge of the trends in transplanted populations is essential to document success in transplantation efforts. Success cannot be assumed until it has been determined that a stable or increasing population has persisted for at least 10 years. Introduced populations will be monitored annually for at least the first three years after the initial introduction. The frequency of censuses thereafter will be determined by the need for additional stocking and apparent trends in abundance.

4.3 Monitor habitat protection/enhancement efforts. Streams with established and introduced populations will be monitored, using the techniques outlined in Part 1.1 above. Representative stream sections will be mapped and photographed to document existing conditions for comparison with future surveys. Habitat monitoring will be accomplished concurrently with monitoring of Niangua darter populations (Task 4.1), unless habitat changes or habitat enhancement efforts suggest a need for more frequent monitoring.

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IMPLEMENTATION SCHEDULE

GEN. CAT.	PLAN TASK	TASK #	PRIOR-ITY #	TASK DURATION	RESPONSIBLE AGENCY			FISCAL YEAR COSTS (EST.) (in \$1,000's)			COMMENTS/ NOTES
					FWS		OTHER	FY 1	FY 2	FY 3	
					REGION	PROGRAM					
K-1	Survey known populations	1.1	1	2 years	3	SE	MODOC	50,000	50,000	-	
R-1	Survey for new populations	1.2	2	1 year	3	SE	MODOC	-	-	50,000	
M-2	Select introduction sites	2.1	3	1 year	3	SE	MODOC USFS	-	-	-	Will follow 1.1 and 1.2
M-2	Initiate introduction	2.2	3	2-3 yrs	3	SE	MODOC USFS	-	-	-	After 1.2 & 2.1 are completed
M-3	Protect habitat via project reviews	3.1	1	Ongoing	3	SE	MODOC	2,000	2,000	2,000	
A-all	Protect habitat via purchase or lease	3.2	2	5 years	3	SE,RE	MODOC	-	185,000	185,000	
O-1 M-3	Landowner education and public support	3.3	2	Ongoing	3	SE	MODOC	2,000	2,000	2,000	
M-3	Management of publicly owned habitat	3.4	2	Ongoing	3	SE	MODOC MODOT USFS	10,000	10,000	10,000	Includes improv- ing, then main- taining habitat
I-1	Monitoring known populations	4.1	1	10-year inter- vals	3	SE	MODOC				Accomplished for first interval under 1.1 & 1.2
I-1	Monitor introduced populations	4.2	3	Annually for 3 years	3	SE	MODOC USFS				Subsequent monitoring frequency TBD
I-2	Monitor habitat protection and enhancement efforts	4.3	1	Ongoing	3	SE	MODOC				

Appendix I. American Fisheries Society Guidelines for Introductions of Threatened and Endangered Fishes.

These proposed guidelines were excerpted from Williams et al. . At the time this recovery plan was prepared, they had not been presented to the AFS Executive Committee for approval, and as yet have not been officially adopted by the American Fisheries Society.

1. Selecting the Introduction Site

A. Restrict introductions to within the native or historic habitat whenever possible.

For a broadly ranging species, such as the Colorado squawfish, the historic habitat includes the mainstem Colorado River and many of its major tributaries, from the Green River of Wyoming to the Gila River of Arizona. On the other hand, a single-spring endemic, such as the Devils Hole pupfish, has a historic distribution of narrowest proportions.

Any attempt to introduce an endangered or threatened fish outside of its historic range should be viewed with great caution. The historic habitat of a species is herein considered to be those localities from which the species is known plus any interconnected waters from which it could reasonably have occurred. Introductions outside of a species' historic habitat may be necessary, but should be considered only when all locations within the historic range are unsuitable and/or unrestorable, when extant historical habitat is clearly threatened with imminent loss, or when the introduction is proposed within a controlled site (such as a hatchery).

B. Restrict introductions to a protected site.

Any site selected to receive introductions should be secure from imminent or future threats of habitat destruction. In order to protect the habitat, some form of management agreement with the landowner or land management agency is advisable. Placing the site in land dedicated to protecting the species, whether public or private ownership, is preferable.

C. Restrict introductions to sites where the potential for dispersal has been determined and is acceptable.

Depending on the introduction goal it may be advisable to choose sites with little or no opportunity for further dispersal of the introduced population. This is especially true for releases made outside the historic habitat where additional range expansion may not be desired. Conversely, some introductions are intended to expand an existing population within its historic range. In such cases, further dispersal routes may be a prerequisite for site selection.

D. Restrict introductions to sites that fulfill life history requirements of the species.

Adequate food, spawning, and rearing habitat for all life stages should be available. Habitat variables should be measured (Orth 1983) and water quality analyzed (U.S. Environmental Protection Agency 1976) to establish baseline habitat conditions and to determine the presence of any harmful substances. Water quality should be similar to that observed in undisturbed natural habitat.

E. Restrict introductions to sites that contain sufficient habitat to support a viable population.

To maintain population viability, sufficient individuals must be present to prevent serious inbreeding and loss of genetic variation by random drift. The number of individuals actually contributing to recruitment of the next generation (i.e., effective population size), however, is usually only a fraction of the total population size (i.e., census population size). Allendorf and Ryman (1987), for example, recommended an effective population size of 200 for sustaining hatchery stocks of salmonids. In the wild, a much larger census population would be needed to compensate for unbalanced sex ratios, age structure, etc. Sufficient habitat would be needed to maintain a viable population in the face of floods, drought or other stochastic events. Because of these factors, habitat necessary to support many thousands of individuals could be required to maintain an effective breeding population of 200.

F. Prohibit introductions into areas where the endangered or threatened fish could hybridize with other species or subspecies.

Many rare fishes, particularly those of isolated drainages in the West, have had little opportunity to develop reproductive isolating mechanisms to prevent hybridization with closely related taxa. Some groups of fishes, such as the suckers (family Catostomidae), readily hybridize and intergeneric hybrids are common. Introductions should not proceed when the subject species could hybridize with a fish already present in the habitat.

An exception to this guideline would apply to a limited number of taxa and situations. If hybrids with the taxon to be introduced are known or are suspected to occur at the introduction site, and if the incidence of hybridization is low and is a natural occurrence in the area, then such sites can be considered for the introduction. Some catostomids and some chubs of the genus *Gila*, for example, exhibit limited hybridization with naturally sympatric taxa.

G. Prohibit introductions into areas where other rare or endemic taxa could be adversely affected.

If an introduction is proposed outside the species' historic range, pre-introduction surveys should be conducted to determine the presence of rare invertebrate, fish or other aquatic species that might be adversely affected by release of the endangered or threatened fish. Appropriate taxonomists in entomology, malacology, or other invertebrate zoological specialities should be consulted. If an introduction is proposed within the species' historic range, the need for surveys of other rare aquatic species may be advisable, especially if physical modification of habitats is proposed as part of the introduction effort. Such surveys could have prevented loss of a population of hydrobiid snail species

endemic to the Fish Slough area in eastern California. The snail population was eliminated during habitat modification efforts associated with introduction of the Owens pupfish into Fish Slough (Landye 1983). For introductions within the species' historic range that do not include physical manipulation of habitats, surveys for other rare species, while potentially valuable, should not be required.

2. Conducting the Introduction

A. Choose introduction stock from appropriate source.

For rare fishes with more than one population, a source for the introduction stock must be selected. It is important to realize that each isolated population of a rare fish is likely to be a unique gene pool with specific adaptations to local conditions (Meffe 1986). Fishery managers, therefore, may have a choice of unique stocks to select from, or perhaps to mix. The availability of life history and genetic information on the candidate source stocks will greatly facilitate the proper selection.

Selection criteria will vary with the intended purpose of the introduction, but consideration may be given to selecting the most genetically pure stock, the rarest stock, the stock closest geographically to the introduction site, or the stock closest ecologically. Meffe (1987) pointed out that populations at the edge of a range may have lower genetic variance than do those near the center. It is possible that individuals from centrally located populations may display a higher fitness in characters such as growth rate, survivorship, fecundity, etc. (Meffe 1987). This phenomenon was well documented in an electrophoretic analysis of 21 populations of the Sonoran topminnow, *Poeciliopsis occidentalis*. Vrijenhoek et al. (1985) demonstrated that the source topminnow population being used for restocking was genetically invariant and displayed a very low fecundity. This study prompted a switch in the source population used for restocking efforts.

Mixing of naturally isolated stocks to establish a population should be discouraged because it may reduce genetic fitness by loss of closely-linked or coadapted genes (Dobzhansky 1970). That is, genes that are coadapted within one population may be broken up by hybridization and combined into gene complexes that do not function well together (Meffe 1986). Evidence of this phenomenon was observed when isolated stocks of Atlantic salmon, *Salmo salar*, were mixed (Stahl 1981). Often, the first generation hybrids are robust, but subsequent generations lose fitness as the coadapted gene complexes are broken up. Meffe (1986, 1987) presented good reviews of the problems of mixing isolated stocks of rare fishes and recommended against it in nearly all cases.

B. Examine taxonomic status of introduction stock.

Introduction stock should be examined prior to transport by an appropriate taxonomist in order to insure that only the desired form is present. If the taxonomy is questionable but the introduction nonetheless proceeds, a subsample of the stock should be preserved for future analysis.

C. Examine introduction stock for presence of undesirable pathogens.

Unwanted parasites and diseases frequently have been introduced through fish transfers (Hoffman and Schubert 1984). Samples of the introduction stock should be examined by a qualified fish pathologist prior to shipment. Ideally, the sample should be quarantined for at least two weeks so that parasites may complete their life cycle or become numerous enough to detect (Hoffman and Schubert 1984). Stock held in culture facilities often are subjected to crowded conditions that may produce higher parasite loads. Culture stocks should be regularly inspected for undesirable parasites and diseases. If sufficient introduction stock is available, Ossiander and Wedemeyer (1973) recommended a sample of at least 60 fish to determine the presence or absence of a pathogen in the population.

The authors recognize that conditions may not allow for the necessary quarantine and inspection of the introduction stock. In a crisis situation where the last population of a species is imminently threatened, for example, no time may be available for a quarantine. Also, the transfer of *wild* stock *within* a drainage presents a lower risk of introducing a new parasite or disease. In such cases, a quarantine may not be required.

D. Obtain introduction stock of sufficient number and character.

An introduced population should be founded with enough individuals to adequately reflect the genetic composition present in the source population. Estimating the precise number of individuals necessary to accurately reflect the source population may be enigmatic. In general, a population of fish from a homogeneous habitat (such as a small stenothermal spring) may possess a narrower range of genetic variability than a population from a heterogeneous habitat (such as a eurythermal stream) (Vrijenhoek et al. 1985). Therefore, a smaller number of individuals may be required to encompass the available genetic variability from a constant environment habitat compared to a variable environment. If the source population is not threatened by imminent loss, no more than 10% of the available stock should be utilized annually for introductions.

Other important considerations include sex ratio and age structure of the introduction stock. A sex ratio near 1:1 and a range of age classes should increase the chance of a successful translocation. No ideal number exists, although researchers have suggested that 25 males and 25 females of the proper age and condition is an absolute minimum to establish salmonid populations in highly controlled hatchery settings (Allendorf and Ryman 1987; Ryman and Stahl 1980). Less controlled environments, where each individual does not contribute equally in reproduction, require a greater number of fish.

Collection techniques should disrupt natural habitats as little as possible. Spring systems often are particularly sensitive to small amounts of human disturbance.

E. Carefully and quickly transport stock.

A stress response usually results when fish experience fright, discomfort, or pain (Schreck 1981). Transported stock are most commonly stressed by physical handling and by confinement of large numbers of individuals in small con-

tainers. Loss of mucus or scales, disturbance to integument, or damage to internal organs can lead to shock, increased susceptibility to infection, immune system suppression and/or delayed mortality (Mazeaud et al. 1977; Schreck 1981). The detrimental effects of repetitive stress are cumulative (Schreck 1982). Therefore, an adequate recovery period should be provided between each stressful event. Stress also can impair a fish's ability to learn for up to several weeks (C.B. Schreck, personal communication). This could block imprinting processes needed for adult homing or migration. Stress can be reduced by darkness or the use of anesthetics (Schreck 1981).

A general discussion of handling live fish is presented by Stickney (1983). In addition, Johnson (1979) presented data on numbers and weights of fish that can safely be transported in plastic bags containing water saturated with oxygen.

F. Introduce stock under most favorable conditions.

Stock should be introduced during favorable weather and hydrologic conditions. Thermal shock should be avoided by equalizing the transport water temperature to that of the habitat. Further, introducing stock at the proper time of day can reduce initial predation losses. For example, because sight-feeding predators would be less active at night, introductions into waters containing such predators should occur during dark conditions.

G. Document the translocation.

It is vital that the procedures and location of introductions be made available in the scientific literature. Simply filing the appropriate data in a handy institutional cabinet is insufficient to allow necessary accessibility. Introduction data should be made available through regularly distributed scientific literature, or through administrative reports of the lead agency. At a minimum, the following should be reported: identity of those conducting the introduction, taxon involved, source of the introduction sample, numbers of introduced individuals and their sex, age and/or size distribution, date of introduction, and precise location of the receiving habitat.

3. Post-Introduction Activities

A. Conduct systematic monitoring of introduced populations.

Regular surveys should be conducted to determine initial survival, recruitment of young, and persistence through environmental stochasticity (such as floods, drought, or fire). During the first year, quarterly monitoring may be warranted. If the population becomes established, annual monitoring should be continued for many years to determine long-term survivorship. Life history studies of introduced populations are advisable. Rapid evolution of life history strategies has been documented in introduced populations of guppies, *Poecilia reticulata*, as a result of new predators and/or novel habitats (Reznick and Bryga 1987).

B. Restock if warranted.

In some cases, it may be advisable to supplement the initial stocking of the endangered or threatened fish in order to facilitate establishment or increase gene flow. Subsequent electrophoretic analysis of the introduced population would reveal loss of genetic variation by founder effect, genetic

bottlenecks, inbreeding or drift. As such, genetic studies of introduced populations are an underutilized tool available to the fishery manager (G. K. Meffe, personal communication). The supplemental stock should be collected from the same source as the original introduction in order to maintain genetic fitness as described above (see also Meffe 1987; Meffe and Vrijenhoek 1988). The same care should be taken in acquisition of individuals for the restocking effort as was taken in selection of the original introduction stock. In some cases of failure, restocking still may be advisable. If failure occurs, however, the casual factor(s) should clearly be identified and eliminated prior to restocking.

C. Determine cause of failures.

If an introduction fails, efforts should immediately be initiated to determine the cause or causes. Understanding failed introductions ultimately may be more important in promoting recovery than certain successes.

D. Document findings and conclusions reached during the post-introduction process.

Results of monitoring efforts and causes of failures should be made available in the scientific literature or administrative reports and widely distributed.

Appendix II. Reviewers

The following organizations or individuals were provided one or more drafts of the recovery plan for their review and comments. All comments have been retained at the Twin Cities, Minnesota, Regional Office of the U.S. Fish and Wildlife Service.

Office of Public Affairs
U.S. Fish and Wildlife Service
Washington, D.C.

Office of International Affairs
Attention: Mark Schaffer
U.S. Fish and Wildlife Service
Washington, D.C.

Division of Refuges
U.S. Fish and Wildlife Service
Washington, D.C.

Division of Realty
U.S. Fish and Wildlife Service
Washington, D.C.

Division of Fish Hatcheries
U.S. Fish and Wildlife Service
Washington, D.C.

Division of Endangered Species and Habitat Conservation
U.S. Fish and Wildlife Service
Washington, D.C.

Branch of Listing and Recovery
U.S. Fish and Wildlife Service
Washington, D.C.

Region 8 (Research)
U.S. Fish and Wildlife Service
Washington, D.C.

Fisheries and Federal Assistance
U.S. Fish and Wildlife Service
Federal Building, Fort Snelling
Twin Cities, MN 55111

Ohio Cooperative Fish & Wildlife Research Unit
Department of Zoology
1735 Neil Avenue
Columbus, OH 43210

Missouri Cooperative Fish & Wildlife Research Unit
Stephens Hall
University of Missouri
Columbia, MO 65211

Ecological Services
U.S. Fish and Wildlife Service
P.O. Box 1506
Columbia, MO 65205

National Fisheries Center-LaCrosse
P.O. Box 818
La Crosse, WI 54601

National Fisheries Contaminants Research Center
Route 1
Columbia, MO 65201

National Fisheries Center
U.S. Fish and Wildlife Service
Box 700
Kearneysville, WV 25430

Dr. James D. Williams
National Fisheries Research Laboratory
U.S. Fish and Wildlife Service
7920 N.W. 71st Street
Gainesville, FL 32606

Dr. Garland B. Pardue
National Fishery Research & Development Laboratory
U.S. Fish and Wildlife Service
RD #4, Box 63
Wellsboro, PA 16901

Dr. Walter R. Courtenay, Jr.
Chairman, ASIH Environmental Quality Committee
American Society of Ichthyologists and Herpetologists
Department of Biological Sciences
Florida Atlantic University
Boca Raton, FL 33431

Mr. Robert E. Radtke
U.S. Forest Service
310 West Wisconsin Avenue
Milwaukee, WI 53203

Hazard Evaluation Division - EEB (TS769C)
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, D.C. 20460

Colonel James E. Corbin
District Engineer
U.S. Army Engineer District St. Louis
210 Tucker Boulevard North
St. Louis, MO 63101-1986

Mr. Rod Miller
Missouri Field Office
The Nature Conservancy
2800 S. Brentwood Boulevard
St. Louis, Missouri 63144

Missouri Highway & Transportation Department
Highway and Transportation Building
P.O. Box 270
Jefferson City, MO 65102

Mr. Charles Kruse, Director
Department of Agriculture
100 E. Capitol Avenue
Jefferson State Office Building
P.O. Box 630
Jefferson City, MO 65102

Appendix III. Public Notification

Public notices were placed in the following six newspapers in the area potentially affected by this recovery plan. The notices announced the opening of a 30-day public comment period and advised interested individuals how to view the draft plan, obtain a copy, and submit comments for consideration by the U.S. Fish and Wildlife Service. One request for a copy of the draft plan was received and honored. No public comments were received.

Springfield News-Leader
P.O. Box 651
651 Booneville Avenue
Springfield, MO 65806

St. Louis Post-Dispatch
900 North Tucker Boulevard
St. Louis, MO 63101

St. Louis Globe-Democrat
710 North Tucker Boulevard
St. Louis, MO 63101

Jefferson City News and Tribune
P.O. Box 420
210 Monroe Street
Jefferson City, MO 65102

Bolivar Herald-Free Press
P.O. Box 330
Bolivar, MO 65613

Lebanon Record
P.O. Box 192
290 South Madison
Lebanon, MO 66536