

**The Implications of Rotenone Eradication  
on the Fish Community of Eagle Creek in  
Central Indiana**

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**Introduction**

The use of rotenone in the reclamation of fish populations first came into use in the United States in 1934 (Krumholz 1948). Since then, the eradication of undesirable fishes from ponds, lakes, and streams by the use of toxicants has become an accepted fisheries management practice. Forty-nine states, including Indiana, have reclaimed their waters by chemical methods, mainly since 1953 (Lennon et al. 1971).

In the summer of 1966, Eagle Creek and its tributaries were surveyed prior to impoundment by the Division of Fish and Game of the Indiana Department of Natural Resources to determine the relative abundance of "undesirable" fish species, i.e., carp, *Cyprinus carpio*, and gizzard shad, *Dorosoma cepedianum*. It was concluded from the study that, "no part of the watershed of Eagle Creek Reservoir could be omitted from an eradication project" (McGinty 1966).

Twelve years later, Eagle Creek was chosen as an experimental study stream in a Model Implementation Program (MIP) initiated by the U.S. Environmental Protection Agency and the Department of Agriculture. The goal of the study was to assess the effects of improved agricultural land-use practices on the water quality and stream biota of Eagle Creek.

A comparison of the data collected prior to the reclamation and impoundment of Eagle Creek with that gathered following yields some disturbing results and raises some serious questions about the validity of this accepted and commonly used reservoir management practice.

**Methods and Materials**

Fish were collected from 16 stations on Eagle Creek and its tributaries by the Division of Fish and Game of the Indiana Department of Natural Resources from 8 to 17 August 1966. Ten stations were located in the stream proper, whereas the remaining six consisted of adjacent gravel pits and a farm pond (Figure 1). Rotenone was used as a toxicant.

During the summers of 1978, 1979, and 1980, nine stations on Eagle Creek and its tributaries were sampled at least twice each summer. Four other sites were sampled only once during the three-year period (Figure 1). Fish were collected using a 30-foot, A.C. electroseine, a D.C. electric boat-shocking apparatus, and a one-eighth-inch-mesh nylon seine. Most of the fish collected were identified, weighed, and measured in the field and returned to the stream. Voucher specimens for many of the species are kept in the museum at DePauw University. Forty-nine

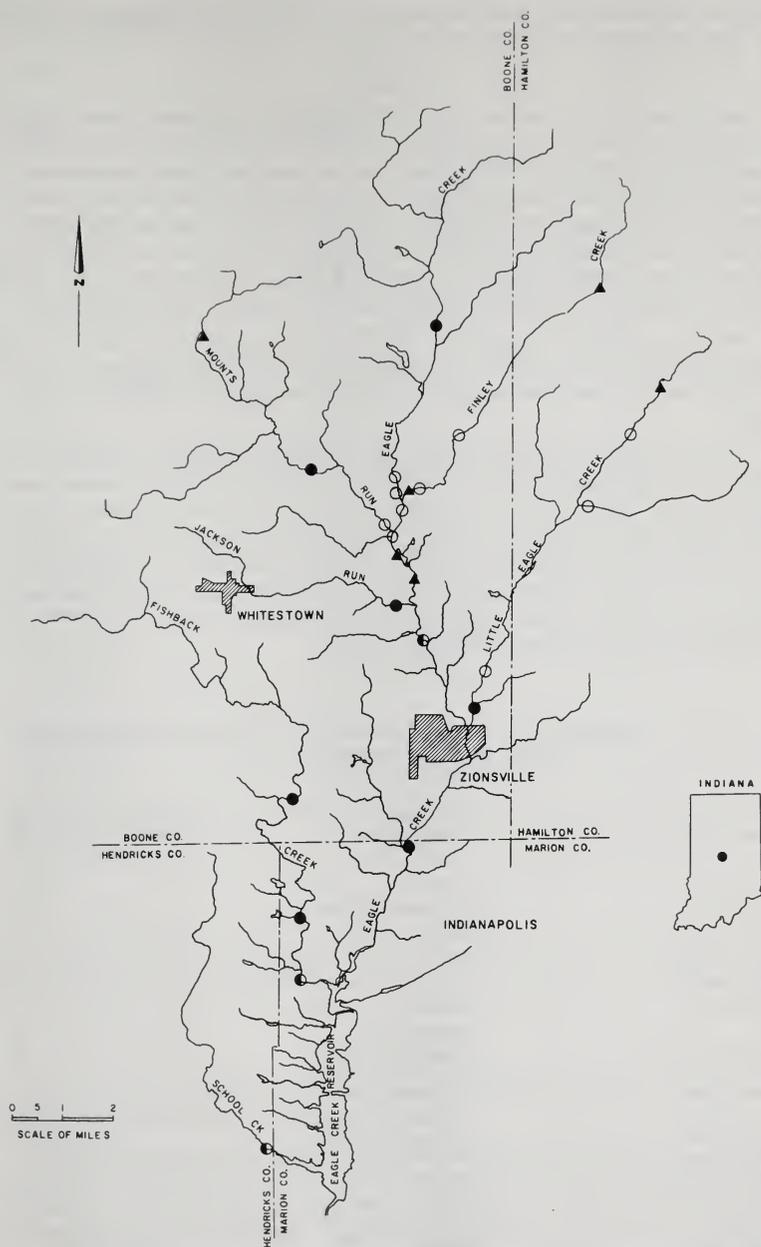


FIGURE 1. Map of Eagle Creek drainage showing 1966, and 1978-1980 sampling stations. Closed circles (●) denote 1966 stream stations, closed triangles (▲) denote 1966 gravel pits and/or a farm pond, open circles (○) denote 1978-1980 stream stations, and half-closed circles (◐) denote 1966 and 1978-1980 stations sampled alike.

individual collections were made during the three-year period. Common and scientific names of fishes follow Bailey et al. (1970).

### Results

Data from the 1966 survey were obtained from an Indiana Department of Natural Resources report that, with one exception, listed only the species collected at each station (McGinty 1966). Therefore, to compare those data with the 1978-1980 data, values are expressed in percentage frequency of occurrence at sampling stations, that is, the number of stations at which a species was collected divided by the total number of stations collected, times 100. Six stations from the 1966 survey were excluded from the calculations (i.e., adjacent gravel pits and a farm pond) because comparable collections were not made in the 1978-1980 study.

All stream stations sampled in the 1978-1980 study were included in the calculations. Data from four stations located close to one another on the mainstem of Eagle Creek, and sampled only once in 1978, were grouped together as one collection.

Of the 49 species taken during both surveys, 43 were taken in the 1966 study, whereas 37 were collected in the 1978-1980 survey (Table 1). Five species: gizzard shad, rosy-face shiner *Notropis rubellus*, quillback *Carpiodes cyprinus*, spotted sucker *Minytrema melanops*, and black crappie *Pomoxis nigromaculatus* were collected only from gravel pits and a farm pond during the 1966 survey. Noteworthy changes in the percentage frequency of occurrence following the treatment and impoundment include redbfin shiner *Notropis umbratilis* (from 10 to 80%) and bluegill *Lepomis macrochirus* (from 40 to 90%).

TABLE 1. A combined list of species collected from the Eagle Creek drainage during 1966 and 1978-1980 surveys.

Common name	Scientific name	1966	1978	1979	1980
Herrings	<i>Clupeidae</i>				
Gizzard shad	<i>Dorosoma cepedianum</i>	X	X		X
Pikes	<i>Esocidae</i>				
Grass Pickerel	<i>Esox americanus vermiculatus</i>	X	X	X	X
Minnnows and carp	<i>Cyprinidae</i>				
Stoneroller	<i>Campostoma anomalum</i>	X	X	X	X
Carp	<i>Cyprinus carpio</i>	X	X	X	X
Silverjaw minnow	<i>Ericymba buccata</i>	X	X	X	X
Hornyhead chub	<i>Nocomis biguttatus</i>	X			
Golden shiner	<i>Notemigonus crysoleucas</i>	X			
Emerald shiner	<i>Notropis atherinoides</i>	X			
Striped shiner	<i>Notropis chrysocephalus</i>		X	X	X
Common shiner	<i>Notropis cornutus</i>	X			
Rosyface shiner	<i>Notropis rubellus</i>	X			
Spotfin shiner	<i>Notropis spilopterus</i>	X		X	
Sand shiner	<i>Notropis stramineus</i>	X			
Redfin shiner	<i>Notropis umbratilis</i>	X	X	X	X
Suckermouth minnow	<i>Phenacobius mirabilis</i>	X			X
Southern redbelly dace	<i>Phoxinus erythrogaster</i>	X			X
Bluntnose minnow	<i>Pimephales notatus</i>	X	X	X	X
Fathead minnow	<i>Pimephales promelas</i>		X		
Blacknose dace	<i>Rhinichthys atratulus</i>	X			
Creek chub	<i>Semotilus atromaculatus</i>	X	X	X	X

TABLE 1. *Continued.*

Common name	Scientific name	1966	1978	1979	1980
Suckers	<i>Catostomidae</i>				
Quillback	<i>Carpionodes cyprinus</i>	X			
White Sucker	<i>Catostomous commersoni</i>	X	X	X	X
Creek chubsucker	<i>Erimyzon oblongus</i>	X	X	X	X
Northern hog sucker	<i>Hypentelium nigricans</i>	X			
Spotted sucker	<i>Minytrema melanops</i>	X	X	X	X
Golden redbhorse	<i>Moxostoma erythrurum</i>	X			
Catfishes	<i>Ictaluridae</i>				
Black bullhead	<i>Ictalurus melas</i>	X	X	X	X
Yellow bullhead	<i>Ictalurus natalis</i>	X	X	X	X
Brindled madtom	<i>Noturus miurus</i>	X			
Killifishes	<i>Cyprinodontidae</i>				
Blackstripe topminnow	<i>Fundulus notatus</i>	X			X
Silversides	<i>Athermidae</i>				
Brook silversides	<i>Labidesthes sicculus</i>	X			X
Bass and Sunfishes	<i>Centrarchidae</i>				
Rock bass	<i>Ambloplites rupestris</i>	X	X	X	X
Green sunfish	<i>Lepomis cyanellus</i>	X	X	X	X
Bluegill	<i>Lepomis macrochirus</i>	X	X	X	X
Longear sunfish	<i>Lepomis megalotis</i>	X	X	X	X
Redear sunfish	<i>Lepomis microlophus</i>		X		
Smallmouth bass	<i>Micropterus dolomieu</i>	X		X	X
Spotted bass	<i>Micropterus punctulatus</i>		X	X	X
Largemouth bass	<i>Micropterus salmoides</i>	X	X	X	X
White crappie	<i>Pomoxis annularis</i>	X	X	X	
Black crappie	<i>Pomoxis nigromaculatus</i>	X			X
Perches	<i>Percidae</i>				
Greenside darter	<i>Etheostoma blennioides</i>	X			X
Rainbow darter	<i>Etheostoma caeruleum</i>	X	X	X	X
Fantail darter	<i>Etheostoma flabellare</i>	X			
Johnny darter	<i>Etheostoma nigrum</i>	X	X	X	X
Orangethroat darter	<i>Etheostoma spectabile</i>		X	X	X
Logperch	<i>Percina caprodes</i>	X	X	X	X
Blackside darter	<i>Percina maculata</i>	X	X	X	X
Sculpins	<i>Cottidae</i>				
Mottled sculpin	<i>Cottus bairdi</i>		X	X	X
Total number of species		43	29	28	33

**Notable Additions**

Of those six species collected during the 1978-1980 study, but not found in the 1966 survey, four deserve further explanation.

Striped shiners *Notropis chrysocephalus* were taken at 90% of the 1978-1980 stations. It was probably identified as *Notropis cornutus* the common shiner in the 1966 study, as it occurred at all of the stations surveyed. Gerking (1945) recognized *N. chrysocephalus* only as a subspecies of *N. cornutus* (*N. cornutus chrysocephalus*) in his work.

Spotted bass *Micropterus punctulatus* were collected at 90% of the post-treatment stations. This species was originally identified in Eagle Creek by Gerking (1945). It may have possibly been overlooked in the 1966 survey.

Orangethroat darters *Etheostoma spectabile* were collected at all of the

1978-1980 stations. It was probably confused with the closely related rainbow darter *E. caeruleum* in the 1966 study.

Mottled sculpins *Cottus bairdi*, collected at 70% of the 1978-1980 survey stations, were notably absent from the 1966 survey.

The remaining two species additions, fathead minnow *Pimephales promelas* and redear sunfish *Lepomis microlophus*, were present at only 10% of the stations. Their presence is probably due to introduction as bait species by fishermen for the former, and as a stocked species in the latter case.

#### Notable Deletions

Perhaps of greater significance are the species taken in 1966 that were not found in the 1978-1980 survey (Table 1). It should be noted here that failure to find those species in 1978-1980 does not necessarily verify their extirpation, it means only that they were taken in one series of samples and not in another. What is important is that those species, some of which comprised a major portion of the systems biomass, have been either greatly reduced in numbers or extirpated. The result is a significant change in the fish community of Eagle Creek.

Northern hog suckers *Hypentilium nigricans* were captured at 80% of the 1966 stations. Their absence is particularly noteworthy since Eagle Creek appears to have an ideal habitat (e.g., deep riffles, rocky bottoms, and permanent flow) for this species.

Golden redhorse *Moxostoma erythrurum* were taken from 70% of the 1966 stations. Again, the deep pools, permanent rocky substrate, and constant flow currently found in Eagle Creek would appear to favor the presence of this species.

Fantail darters *Etheostoma flabellare* were captured at 50% of the 1966 sites. This species was not taken at any of the 1978-1980 stations or any of the 1966 stations sampled in the 1978-1980 survey.

With the exception of the common shiner discussed earlier, none of the seven species of minnows missing from the 1978-1980 list were taken from more than 20% of the 1966 stations. Nevertheless, their absence is significant since they are common components of streams found in this area. The absence of *Noturus miurus*, the brindled madtom, is also noteworthy as it was listed as the fifteenth most abundant species by weight in an "average stream environment" of Eagle Creek.

To illustrate changing patterns in species abundance further, weight data from a 1966 station on the mainstem of Eagle Creek that was considered to "typify average stream environment for this area," was compared with a series of collections made in this same area and upstream during 1978 (Table 2). Although sampling techniques and exact locations of the collections differ, the results probably reflect a trend in species composition and abundance.

Of the top four species collected in 1966, the number one species, golden redhorse, and the number four species, northern hog sucker have not been captured to date. Furthermore, only three specimens of the second most abundant species by weight, smallmouth bass *Micropterus dolomieu* have been collected, two of which were young-of-the-year. Smallmouth bass were taken from 50% of the sampling stations in the pretreatment survey.

In the 1978 collections, carp, one of the undesirable target species, ranked number one in biomass abundance, whereas the other target species, gizzard shad, was number eight. That trend, no doubt, is influenced by the reservoir. The

number two species white sucker *Catostomous commersoni*, found at 70% of the 1966 stations, was taken from all of the 1978-1980 sites.

### Discussion

The reclamation of streams in the United States through the use of toxicants has enjoyed only limited success. Numerous authors have noted that complete fish kills in streams rarely, if ever, occur and that reinfestation by rough, or "undesirable" fish is rapid (cf. Lennon, *et al.* 1971).

Data gathered in this and other related studies support these findings. Two surveys of the Eagle Creek reservoir by the Indiana Department of Natural Resources Fish and Game Division in 1975 listed gizzard shad as the most abundant species captured both by number and by weight, whereas carp ranked sixth in numerical abundance and second in biomass abundance. A later 1978 IDNR survey of the reservoir showed that the gizzard shad was third by number and first by weight, while the carp ranked fifth by number and first by weight. The 1978 data gathered for this study (Table 2) seem to support the trend. Some rough fish species (i.e., carp) are relatively resistant to toxicants and this resistance, coupled with their extremely high fecundity rates, allows them to increase rapidly both in size and in numbers. Therefore, any reduction of rough fish is made up often in the first breeding season following the eradication (Hubbs 1963).

More recently, some serious questions have been raised about the validity of using poisons for the control of non-game fish species (Hubbs 1963, Becker 1975, Li 1975, Pister 1976, and Moyle 1978). The general assumption underlying nongame fish control, that game fish populations or growth rates are being limited by competition and/or predation from nongame fish, is at best questionable. Moyle (1978) reported a growing body of evidence demonstrating that most game fish can hold their own, and may serve to check nongame fish populations under "natural conditions," that is, in the absence of excessive harvest or habitat alteration. Furthermore, the contention that competition and predation between nongame fish and game fish is severely limiting game fish production is based largely on inferences from limited quantitative and qualitative data (Moyle 1977a, 1977b).

TABLE 2. *A relative comparison of the ten most abundant species by weight collected from a typical stream environment of Eagle Creek on 9 August 1966 and 15 September 1978.*

Species	1966	Weight (kg)	Species	1978	Weight (kg)
Golden redhorse		11.22	Carp		7.04
Smallmouth bass		2.95	White sucker		3.98
Common shiner		2.40	Longear sunfish		2.49
Northern hog sucker		1.69	Rock bass		1.82
Yellow bullhead		1.15	Spotted sucker		1.10
Rock bass		0.76	White crappie		0.84
Largemouth bass		0.76	Creek chub		0.81
Longear sunfish		0.61	Gizzard shad		0.26
White crappie		0.37	Grass pickerel		0.24
Stoneroller		0.33	Yellow bullhead		0.20

That game fish may actually benefit from a commensal feeding relationship with rough fish is implied by Reighard (1920) and Greely (1935). Both reported that smallmouth bass take a position downstream from hog suckers and feed on drifting aquatic insects dislodged as the hog sucker turns over rocks. Larimore *et al.* (1952) noted a strong correlation ( $r = 0.85$ ) between the weight distribution of smallmouth bass and hog suckers. Perhaps the current paucity of smallmouth bass in Eagle Creek is due, in part, to the absence of hog suckers from the system.

In general, the interactions between game fish and non-game fish are poorly understood. A need exists for sound ecological analysis of these relationships as a basis for thoughtful and sound fisheries management programs. Pister (1976) concluded that, "'Management' has been manifested in nongame species destruction, often with virtually no biological justification, . . . (while) little effort has been expended by agency fishery biologists in researching and understanding interspecific relationships."

The present strategy of reservoir management wherein the fish community is disrupted by rotenone for the control of a few species is questionable. The present reservoir preimpoundment eradication program should be re-evaluated. Less destructive reservoir management techniques exist for the control of rough fish (i.e., construction of barrier dams and the institution of maximum size limits on game fish, etc.) and may provide additional solutions.

The recent passage of the Forsythe-Chafee nongame fish and wildlife conservation act (PL 96-366) can provide the needed impetus for the careful conservation and management of our nongame resources. Pister (1976) has stressed the need for the management of nongame fish and wildlife, primarily in response to the projected increasing demand by the populace for outdoor oriented recreation. Thus, the fisheries biologist must be concerned with a broader portion of the aquatic biota. Moyle (1978) recognized this need for the management of all fish, ". . . fisheries biologists should start considering themselves as stewards of ecosystems and native faunas, as well as managers of game fish populations for consumption."

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