Fisheries Use Attainability Study for Cow Bayou (Segment 0511)

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Cow Bayou (Segment 0511) was sampled by Texas Parks and Wildlife (TPWD) Resource Protection Division staff as part of a use attainability analysis being prepared by the Texas Water Commission (TWC). The role of TPWD was to provide the TWC with a characterization of the fish community in this stream segment.

Study Site

Located in Orange County in southeast Texas, Cow Bayou (Segment 0511) is a small, tidally influenced water body in the Sabine River basin. The bayou flows in a southerly direction through Orange County and enters the Sabine River about 7.7 km east of Bridge City. The designated boundaries for Segment 0511 are from Interstate 10 to the Sabine, a distance of 26.4 km. Upper and lower portions of the bayou are markedly different in character. The bayou near Interstate 10 is in a somewhat natural state with no major wastewater inputs. Low dissolved oxygen levels and high fecal coliform densities have been recorded in the upper portion and are believed to result from natural processes (Kirkpatrick 1985). The bayou below Orangefield has been channelized, leaving numerous oxbows and side channels branching off from the new channel.

Four stations were sampled on Cow Bayou (Figure 1). The site on Cow Bayou near Interstate 10 was lined with lush vegetation including willow (*Salix*), bald cypress (*Taxodium*), tallow (*Sapium*) and pine (*Pinus*). Canopy covered about 30% of the bayou. Soil consisted of sandy loam. Leaching from surrounding vegetation (tannins, etc.) was apparent in the water. Maximum depth was 2.1 m, whereas mean depth was 1.8 m (Table 1). Flow was sluggish and was measured at 0.12 m^3/sec. Adequate habitat was available for aquatic organisms in the form of snags and fallen timber. This sampling site was different from the lower three sites, which were quite similar. Conductivities at the I-10 site indicated a freshwater situation, whereas the lower three sites were more estuarine influenced.

At the lower sites, the bayou was channelized and lined with low vegetation, including cypress at Highway 87 and giant reed (*Phragmites*) and pickerelweed (*Pontedaria*) at Round Bunch Road and the Sabine River confluence. Aquatic vegetation at the three sites included *Ludwigia*, *Myriophyllum*, and *Nitella*. No significant canopy was present. The bottom was relatively uniform and fairly firm, though covered with silt. Stream width and depth are reported in Table 1. Adequate habitat for a diverse fish community was available in the form of aquatic macrophytes.

Methods

Fish were collected July 29-30, 1987. Representative habitats were sampled by common sense seine and experimental gill nets. The seine measured 4.5 m in length, 1.2 m in depth, and was composed of 3.1 mm ace weave mesh. Gill nets were constructed of monofilament and were 60 m in length, 2.4 m in depth, and were composed of eight 7.5 m panels varying in bar mesh size from 12.5 to 100 mm.

Each station was seined for three 5-minute periods. Weight (g) and total length (mm) were recorded for larger individuals. Twenty-five randomly chosen fish from each sample were examined for disease and other abnormalities. All fish were preserved in 10% formalin and transported to the laboratory for identification. Taxonomic references include Eddy and Underhill (1978), Hubbs (University of Texas unpublished 1970 manuscript), and Pflieger (1975).

One gill net was set at each station for 15 to 17 hours. Sets were made so the period sampled included dawn, dusk, and evening periods, when fish are more active. Gill nets were set on the inside banks of meanders with the small mesh abutting the shoreline. Fish were identified, weighed, measured, and examined for disease and other abnormalities before their release.

Dissolved oxygen, pH, temperature, and conductivity were monitored at each station using a Hydrolab Surveyor II. Water transparency was measured with a Secchi disk. Stream width was

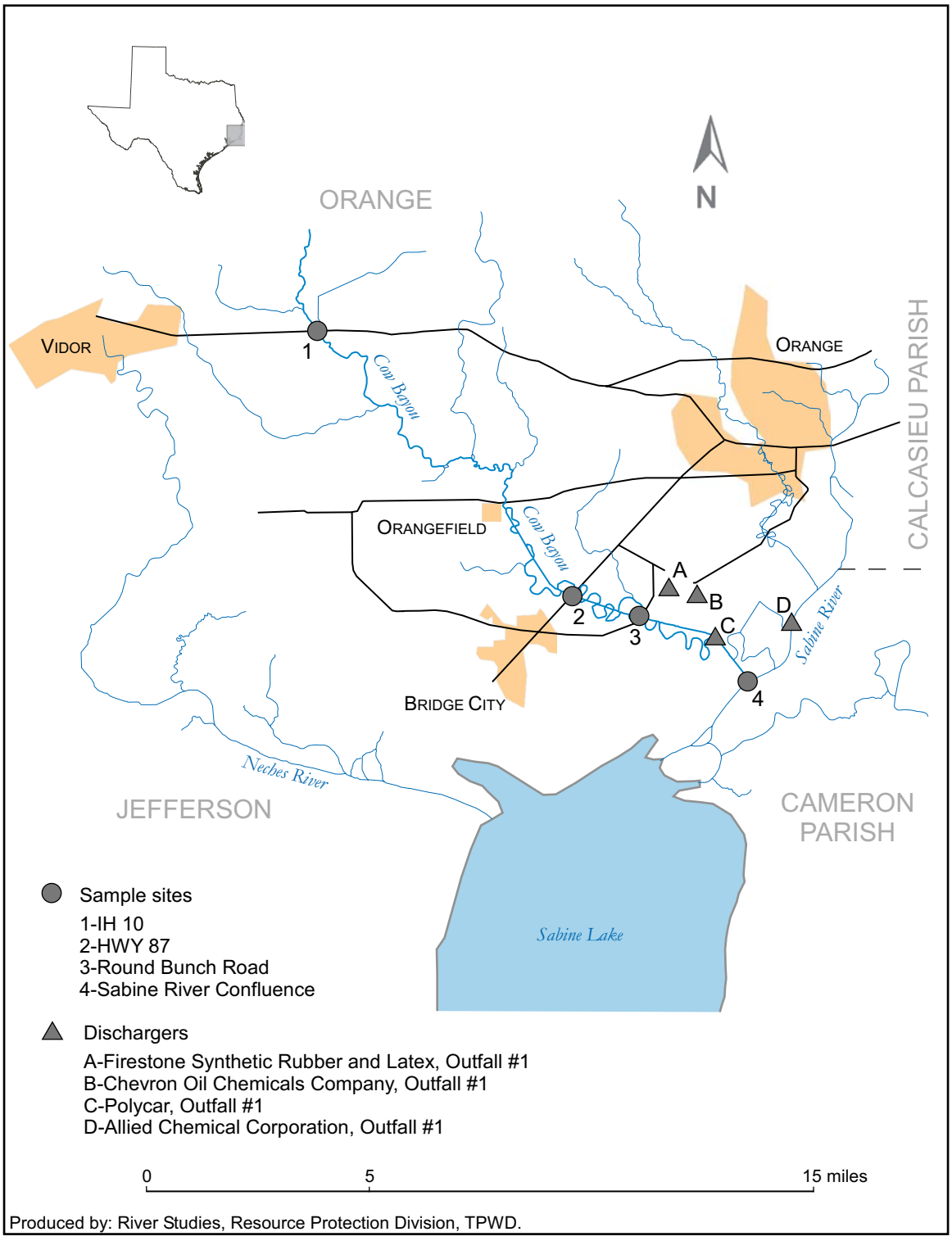

Figure 1.—Map of sampling area.

Table 1. Physiochemical measurements taken on Cow Bayou (July 1987).

	IH-10		Hwy. 87		Round Bunch Road		Sabine River Confluence	
Date	7/29/87	7/30/87	7/28/87	7/29/87	7/28/87	7/29/87	7/29/87	7/29/86
Channel Width (m)	15.8		30.0		30.0		45.0	
Mean Depth (m)	1.0		3.0		3.6		3.0	
Maximum Depth (m)	2.1		4.5		4.5		4.5	
Time	18:18	9:30	17:08	10:36	16:48	9:52	16:20	8:49
DO (mg/L)	6.25	5.79	4.68	2.86	5.63	3.31	6.62	5.57
Conductivity (umhos)	145	89	1082	1141	1580	1580	1950	1600
pH	6.22	6.09	6.12	6.06	6.45	6.22	6.79	6.66
Temperature (°C)	28.55	28.96	31.96	30.23	32.27	29.77	30.32	28.78
Secchi Transparency (m)		0.25	0.43		0.45		0.61	
Discharge (m^3/sec)	0.12		Undetectable		Undetectable		Undetectable	
Canopy Cover		30%		0%		0%		0%

measured by tape. A Lowrance depth flasher was employed for depth readings, and a Montedoro-Whitney Model PVM-2A flow meter was used for taking flow measurements. Discharge was calculated using the method presented by Orth (1983). Canopy cover was estimated by visual observation.

Fish captured by seine and gill net at each station were considered as one sample for data analysis, since the main intent of the study was to compare values among sites more than against literature values. Equal sampling effort was exerted at each station, so the combination of collections was justified. Several methods were utilized in analyzing the data, as discussed below.

Species diversity was calculated according to the equation presented in Wilhm (1970):

$$\overline{H} = -\sum_{i-1}^{s} (n_i/n) \log_2 (n_i/n),$$

where $\overline{H}$ = species diversity, n_i = number of individuals in the i^{th} species, n = number of individuals in the sample, and S = number of species. Generally, values less than 1.0 indicate severely degraded conditions, 1.0 - 3.0 indicate moderately polluted streams, and greater than 3.0 indicate clean water streams (Wilhm and Dorris 1968).

Index of similarity, a measure of the degree of resemblance in species composition between two sites, was calculated according to the equation presented in Odum (1971)

$$S = 2C/A + B,$$

where S = index of similarity, A = number of species in sample A, B = number of species in sample B, and C = number of species common to both samples. Values can range from 0, meaning the sites are dissimilar, to 1.0, indicating the two sites are the same.

Condition factors, a measure of the well-being or plumpness of a fish, were calculated according to the equation presented in Carlander (1969, 1977):

$$K = W10^5/L^3,$$

where K = condition factor, W = weight in grams, L = length in millimeters, and 10^5 is a factor to bring the value of K near unity. K-factors were calculated only for species for which Carlander (1969, 1977) presents comparative data. In selecting values for comparisons, an effort was made to find data in Carlander (1969, 1977) for fish from a similar geographical area and of a similar size to that collected in this study. K-factors vary with species and size, but larger values generally are indicative of better fish condition.

Species richness, number of pollution intolerant species, proportion of population comprised of pollution tolerant individuals, proportion of diseased fish, and trophic structure were emphasized in characterizing the fish community. A gauge of system health is the number and types of species present, with a greater number of species typically suggesting a more stable and healthy system. This reasoning must be used with care, but as Young *et al.* (1973) point out, the presence of some fish species upstream of an entry point of waste and their absence downstream of that point suggests the waste is limiting their occurrence.

Sampling sites were compared to Index of Biotic Integrity (IBI) integrity classes (Karr *et al.* 1986), which are listed in Appendix A. The IBI was not directly employed because of the estuarine nature of the lower three sites and their fish communities.

Less emphasis was placed on species diversity, similarity indices and condition factors. They are not reliable indicators in themselves, but when used in conjunction with other methods can provide additional information for characterizing the system.

Results and Discussion

Water Quality Parameters

Physiochemical data are presented in Table 1. Morning dissolved oxygen readings were lowest at the Highway 87 station. Typically, low dissolved oxygen levels have been reported in the upper section of the bayou (Kirkpatrick 1985) rather than near Highway 87. That station, as well as the lower two, should benefit from tidal action and the Sabine River's influence. No major wastewater discharges are located upstream of Highway 87, but a fair amount of organic material from aquatic macrophytes and algae was present during the survey.

Similar pH levels were recorded at the two upper stations (IH-10 and Highway 87), whereas pH progressively increased at the lower stations (Round Bunch Road and Sabine River confluence). Conductivity increased in a downstream direction,

demonstrating the estuarine influence on the three downstream sites.

Fisheries Parameters

Fish species collected by seine and gill net are presented in Tables 2 and 3, respectively. Thirty-eight different fish species were collected in Cow Bayou. Similar collections made by Wenger (1966) produced only 25 species, though in that study, seining was not as extensive as in the present one.

Fish species collected by gill net compare favorably with historical data. Wenger (1966) collected 21 different species, whereas 17 species were collected by gill net in this study. However, based on gill net collections, the trophic structure was more balanced in the present survey. Karr *et al*. (1986) suggested that a balanced fish community trophic structure is one comprised of less than 20% omnivores, more than 80% insectivores, and more than 5% piscivores. Omnivorous individuals accounted for 50% of the population in the study by Wenger (1966), whereas 19% were omnivores in this study. Wenger (1969) found 47% piscivorous individuals compared to 79% in this study. The insectivorous community was similar, 2% in the earlier survey and 3% in this one.

Pugnose minnow (*Notropis emiliae*), dusky darter (*Percina sciera*), and spotted sucker (*Minytrema melanops*), all considered pollution intolerant by the United States Environmental Protection Agency (1983), were collected in this study. No pollution intolerant species were collected by Wenger (1966).

Saltwater and estuarine species replaced freshwater species in a downstream direction. No estuarine fishes were collected at IH-10, whereas one species was collected at Highway 87, nine species at Round Bunch Road, and 11 species at the Sabine River confluence. During high flow periods a greater percentage of freshwater species may inhabit the lower section of the bayou.

Fishermen definitely use the bayou at the lower stations. Approximately seven boats of anglers were observed during the survey. Water skiers were also in evidence.

IH-10 Station

Seventeen fish species, including the three pollution intolerant species, were collected at this station (Tables 2 and 3). This station was the only location where pollution intolerant freshwater species were collected, probably because of salinities at the downstream stations. The second largest proportion of pollution tolerant individuals occurred at this station. Trophic structure was balanced, with only a slightly low proportion of piscivorous individuals. No diseased fish were collected.

Species diversity was second highest at this station (Table 4) and in the range considered indicative of moderate pollution ($\overline{H}$ of 1.0-3.0; Wilhm and Dorris 1968). The index of similarity between this station and the station at the Sabine River confluence was the lowest in the study (Table 5), primarily because of estuarine species present at the downstream station.

Condition factors at this station (Table 6) for blue catfish (*Ictalurus furcatus*) were similar to values from Carlander (1969, 1977), and low for gizzard shad (*Dorosoma cepedianum*), black crappie (*Pomoxis nigromaculatus*), channel catfish (*Ictalurus punctatus*), and spotted sucker. Low values for channel catfish and spotted sucker may be attributed to seasonal stress or a low abundance of bottom food organisms, whereas the low value for gizzard shad suggested a low abundance of suspended food particles. The values for blue catfish and black crappie, both piscivores, suggested a less than adequate prey base for supporting the entire piscivorous population. These values should not be considered definitive, since in some instances only one fish per species was collected.

This station was assigned a rating of good based on the attributes described in Appendix A (Karr *et al*. 1986).

Hwy. 87 Station

Sixteen fish species were collected at this station (Tables 2 and 3). The highest proportion of pollution tolerant individuals occurred at this station. Trophic structure was balanced, with a slightly low proportion of piscivorous individuals. Sunfish reproduction was evident by the abundance of juveniles. No diseased fish were collected.

Species diversity was lowest at this station (Table 4) and in the range considered indicative of moderate pollution ($\overline{H}$ of 1.0-3.0; Wilhm and Dorris 1968). The index of similarity between this station and the station at Round Bunch Road was the highest in the study (Table 5).

Condition factors at this station (Table 6) for largemouth bass (*Micropterus salmoides*) were similar to values from Carlander (1969, 1977), and high for smallmouth buffalo (*Ictiobus bubalus*),

Table 2. Fishes collected by seine from Cow Bayou (July 1987).

Taxa	Common Name	IH-10	Hwy. 87	Round Bunch Road	Sabine River Confluence
Anchoa mitchilli	Bay anchovy		2	23	46
Brevoortia patronus	Gulf menhaden				3
Citharichthys spilopterus	Bay whiff				2
Etheostoma chlorosomum	Bluntnose darter	5			
Fundulus blairae	Blair's starhead topminnow	1			
Fundulus chrysotus	Golden topminnow	1	3		
Fundulus grandis	Gulf killifish				1
Fundulus notatus	Blackstripe topminnow	10			
Gambusia affinis	Mosquitofish	53	201		
Gobinellus boleosoma	Darter goby				29
Gobiosoma bosci	Naked goby			1	1
Leiostomus xanthurus	Spot				2
Lepomis macrochirus	Bluegill sunfish	12	11	11	
Lepomis microlophus	Redear sunfish	18	1	4	
Lepomis punctatus	Spotted sunfish		9	4	
Lepomis sp. (juvenile)	Sunfish		37	24	1
Lucania parva	Rainwater killifish		50	36	4
Menidia beryllina	Tidewater silverside		83	17	114
Microgobius gulosus	Clown goby			3	
Mugil cephalus	Striped mullet				5
Notropis emiliae	Pugnose minnow	19			
Percina sciera	Dusky darter	2			
Pimephales vigilax	Bullhead minnow	47	1		
Syngnathus scovelli	Gulf pipefish			13	3
Total # of individuals		168	398	136	211

Table 3. Fishes collected by gill net from Cow Bayou (July 1987).

Taxa	Common Name	IH-10	Hwy. 87	Round Bunch Road	Sabine River Confluence
Aplodinotus grunniens	Freshwater drum	1			
Dorosoma cepedianum	Gizzard shad	3		1	
Ictalurus furcatus	Blue catfish	1			
Ictalurus punctatus	Channel catfish	1	2	2	
Ictiobus bubalus	Smallmouth buffalo		1		
Leiostomus xanthurus	Spot			1	
Lepisosteus oculatus	Spotted gar	4	3	6	8
Lepisosteus spatula	Alligator gar				3
Micropogon undulatus	Croaker			1	
Micropterus salmoides	Largemouth bass		4	2	
Minytrema melanops	Spotted sucker	1			
Morone mississippiensis	Yellow bass		1	1	1
Mugil cephalus	Striped mullet				1
Paralichthys lethostigma	Southern flounder			1	
Pomoxis annularis	White crappie		1		
Pomoxis nigromaculatus	Black crappie	1	1	3	
Strongylura marina	Atlantic needlefish			1	
Total # of Individuals		12	13	19	13

Table 4. Fish community indices calculated for each station on Cow Bayou (July 1987).

Station	Species Richness	Species Diversity
IH-10	17	2.92
Hwy. 87	16	2.26
Round Bunch Road	19	3.34
Sabine River Confluence	15	2.27

Table 5. Index of similarity results on fish species composition among each possible combination of stations on Cow Bayou (July 1987).

	IH-10	Hwy. 87	Round Bunch Road	Sabine River Confluence
IH-10	-	-	-	-
Hwy. 87	0.47	-	-	-
Round Bunch Road	0.32	0.59	-	-
Sabine River Confluence	0.03	0.31	0.46	-

Table 6. Mean condition factors calculated for fishes collected in Cow Bayou (July 1987). Values from Carlander (1969, 1977) are included for comparison. Values in parentheses indicate the number of fish used. Standard deviations for each species are listed when condition factors for at least three specimens were calculated.

Species	IH-10	Hwy. 87	Round Bunch Road	Sabine River Confluence	Carlander
Dorosoma cepedianum	0.84 (3) ±0.14		0.90 (1)		1.02
Ictiobus bubalus		1.92 (1)			1.53
Minytrema melanops	0.23 (1)				1.07
Ictalurus punctatus	0.61 (1)	1.02 (2)	0.81 (2)		0.75
Ictalurus furcatus	0.95 (1)				0.90
Micropterus salmoides		1.56 (2)			1.51
Lepomis microlophus			1.36 (1)		1.72
Lepomis macrochirus			1.75 (2)		1.79
Pomoxis nigromaculatus	1.17 (1)	1.84 (1)	1.80 (3) ±0.08		1.52

channel catfish, and black crappie. High values for smallmouth buffalo and channel catfish suggested a healthier or more abundant benthic macroinvertebrate community than at the upstream station. Condition factors for piscivores suggested an adequate prey base. These values should not be considered definitive, since in some instances only one fish per species was employed for K-factor calculations.

This station was assigned a rating of fair to good based on the attributes described in Appendix A (Karr *et al*. 1986).

Round Bunch Road Station

The highest species richness in the study occurred at this station with 19 species collected (Tables 2 and 3). Trophic structure was balanced, with a slightly low proportion of insectivorous individuals. Sunfish reproduction was evident by the abundance of juveniles. No pollution tolerant or diseased fish were collected.

Species diversity was highest at this station (Table 4) and in the range considered indicative of clean water ($\overline{H}$ of >3.0; Wilhm and Dorris 1968). The index of similarity between this station and the Highway 87 station was the highest in the study (Table 5).

Condition factors at this station (Table 6) for bluegill sunfish (*Lepomis macrochirus*) and channel catfish were similar to values from Carlander (1969, 1977), low for redear sunfish (*Lepomis microlophus*) and gizzard shad, and high for black crappie. The low value for gizzard shad may be attributed to seasonal stress or a low abundance of suspended food particles, whereas the average value for channel catfish suggested an adequate benthic macroinvertebrate community. Condition factors for insectivores and piscivores suggested adequate food bases. These values should be used with caution, since in many cases, only one fish per species was used to calculate K-factors.

This station was assigned a rating of fair to good based on the attributes described in Appendix A (Karr *et al*. 1986).

Sabine River Confluence Station

The lowest species richness for the study occurred at this station with 15 species collected (Tables 2 and 3). Trophic structure was balanced, with a slightly low proportion of insectivorous individuals. No pollution tolerant or diseased fish were collected.

Species diversity was second lowest at this station (Table 4) and in the range considered indicative of moderate pollution ($\overline{H}$ of 1.0-3.0; Wilhm and Dorris 1968). The index of similarity between this station and the station at IH-10 was the lowest in the study (Table 5).

Condition factors were not calculated at this station since no comparative data on the fish species collected are offered by Carlander (1969, 1977).

This station was assigned a rating of fair to good based on the attributes described in Appendix A (Karr *et al*. 1986).

Conclusion

Overall, data for Cow Bayou indicate the potential for a diverse and healthy fish community. Condition factors suggest that ample food was available throughout the bayou, with the possible exception of the uppermost station where values for piscivores, bottom feeders, and grazers were all low. Large numbers of juvenile sunfish were collected at two of the stations, indicating that nursery habitat existed.

Fish species composition at the upper station was very dissimilar to the lowest station. The number of estuarine fish species increased downstream. Potential for recovery is good at the lower stations, given the proximity of the Sabine River.

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APPENDIX A. Total Index of Biotic Integrity (IBI) scores, the designated integrity class, and the attributes of those classes as modified from Karr et al. (1986).

Total IBI score (sum of the 12 metric ratings)	Integrity class	Attributes
58-60	Excellent	Comparable to the best situations without human disturbance; all regional expected species for the habitat and stream size, including the most intolerant forms, are present with a full array of age (size) classes; balanced trophic structure.
48-52	Good	Species richness somewhat below expectation, especially due to the loss of the most intolerant forms; some species are present with less than optimal abundances or size distributions; trophic structure shows some signs of stress.
40-44	Fair	Signs of additional deterioration include loss of intolerant forms, fewer species, highly skewed trophic structure (e.g., increasing frequency of omnivores and green sunfish or other tolerant species); older age classes of top predators may be rare.
28-34	Poor	Dominated by omnivores, tolerant forms, and habitat generalists; few top carnivores; growth rates and condition factors commonly depressed; hybrids and diseased fish often present.
12-22	Very Poor	Few fish present, mostly introduced or tolerant forms; hybrids common; disease, parasites, fin damage, and other anomalies regular.
	No fish	Repeated sampling finds no fish.