National Biological Assessment and Criteria Workshop

Advancing State and Tribal Programs

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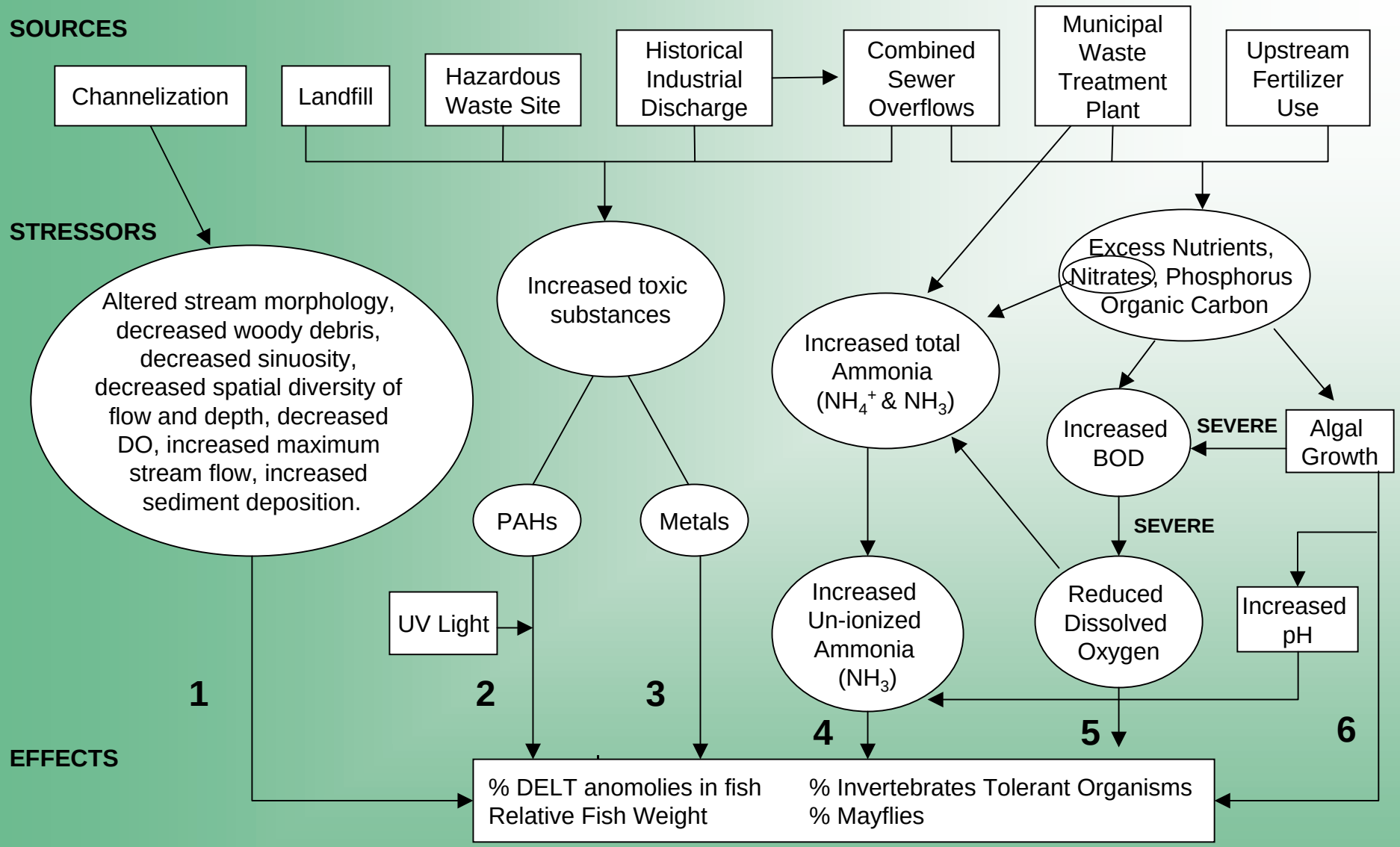
SI 201

Case Study: Little Scioto River

Answers



A conceptual model of the six candidate causes for the Little Scioto stressor identification. Potential sources are listed in top most rectangles. Potential stressors and interactions are located in ovals. Candidate causes are numbered (1) through (6). Note that some causes have more than one stressor or more than one step associated with it. The impairments are located in the lower rectangle.

Step 1: List Candidate Causes
g: Refine List of Candidate Causes

Candidate Cause	Notes
1. Habitat alteration	Includes altered stream morphology, decreased woody debris, decreased sinuosity, decreased spatial diversity of flow and depth, decreased DO, increased maximum stream flow, and increased sediment deposition.
2. PAH toxicity 3. Metal toxicity	Historically, the river has provided a means of waste disposal for various industries, whose effluents have contained metals, PAHs, and creosote. Exposure of fish and macroinvertebrates to these contaminants could occur through food, water, and direct contact with sediment. Exposure to UV light enhances the toxicity of PAHs in sediment and water to both fish and invertebrates.
4. Ammonia toxicity	Ammonia is directly discharged into streams by point sources. Ammonia also can be formed as the result of nutrient enrichment. When DO levels are low nitrates are reduced to ammonium ion.
5. Low dissolved oxygen/ high biological oxygen demand	Potential sources of excess organic matter within the study area include a wastewater treatment plant and several combined sewer outfalls, as well as upstream, nonpoint sources. Since depletion of dissolved oxygen commonly occurs from organic enrichment, BOD alone is not considered as a candidate cause.
6. Nutrient enrichment	Mild nutrient enrichment results in increased primary production and organic matter loading to the sediments, but does not reduce DO. This can cause changes in fish and macroinvertebrate assemblages, including changes in dominant species, and greatly increased abundance and biomass. This form of nutrient enrichment is also associated with DELT anomalies. Since the effects from nitrate and phosphorus enrichment can not be teased out, these were considered together as nutrient enrichment.

Step 1: List Candidate Causes
h: Cross walk available measurements relevant to each candidate cause

Candidate Cause	Relevant Measurements
1. Habitat alteration	Channel score, embeddedness subscore, siltation subscore, dissolved oxygen
2. PAH toxicity	PAH concentrations in sediments, bile metabolites in fish
3. Metal toxicity	Metal concentrations in sediments, water and fish tissue
4. Ammonia toxicity	Ammonia concentrations in water
5. Low dissolved oxygen/high biological oxygen demand	Dissolved oxygen, biological oxygen demand of water
6. Nutrient enrichment	Nitrate and nitrite concentrations in water, total phosphorus concentrations in water

Step 2a: Analyze Evidence for Elimination

Spatial co-location of candidate causes with Impairments A and B

Candidate Cause	Detected at Site A?	Decreased quality at Site A compared with Upstream Site?	Exposure pathway complete at Site A?
Habitat alteration	Yes	Yes	Yes
PAHs	No	No	No
Metals	Yes	Yes	Yes
Ammonia	No	No	No
Low-dissolved oxygen/BOD	Yes	DO: Yes BOD: No [1]	
Nutrient enrichment	Yes	Yes	Yes

[1]Although dissolved oxygen was not measured at Site B, BOD was measured and was elevated compared with Site A.

Step 2b:

Candidate Causes Remaining after Elimination

	RM 7.9 Impairment A
#1 Habitat alteration	X
#2 PAH Contamination	
#3 Metal Contamination	X
#4 Ammonia	
#5 Low DO/BOD	
#6 Nutrient Enrichment	X

4b. Compare strength of evidence for the three candidate causes of Impairment A

Causal Consideration	Evidence	Score	Evidence	Score	Evidence	Score
Case-Specific Considerations						
	Habitat Alteration		Metals Contamination		Nutrient Enrichment	
Co-occurrence	Compatible: At and below site A the habitat of the Little Scioto is altered as a result of channelization. The degree of habitat alteration remains about the same to the mouth of the river. Substrate scores and DO are lower than upsteam. The Upstream Site is not channelized and habitat is good.	+	Compatible: All sediment metal concentrations were slightly higher at site A compared to upstream	+	Compatible: NO_x was elevated by 0.2mg/L in 1992 compared to upstream. Total P was elevated compared to upstream by 0.01 mg/L .	+
Temporality	No evidence	NE	No evidence	NE	No evidence	NE
Consistency of Association	No evidence	NE	No evidence	NE	No evidence	NE

NE = no evidence; NA = not applicable/not available

4b. Compare strength of evidence for the three candidate causes of Impairment A (continued)

Causal Consideration	Evidence	Score	Evidence	Score	Evidence	Score
Case-Specific Considerations						
	Habitat Alteration		Metals Contamination		Nutrient Enrichment	
Biological Gradient	Increased relative weight: None for channel, sediment, low DO was weakly correlated, but relative weight decreases with decreasing DO	-	Increased relative weight: Weak correlation with zinc, but relative weight decreases with increasing Zn	-	Increased relative weight: Clear association but wrong sign: Weak correlations with NO_x and total P, but relative weight decreases with increasing nutrient concentrations.	-
	Increased %DELT: None for channel, sediment, but low DO was weakly correlated	+	Increased %DELT: Weak correlations with chromium and zinc.	+	Increased % DELT: Weak correlation with NO_x, Strong with total P.	+++
	Decreased % mayflies: None for channel, sediment, but low DO was strongly correlated	+++	Decreased % mayflies: Weak correlations with chromium and zinc.	+	Decreased % mayflies: Weak: correlations with both NO_x and total P	+
	Increased % tolerant organisms: Ambiguous	0	Increased % tolerant organisms: Weak correlation with copper.	+	Increased% tolerant organisms: Ambiguous	0
Complete Exposure Pathway	Not applicable: No known intermediate steps.	NA	No evidence: Internal concentrations of metals were not measured.	NE	No evidence: concentrations of algae or chlorophyll *a* were not measured.	NE
Experiment	No evidence.	NE	No evidence.	NE	No evidence.	NE

NE = no evidence; NA = not applicable/not available

4b. Compare strength of evidence for the three candidate causes of Impairment A (continued)

Causal Consideration	Evidence	Score	Evidence	Score	Evidence	Score
Considerations Based on Other Situations or Biological Knowledge						
	Habitat Alteration		Metals Contamination		Nutrient Enrichment	
Plausibility: Mechanism	Increased Relative Weight: Plausible: Artificially deepened channel allows larger sized fish to survive.	+	Increased Relative Weight: Implausible: No known mechanism for metals. Metals usually cause a decrease in the relative weight of fish (Eisler 2000a, USEPA, 1985a, 1985b, 1985c, 1987).	-	Increased Relative Weight: Plausible: NO_x and total P are nutrients that can increased algal growth. Greater production of algae could provide additional food, increasing fish growth.	+
	Increased DELT: Plausible: No obvious mechanism other than stress due to low DO. DO decreased by 3.1 mg/l (Austin & Austin 1993).	+	Increased DELT: Plausible: Metals cause fin erosion and lesions (Hinton et al. 1993). Pb, Cu, Zn cause deformities (Eisler 2000a, USEPA 1985a, 1985b, 1985c 1987).	+	Increased DELT: Plausible: Nutrients may create conditions that favor opportunistic pathogens and fungi that cause lesions, fin erosion and interfere with wound healing.	+
	Decreased % Mayflies & Increased % Tolerant Organisms: Plausible: Fine sediments provide poor forage, reproductive, and cover habitats for benthic invertebrates including many mayflies. Low DO is not tolerated by many species (Karr and Schlosser 1977, Yount and Niemi 1990, Rankin 1995).	+	Decreased % Mayflies & Increased % Tolerant Organisms: Plausible: metals are known to cause lethal and sublethal effects to invertebrates (Eisler 2000a, USEPA, 1985a, 1985b, 1985c, 1987).	+	Decreased % Mayflies & Increased % Tolerant Organisms: Plausible: Switching to an autochthonous energy source could alter species survival and community composition of invertebrates.	+

NE = no evidence; NA = not applicable/not available

Step 4a. Analyze Evidence for SOE
Using Other Situations or Biological Knowledge
Plausibility: Stressor-Response

Metals concentrations (mg/kg) at the Upstream Site, and Site A. (TEL and PEL values are for *Hyalella azteca* and are normalized to sediment dry weight.)

Chemical		Upstream Site	Site A
TEL	PEL		
Cu		7.4	17.2
28	101.2		
Pb		12.1	19.1
37.2	81.7		
Zn		3.06	79
98.1	544		
Cumulative Toxic Units based on PEL		0.28	0.66

(*) exceeds PEL and TEL; (#) exceeds TEL.

Step 4a. Analyze Evidence for SOE Using Other Situations or Biological Knowledge Plausibility: Stressor-Response

Comparison of the reported concentration of water quality parameters (mg/L) with available criteria.

Criterion	Site A
Dissolved Oxygen[b] 3.0 mg/L for MWH	2.8[e]*
Nitrate-nitrite[c] 1.6 mg/L	1.4
Total phosphorus[d] 0.28 mg/L	0.07

[b] OEPA (1994) dissolved oxygen criterion.
[c] Rankin et al. (1999) proposed nitrate-nitrite criterion
[d] Rankin et al. (1999) proposed total phosphorus criterion
[e] minimum dissolved oxygen concentrations from continuous monitoring over three days in 1987
*** Violates criteria**

Step 4a. Analyze Evidence for SOE
Using Other Situations or Biological Knowledge
Plausibility: Stressor-Response

Comparison of the reported concentration of water quality parameters (ug/L) with available criteria.

Chemical **AWQC (ug/l)** **@ 200 mg/L hardness**	**Upstream Site**	**Site A**
Copper 21	ND	ND
Lead 7.7	ND	ND
Zinc 190	ND	ND

4b. Compare strength of evidence analysis for the three candidate causes of Impairment A (continued)

Causal Consideration	Evidence	Score	Evidence	Score	Evidence	Score
Considerations Based on Other Situations or Biological Knowledge						
	Habitat Alteration		Metals Contamination		Nutrient Enrichment	
Plausibility: Stressor-Response	Increased Relative Weight: No evidence.	NE	Increased Relative Weight: Not applicable: Implausible mechanism.	NA	Increased Relative Inconcordant: NO_x does not limit algal growth in most Ohio streams (Rankin et al 1999, Allan 1995). Magnitude of nutrient change too small to cause effect.	-
	Increased DELT: No evidence.	NE	Increased DELT: Inconsistent: Deformities including lordoscoliosis are reported at water hardness greater than 200 mg/l for 850ug/l lead and 160 ug/l zinc at (USEPA 1987). No metals were detected in water at site A.	-	Increased DELT: Inconcordant: The magnitude of nutrient change was too small to account for the dramatic shifts in invertebrate metrics. NO_x does not limit algal growth in most streams (Allan 1995, Rankin et al 1999). Ohio's proposed criteria nitrogen and phosphorus were not exceeded. Criteria are protective of fish (Rankin et al. 1999).	-

NE = no evidence; NA = not applicable/not available

4b. Compare strength of evidence analysis for the three candidate causes of Impairment A (continued)

Causal Consideration	Evidence	Score	Evidence	Score	Evidence	Score
Considerations Based on Other Situations or Biological Knowledge						
	Habitat Alteration		Metals Contamination		Nutrient Enrichment	
Plausibility: Stressor-Response cont.	Decrease % Mayflies & Increased % Tolerant Organisms: No evidence.	NE	Decrease % Mayflies & Increased % Tolerant Organisms: Inconcordant: No metals exceeded *Hyalella azteca* PEL values. Cumulative toxic index was not exceeded (USEPA 1996b). Hickey and Clements (1998) reviewed invertebrate species richness, particularly of mayflies, which declined in association with metals in water column; however, concentrations at site A were probably less than concentrations reported by Hickey and Clements.	-	Decrease % Mayflies & Increased % Tolerant Organisms: Inconcordant: Magnitude of nutrient change too small to account for change of invertebrate metrics. NO_x does not limit algal growth in most streams (Allan 1995). Virginian streams are associated with algal growth that decrease numbers of EPT taxa, but at higher concentrations than at site A (Lemly 1998). Ohio's proposed nitrogen and phosphorus criteria were not exceeded (Rankin et al. 1999).	-
Consistency of Association	No Evidence	NE	No Evidence	NE	No Evidence	NE

NE = no evidence; NA = not applicable/not available

4b. Compare strength of evidence analysis for the three candidate causes of Impairment A (continued)

Causal Consideration	Evidence	Score	Evidence	Score	Evidence	Score
Considerations Based on Other Situations or Biological Knowledge						
	Habitat Alteration		Metals Contamination		Nutrient Enrichment	
Specificity of Cause	Increased Relative Weight: One of a few.	++	Increased Relative Weight: Not applicable: Implausible mechanism.	NA	Increased Relative Weight: One of a few.	++
	Increased DELT: One of many.	0	Increased DELT: One of many.	0	Increased DELT: One of many.	0
	Decrease % Mayflies & Increased % Tolerant Organisms: One of many.	0	Decrease % Mayflies & Increased % Tolerant Organisms: One of many.	0	Decrease % Mayflies & Increased % Tolerant Organisms: One of many.	0
Analogy	Not applicable	NA	Not applicable	NA	Not applicable	NA
Experiment	No evidence	NE	No evidence	NE	No evidence	NE
Predictive Performance	No evidence	NE	No evidence	NE	No evidence	NE

NE = no evidence; NA = not applicable/not available

4b. Compare strength of evidence analysis for the three candidate causes of Impairment A (continued)

Causal Consideration	Evidence	Score	Evidence	Score	Evidence	Score
Considerations Based on Other Situations or Biological Knowledge						
	Habitat Alteration		Metals Contamination		Nutrient Enrichment	
Consistency of Evidence	Increased Relative Weight: Most Consistent. Biological gradient direction is in the wrong direction for DO.	+	Increased Relative Weight: Multiple Inconsistencies: Implausible mechanism.	---	Increased Relative Weight: Multiple Inconsistencies: Biological gradient is in the wrong direction, implausible stressor response.	---
	Increased DELT: All consistent.	+++	Increased DELT: Most consistent: Stressor response unlikely.	+	Increased DELT: Most Consistent: Magnitude of change inconsistent with magnitude of effect.	+
	Decrease % Mayflies & Increased % Tolerant Organisms: All consistent	+++	Decrease % Mayflies & Increased % Tolerant Organisms: Most consistent: Although metals are present, the concentrations are unlikely to be toxic.	---	Decrease % Mayflies & Increased % Tolerant Organisms: Most consistent: Magnitude of change inconsistent with magnitude of effect.	+
Coherence of Evidence	Increased relative weight of fish likely associated with channelization rather than DO	+	Increased Relative Weight, Increased DELT, Decrease % Mayflies & Increased % Tolerant Organisms: No explanation.	0	Increased Relative Weight, Increased DELT, Decrease % Mayflies & Increased % Tolerant Organisms: No explanation.	0

NE = no evidence; NA = not applicable/not available

Step 4b. Causal Characterization: Strength of Evidence Summary Impairment A

Causal Consideration	Habitat	Metals	Nutrient
Case-Specific Considerations			
Co-occurrence	+	+	+
Temporality	NE	NE	NE
Consistency of Association	NE	NE	NE
Biological Gradient			
Increased relative weight	-	-	-
Increased % DELT	+	+	+++
Decreased % mayflies	+++	+	+
Increased % tolerant	0	+	0
Complete Exposure Pathway	NA	NE	NE
Experiment	NE	NE	NE
Considerations Based on Other Situations or Biological Knowledge			
Plausibility: Mechanism			
Increased relative weight	+	-	+
Increased % DELT	+	+	+
Decreased % mayflies and Increased % tolerant	+	+	+
Plausibility: Stressor-Response			
Increased relative weight	NE	NA	-
Increased % DELT	NE	-	-
Decreased % mayflies and Increased % tolerant	NE	-	-
Consistency of Association	NE	NE	NE
Specificity of Cause			
Increased relative weight	++	NA	++
Increased % DELT	0	0	0
Decreased % mayflies and Increased % tolerant	0	0	0
Analogy	NA	NA	NA
Experiment	NE	NE	NE
Predictive Performance	NE	NE	NE
Considerations from Multiple Lines of Evidence			
Consistency of Evidence			
Increased relative weight	+	---	---
Increased %DELT	+++	+	+
Decreased % mayflies and Increased % tolerant	+++	+	+
Coherence of Evidence	+	0	0

Case Study:
Little Scioto River

Identify Probable Cause

Causal Characterization

Causal Characterization
Impairment A - River Mile 7.9
Habitat Alteration
The probable cause of Impairment A is Habitat Alteration. Increase in relative weight of fish is probably caused by an artificially deepened channel that allows larger fish to survive at Site A. The cause of increased DELT anomalies is uncertain, but is likely caused by general stress associated with altered habitat including low dissolved oxygen. Low substrate texture and low DO associated with the habitat alteration are the most likely causes for the decrease percent mayflies and increase in tolerant organisms. Metal contamination is improbable, because laboratory studies indicate decreases in growth rather than increases. Metal concentrations in both sediment and water were below relevant criteria. Nutrient enrichment is an unlikely cause because the increase in nutrient concentrations was minute.