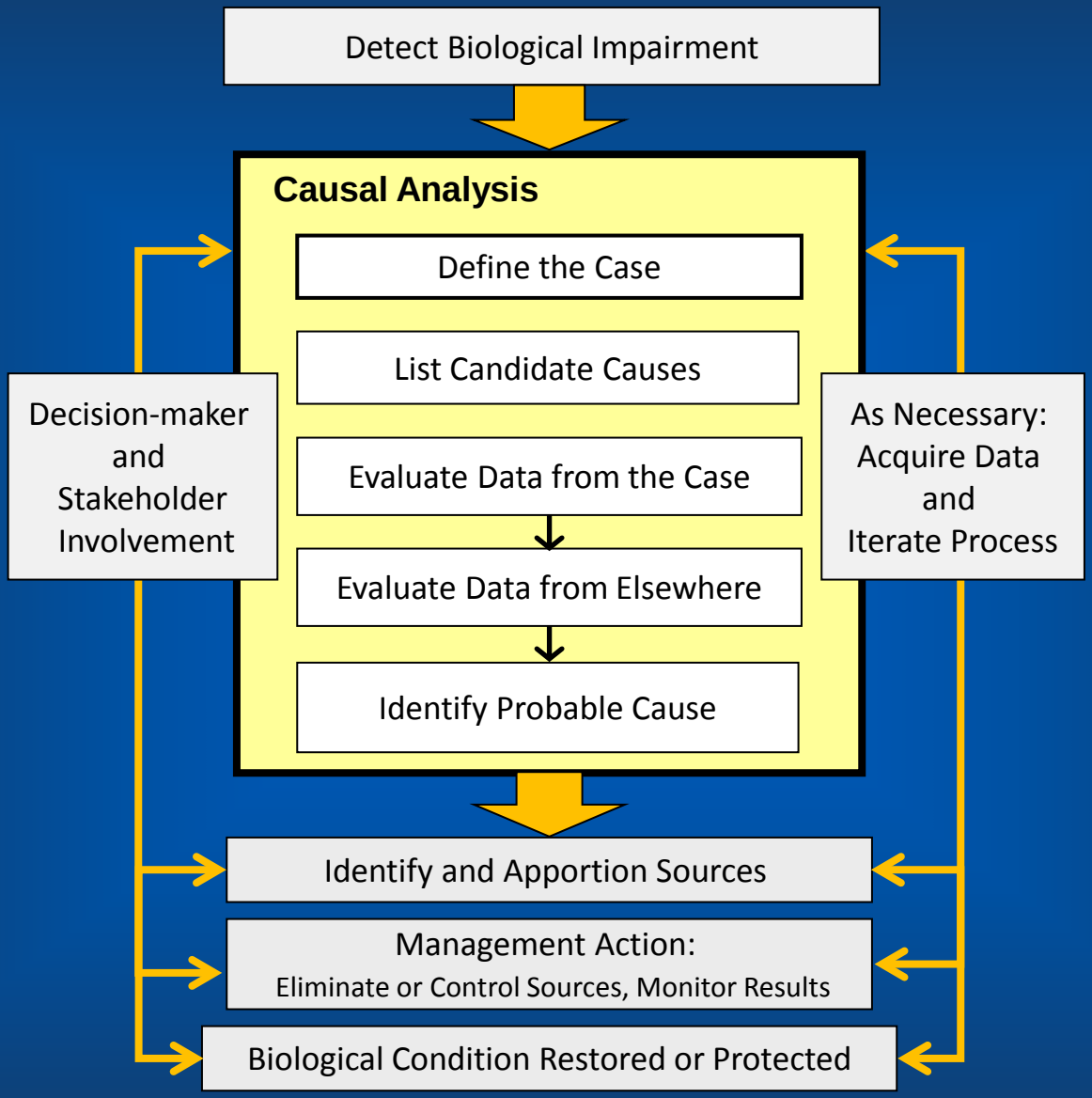
Causal Inference & Identifying a Cause

Step 5

San Diego Creek Causal Assessment Workshop 1
December 17, 2014


Detect Biological Impairment
Causal Analysis
Define the Case
List Candidate Causes
Evaluate Data from the Case
Evaluate Data from Elsewhere
Identify Probable Cause
Decision-maker and Stakeholder Involvement
As Necessary: Acquire Data and Iterate Process
Identify and Apportion Sources
Management Action:
Eliminate or Control Sources, Monitor Results
Biological Condition Restored or Protected

Lines of Evidence --> Results

- This is the interpretation step
  - Based on the patterns of support or non-support among the different lines of evidence a conclusion has to be reached about each candidate cause
- Causes are either likely, unlikely, or indeterminate
  - A narrative supporting the conclusion, detailing the logic it took to arrive at that conclusion, should be created

Legal Parallel:

Jury Deliberation & Reading the Verdict

San Diego River

Candidate Cause		MLS vs. Cedar Creek					MLS vs. TWAS 1					MLS vs. TWAS 2				
		Elevated Conductivity	Habitat Alteration	Heavy Metals	Increased Nutrients	Pesticides	Elevated Conductivity	Habitat Alteration	Heavy Metals	Increased Nutrients	Pesticides	Elevated Conductivity	Habitat Alteration	Heavy Metals	Increased Nutrients	Pesticides
Spatial Co-Occurrence		+	+	NE	+	NE	+	---	+	---	+	+	0	+	+	+
Stressor Response	Collector Abundance	0	+	-	0	-	0	+	-	0	-	0	+	-	0	-
	Non-Insect Taxa	+	0	0	0	+	+	0	0	0	+	+	0	0	0	+
	Tolerant Taxa	-	0	-	0	0	-	0	-	0	0	-	0	-	0	0
	Amphipod Abundance	++	+	++	-	0	++	+	++	-	0	++	+	++	-	0
Reference Condition Comparison		+	+	NE	NE	NE	+	+	NE	NE	NE	+	+	NE	NE	NE
Stressor Response From Outside the Case	Collector Abundance	0	+	0	-	NE	0	+	0	-	NE	0	+	0	-	NE
	Non-Insect Taxa	+	0	0	0	NE	+	0	0	0	NE	+	0	0	0	NE
	Tolerant Taxa	+	0	0	0	NE	+	0	0	0	NE	+	0	0	0	NE
	Amphipod Abundance	0	0	0	0	NE	0	0	0	0	NE	0	0	0	0	NE
Stressor Response From Laboratory		NE	NE	--	NE	--	NE	NE	--	NE	--	NE	NE	--	NE	--

Candidate Cause		MLS vs. TWAS 2-2					MLS vs. TWAS 3				
		Elevated Conductivity	Habitat Alteration	Heavy Metals	Increased Nutrients	Pesticides	Elevated Conductivity	Habitat Alteration	Heavy Metals	Increased Nutrients	Pesticides
Spatial Co-Occurrence		+	0	+	+	+	+	+	+	---	+
Stressor Response	Collector Abundance	0	+	-	0	-	0	+	-	0	-
	Non-Insect Taxa	+	0	0	0	+	+	0	0	0	+
	Tolerant Taxa	-	0	-	0	0	-	0	-	0	0
	Amphipod Abundance	++	+	++	-	0	++	+	++	-	0
Reference Condition Comparison		+	+	NE	NE	NE	+	+	NE	NE	NE
Stressor Response From Outside the Case	Collector Abundance	0	+	0	-	NE	0	+	0	-	NE
	Non-Insect Taxa	+	0	0	0	NE	+	0	0	0	NE
	Tolerant Taxa	+	0	0	0	NE	+	0	0	0	NE
	Amphipod Abundance	0	0	0	0	NE	0	0	0	0	NE
Stressor Response From Laboratory		NE	NE	--	NE	--	NE	NE	--	NE	--

You need to take this and .....

San Diego River

....turn it to this

Outcome	Candidate Cause	Evidence & Comments
Probable Stressors	High Conductivity	Elevated conductivity and total dissolved solids at MLS compared to within and outside the case sites. Consistent stressor response relationship w/ non-insect taxa and amphipods within and outside the case.
	Pesticides	Elevated levels of water column cyhalothrin-λ, fenvalerate, and sediment bifenthrin at MLS compared to comparator sties. Stressor response relationship w/ non-insect taxa within the case. No data were available for herbicides.
Unlikely Stressors	Heavy Metals	Elevated levels of some dissolved metals at MLS compared to comparator sites, but not at toxic levels and inverse stressor response relationships from within the case. No data were available for inference about sediment- or periphyton-bound metals and they could not be refuted.
Unresolved Stressors	Altered Phyical Habitat	Mixed levels at MLS compared to comparator sites. Inconsistent/indeterminant stressor response relationship within and outside the case. Some evidence for sands & fines and habitat simplification. Limted data from outside the case.
	Nutrients	Mixed levels of nutrient responses at MLS compared to within and outside the case. Weakening evidence of stressor-relationship with amphipods within the case. No data from outside the case were available.

One Additional Score to Calculate

- The consistency of the data should be scored
  - Helps to inform the relative degree of confidence in the assessment of a individual cause
- Looking for consistency in support or weakening across LOE
  - Doesn't have to be unanimous

Consistency of Evidence

Consistency of Evidence	All available types of evidence support the case for the candidate cause.	+ + +
	All available types of evidence weaken the case for the candidate cause.	- - -
	Most available types of evidence support the case for the candidate cause or few types are available.	+
	Most available types of evidence weaken the case for the candidate cause, or few types are available.	-
	The evidence is ambiguous or inadequate.	0
	Some available types of evidence support and some weaken the case for the candidate cause.	-

Consistency of Evidence

	Elevated Metals	Elevated Conductivity	Low DO	Loss of complex habitat	Loss of vegetation
Spatial co-occurrence	+	---	+	+	+
Stressor response	0	++	NE	++	--
Lab tests of media	-	0	NA	NA	NA
Reference comparison	-	+	NE	+	NE
Stressor response from lab	-	-	+	NA	NA
Consistency	-	-	+	+	0

Interpreting Data From the Matrix

- There is no magic formula
  - Cases will vary in terms of data quality and quantity, as well as strength of stressors
- Scores should not be simply added up
  - Three –'s doesn't equal a single +++
- Interpretation is a mix of frequency, consistency, and confidence in different LOE

Causal Inference

- Inference is not proving a cause
  - There is no statistical proof, a p-value, etc.
  - Its about the preponderance of compelling evidence
- The narrative structure of the results should reflect this
  - Allows for the inclusion of caveats, comments about data, and the scoring matrix

Best Case Scenario

Compelling evidence for 1 candidate cause; others are weak or refuted...

TYPE OF EVIDENCE	CANDIDATE CAUSE		
	1	2	3
A	++	-	R
B	+	--	
C	+	-	
Consistency	+	-	

…celebrate, then remediate for Candidate Cause 1

Most Likely Scenario

Uneven evidence across candidate causes...

TYPE OF EVIDENCE	CANDIDATE CAUSE		
	1	2	3
A	++	–	
B	+		–
C	+	+	
Consistency	+	–	

- Strong evidence for one candidate cause may be sufficient
- Consider if weakness is due to lack of data – and try to fill holes

No Clear Causes

TYPE OF EVIDENCE	CANDIDATE CAUSE		
	1	2	3
A	+	–	
B	–		–
C		+	
Consistency	-	-	-

- Reconsider the impairment
- Consider additional candidate causes
- Consider episodic events
- Consider gathering more data

Evidence Suggests Multiple Causes

TYPE OF EVIDENCE	CANDIDATE CAUSE		
	1	2	3
A	++	+	+
B	+	+	++
C	++	++	+
Consistency	+	+	+

- Consider new biological endpoints
- Combine causes if they share causal pathways, modes of action, sources and routes of exposure, or if they interact
- Remediate dominant cause
- Design remediation to address multiple causes

My General Suggestions

- Consider your confidence in each line of evidence
  - Correlations of field data vs. laboratory SSD curves vs. exceedance of a threshold
- Consider the quality of the data
  - Single point DO vs. a diel data series
- Consider the consistency of data within each candidate cause