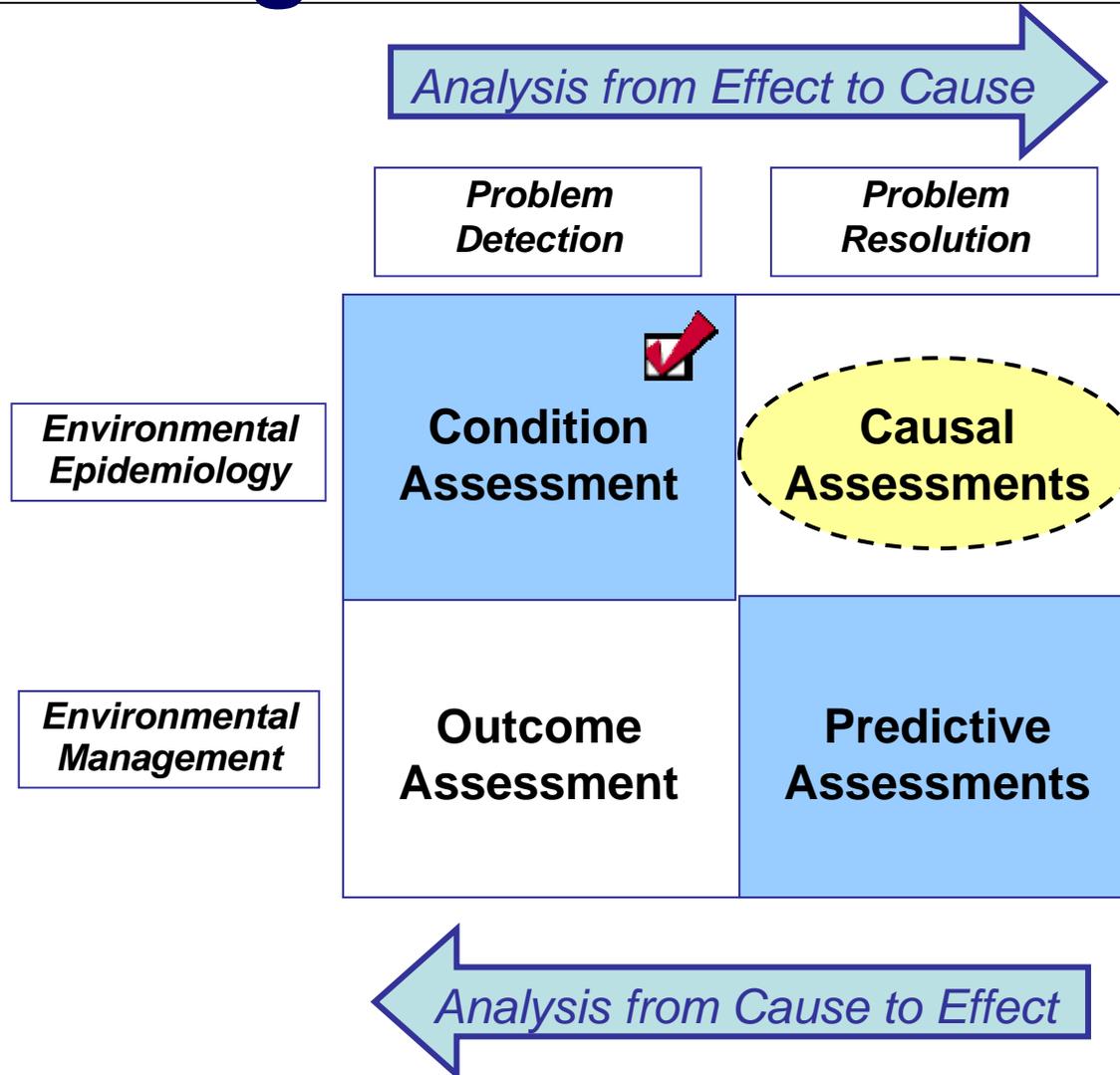


# Introduction to Stressor Identification & CADDIS [Causal Analysis/Diagnosis Decision Information System]

# ***CADDIS: EPA Website for Ecological Causal Assessment***



# Why Stressor Identification?

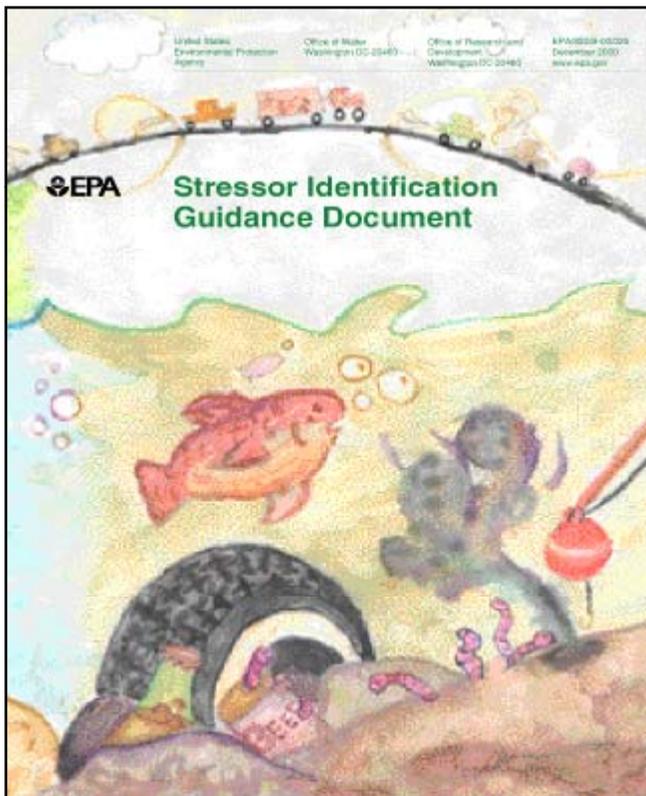
- Many states and several tribes use biological assessments to identify whether streams and small rivers are impaired.
- In many cases, causes of impairment are unknown.

General Impairment Name	Causes of Impairment Reported	Percent of Reported
MERCURY	8555	13.45
PATHOGENS	8526	13.41
SEDIMENT	6689	10.52
METALS (OTHER THAN MERCURY)	6389	10.05
NUTRIENTS	5654	8.89
OXYGEN DEPLETION	4568	7.18
PH	3389	5.33
CAUSE UNKNOWN - BIOLOGICAL INTEGRITY	2866	4.51
TEMPERATURE	2854	4.49
HABITAT ALTERATION	2220	3.49
PCBS	2081	3.27
TURBIDITY	2050	3.22
CAUSE UNKNOWN	1356	2.13
PESTICIDES	1322	2.08
SALINITY/TDS/CHLORIDES	996	1.57
FLOW ALTERATION	591	.93
ALGAL GROWTH	510	.80
AMMONIA	415	.65
OTHER TOXIC ORGANICS	339	.53
TOTAL TOXICITY	292	.46
DIOXINS	290	.46
TOXIC INORGANICS	270	.42
FISH CONSUMPTION	260	

# CADDIS is based on a formal method

## SI Guidance

<http://www.epa.gov/caddis>



2000

U.S. ENVIRONMENTAL PROTECTION AGENCY  
**Causal Analysis/Diagnosis Decision Information System (CADDIS)**

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CADDIS Home  
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Step 3: Evaluate Data from the Case  
Step 4: Evaluate Data from Elsewhere  
Step 5: Identify Probable Cause  
Summary Table of Scores  
Summary Tables of Types of Evidence  
Examples  
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Analyzing Data  
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**CADDIS: Helping Scientists Identify the Causes of Biological Impairments**

Thousands of water bodies in the United States are listed by states as biologically impaired. For many of these, the cause of the impairment is reported as "unknown". Before the [TMDL process](#) can be used to formulate an appropriate management action, the cause of the biological impairment must be determined. Defensible causal analyses require knowledge of the mechanisms, symptoms, and stressor-response relationships for various specific stressors as well as the ability to use that knowledge to draw appropriate conclusions.

CADDIS is an online application that helps scientists and engineers in the Regions, States and Tribes find, access, organize, use and share information to conduct causal evaluations in aquatic systems. It is based on the U.S. Environmental Protection Agency [Stressor Identification process](#) which is a formal method for identifying causes of impairments in aquatic systems. Current features of this site include:

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These two photographs show stream reaches that look very different - one is flowing through an industrialized area and appears to have been channelized; the other is flowing through woods. However, both were found to be biologically impaired. The state of Connecticut used the Stressor Identification process (the basis for CADDIS) to successfully identify the cause of the biological effects observed in

2005, 2007...2010

# Why use a formal method?

---

- To convince stakeholders
- To increase confidence that remedial or restoration efforts can improve biological condition
- To identify causal relationships that are not immediately apparent
- To prevent biases and other lapses of logic

*“Science is a way of trying not to fool yourself. The first principle is that you must not fool yourself – and you are the easiest person to fool.” [Feynman 1964]*

# Causation is one of the most difficult & controversial concepts in philosophy

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- Only one reliable method for establishing causation: **randomized, replicated, controlled** experiment
- Unfortunately, this approach is not usually available...

# Causation is one of the most difficult & controversial concepts in philosophy

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David Hume

- We experience causality as associations between events

John Stuart Mill

- Manipulation of cause results in change in effect



Karl Pearson

- Need to quantify probability of association



Ronald Fisher

- Controlled experiments with replication and randomization

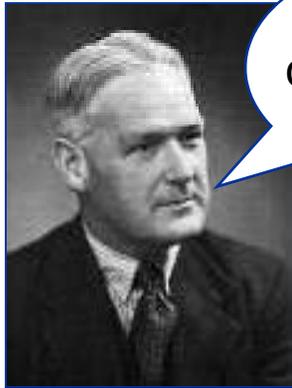
Austin Bradford Hill

- Causality based on strength of evidence



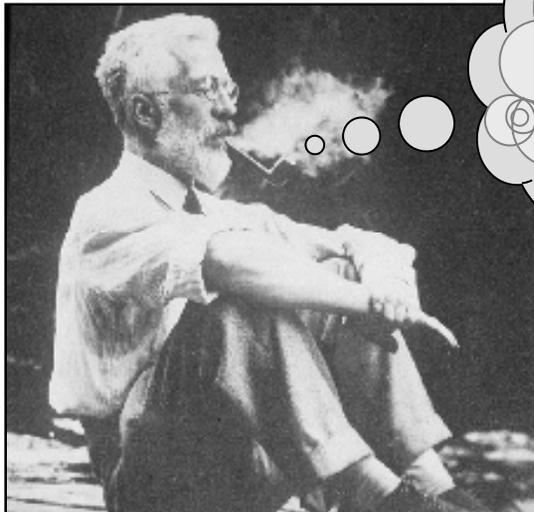
# General vs. Specific causation

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Smoking  
causes lung  
cancer

- General –
  - **Does C cause E?**
    - Does smoking cause lung cancer?



I still don't think  
it caused *my*  
lung cancer

- Specific Cause –
  - **Did C cause E?**
    - Did smoking cause lung cancer in Ronald Fisher?

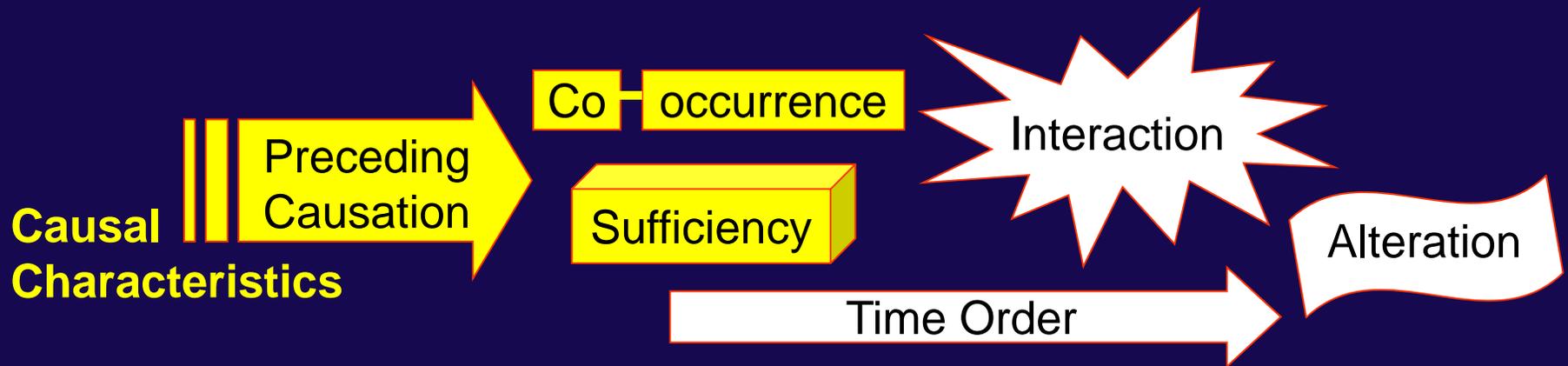
# General vs. Specific causation

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- General – **Does** C cause E?
  - Does increased water temperature reduce bull trout abundance in rivers?
- Specific Cause – **Did** C cause E?
  - Did increased water temperature reduce bull trout abundance in *the Touchet River, Washington?*

# *Defining a Cause*

Type of Causation	Example
Agent	Deoxygenated water causes dead fish
Event	Exposure to deoxygenated water causes fish to die
Process	Exposure to deoxygenated water asphixates fish that die



<b>Time order</b>	The cause precedes the effect
<b>Co-occurrence</b>	The cause co-occurs with the unaffected entity in space and time
<b>Preceding causation</b>	Each causal relationship is a result of a larger web of cause and effect relationships
<b>Sufficiency</b>	The intensity, frequency, and duration of the cause are adequate and the entity is susceptible to produce the type and magnitude of the effect
<b>Physical interaction</b>	The cause physically interacts with the entity in a way that induces the effect
<b>Alteration</b>	The entity is changed by the interaction with the cause.

# Our Causal Strategy: Pragmatic

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- Identify alternative candidate causes
- Logically eliminate when you can
- Diagnose when you can
- Use strength of evidence for remaining
- Identify most likely cause

Do not claim proof of causation

Use consistent process

Document evidence & inferences



This is abductive inference (C.S. Peirce): reasoning to the best solution, given a set of data (observations, facts, etc.) and a set of alternative solutions.



# Causal Analysis/Diagnosis Decision Information System (CADDIS)

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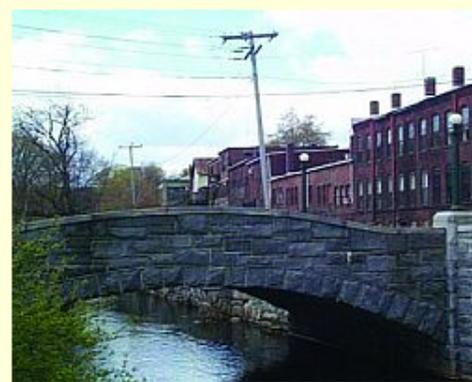
- CADDIS Home
- Basic Information
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# CADDIS

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Causal Analysis/Diagnosis Decision Information System

[www.epa.gov/caddis](http://www.epa.gov/caddis)

## The bad news...

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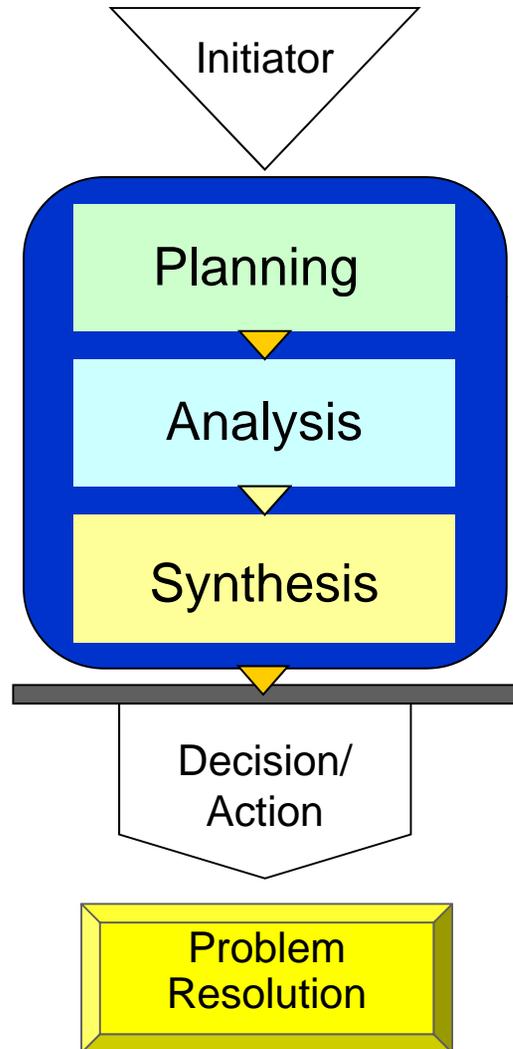
- You can't just push a button on CADDIS to determine the cause of impairment
- You will need data

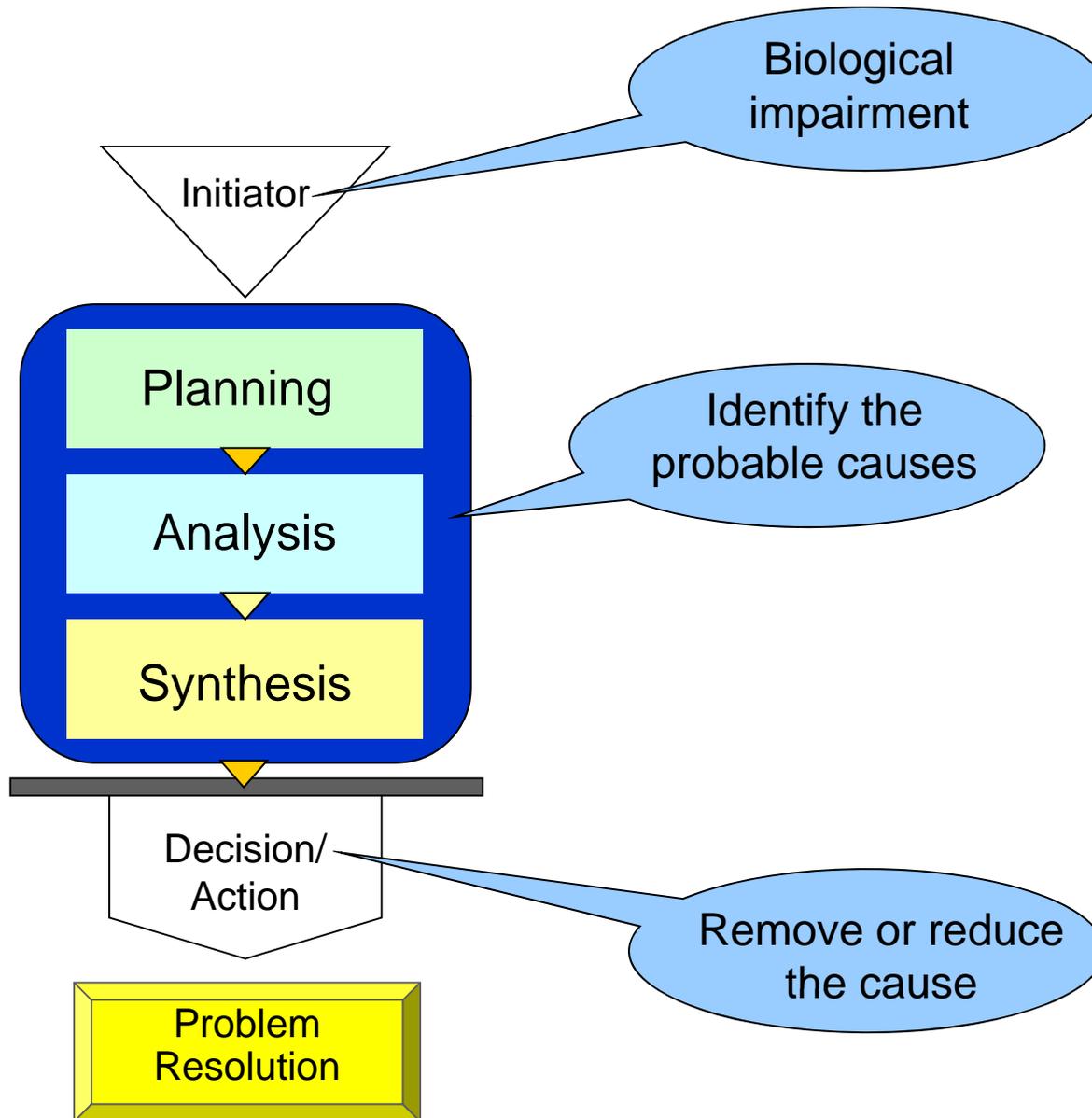
# The good news...

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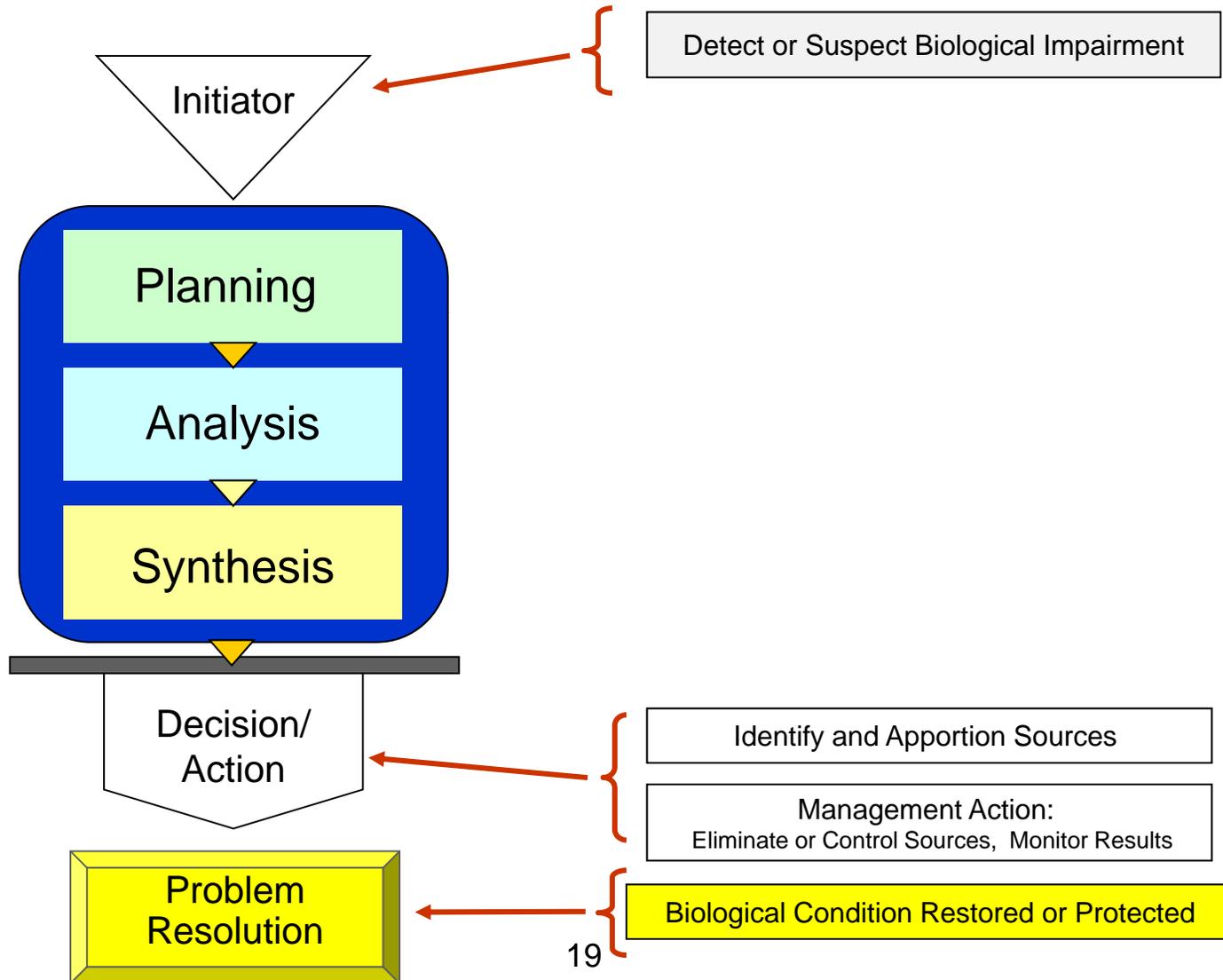
- CADDIS walks you through steps to help you:
  - Identify probable causes
  - Communicate conclusions to others
- CADDIS provides tools & information
- States have used this method to:
  - Direct management action
  - Justify resources for data collection

# Common Assessment Process

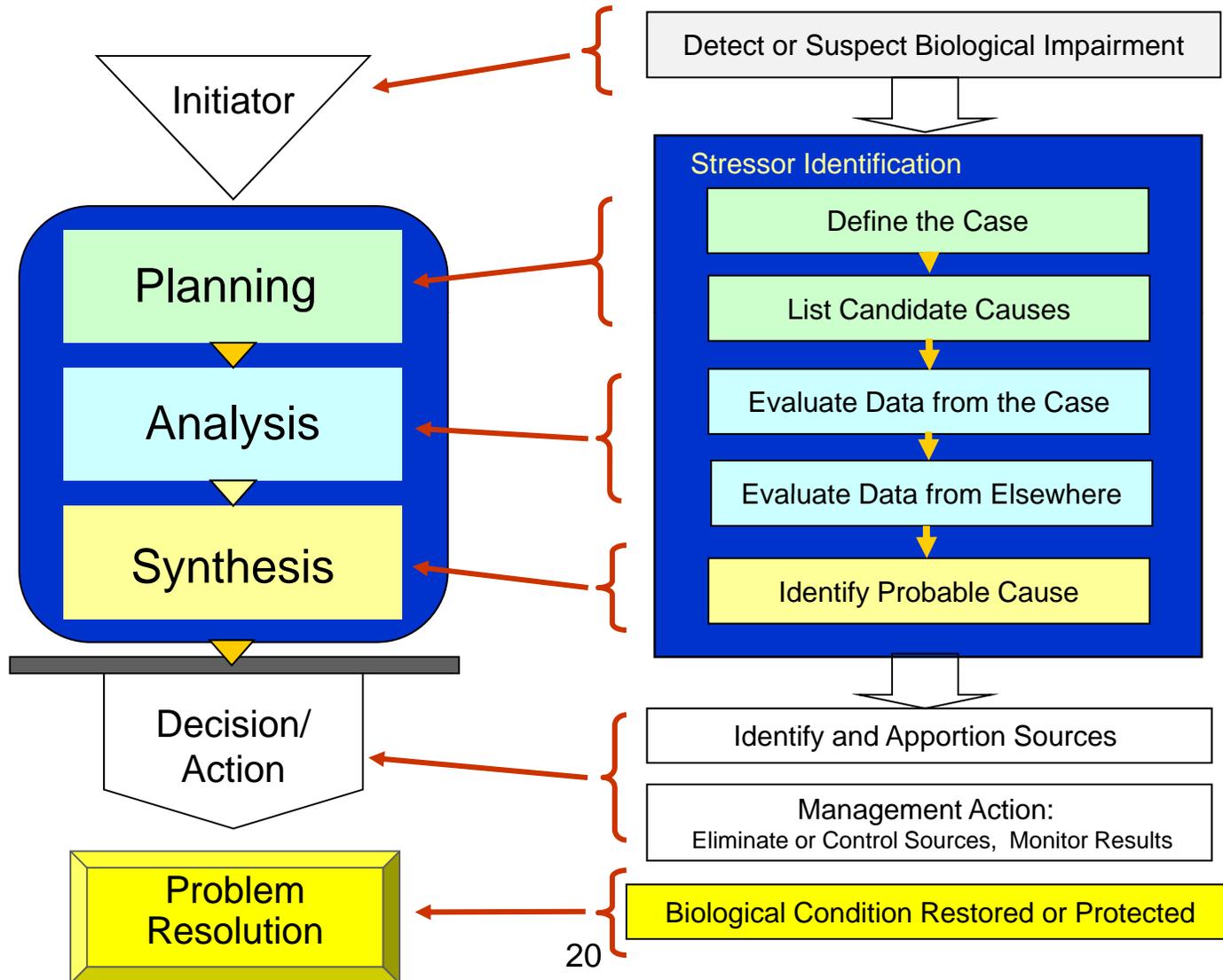




# CADDIS Stressor Identification Process

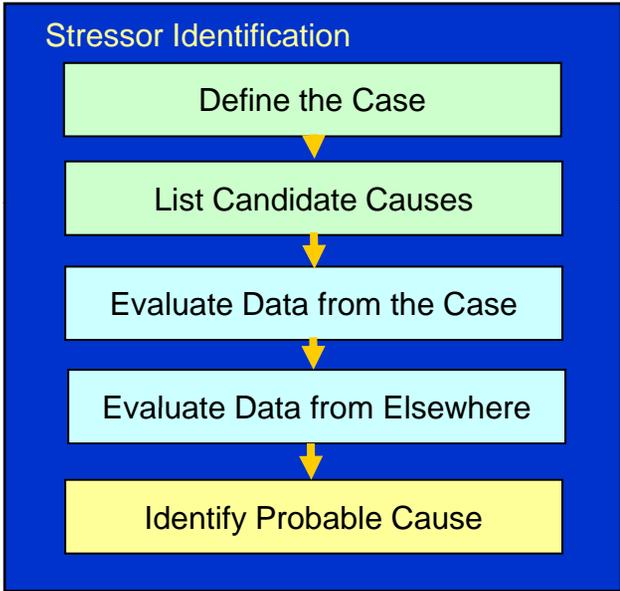
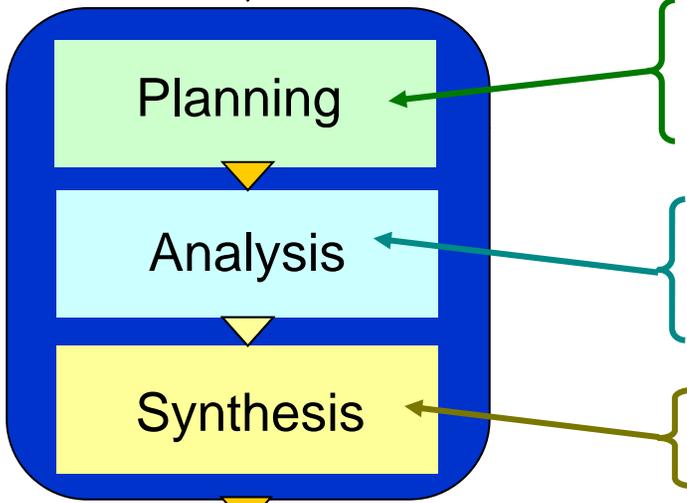


# CADDIS Stressor Identification Process



Common Assessment Process

Initiator

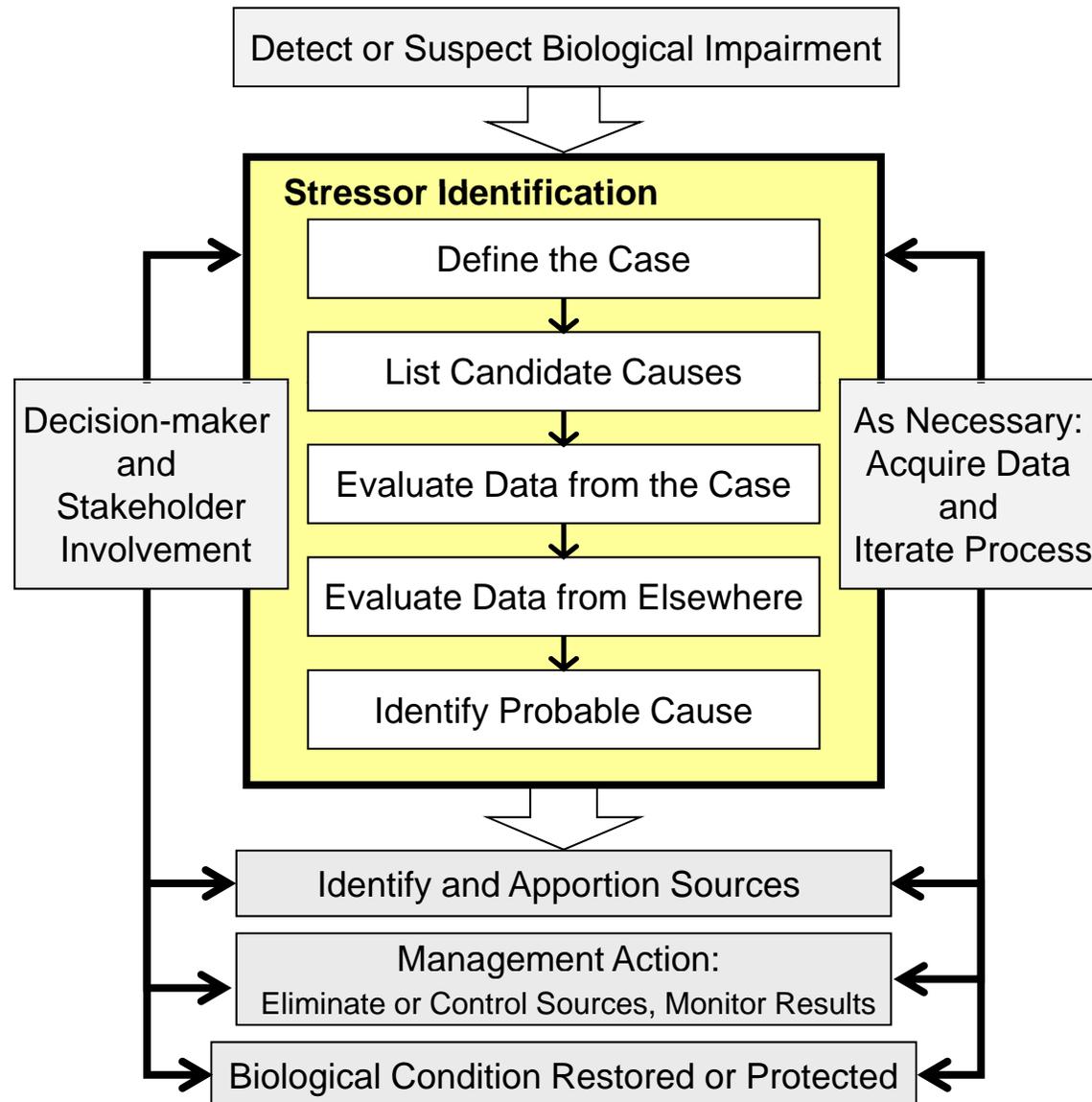


Decision/  
Action

Problem Resolution

# The causal analysis framework

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**Detect or suspect biological impairment**



- Fish kills
- Organismal anomalies
- Changes in community structure
- Low biotic index values

**Stressor Identification**

Define the Case

List Candidate Causes

Evaluate Data from the Case

Evaluate Data from Elsewhere

Identify Probable Cause

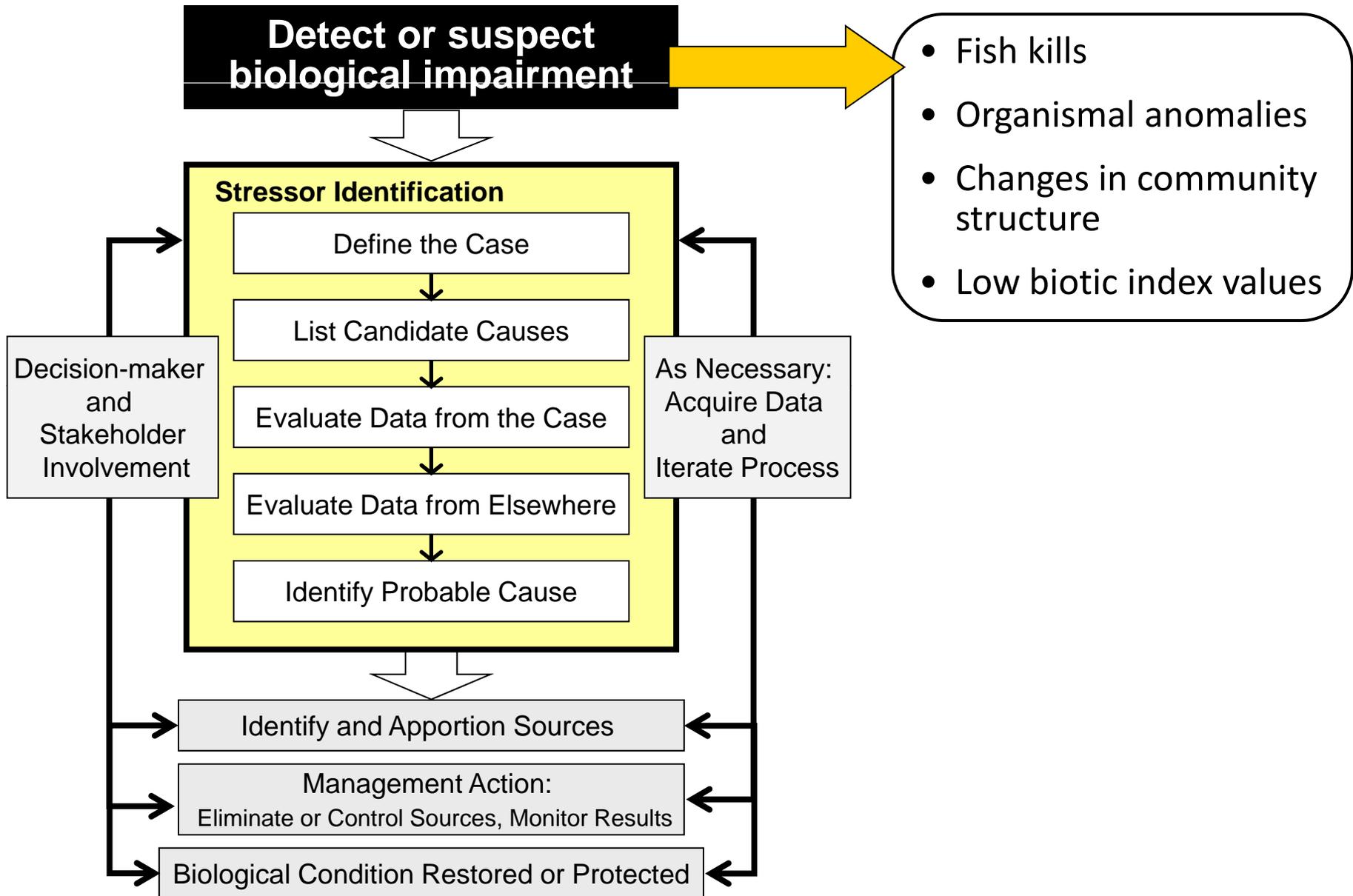
Decision-maker and Stakeholder Involvement

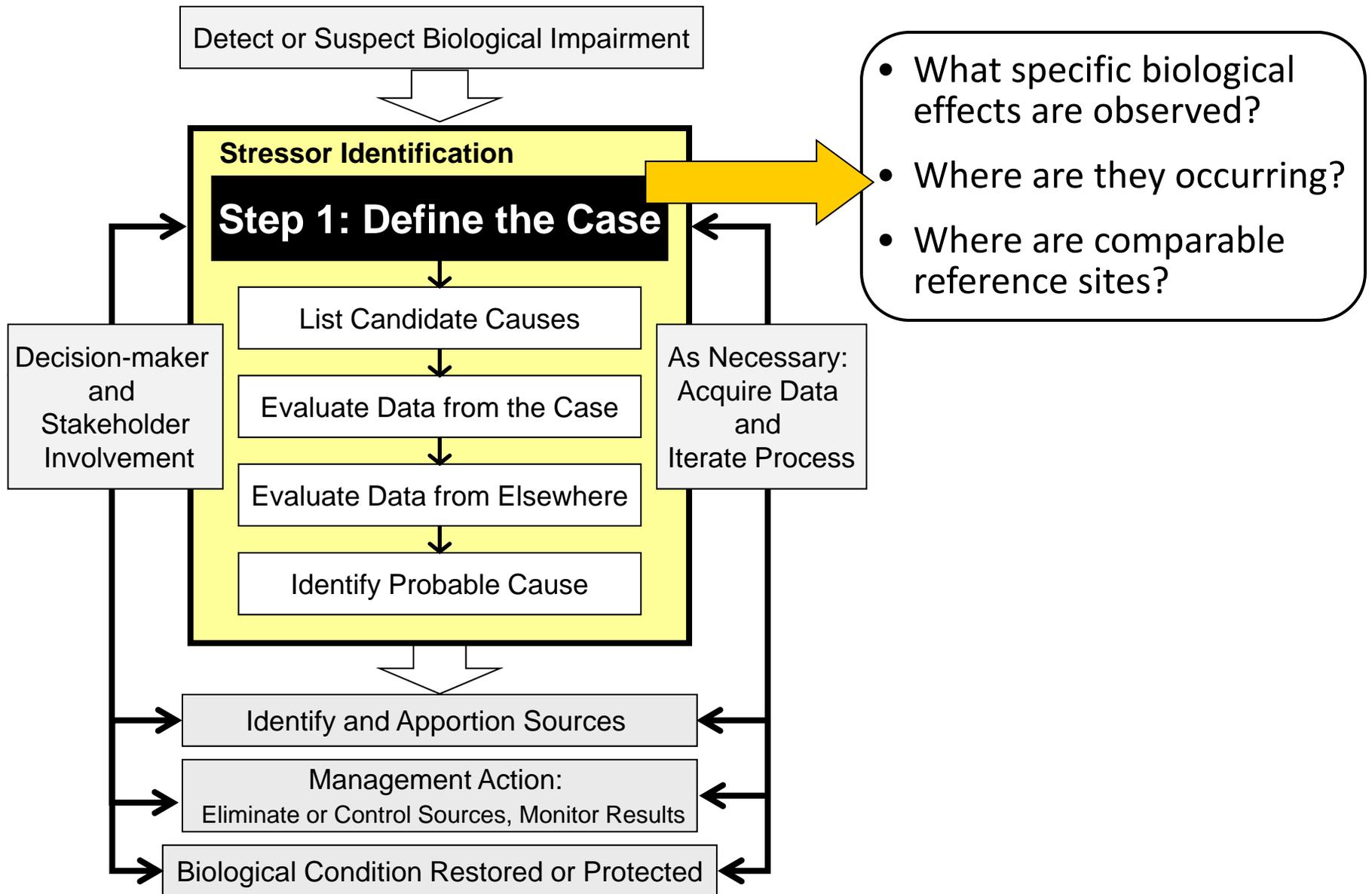
As Necessary: Acquire Data and Iterate Process

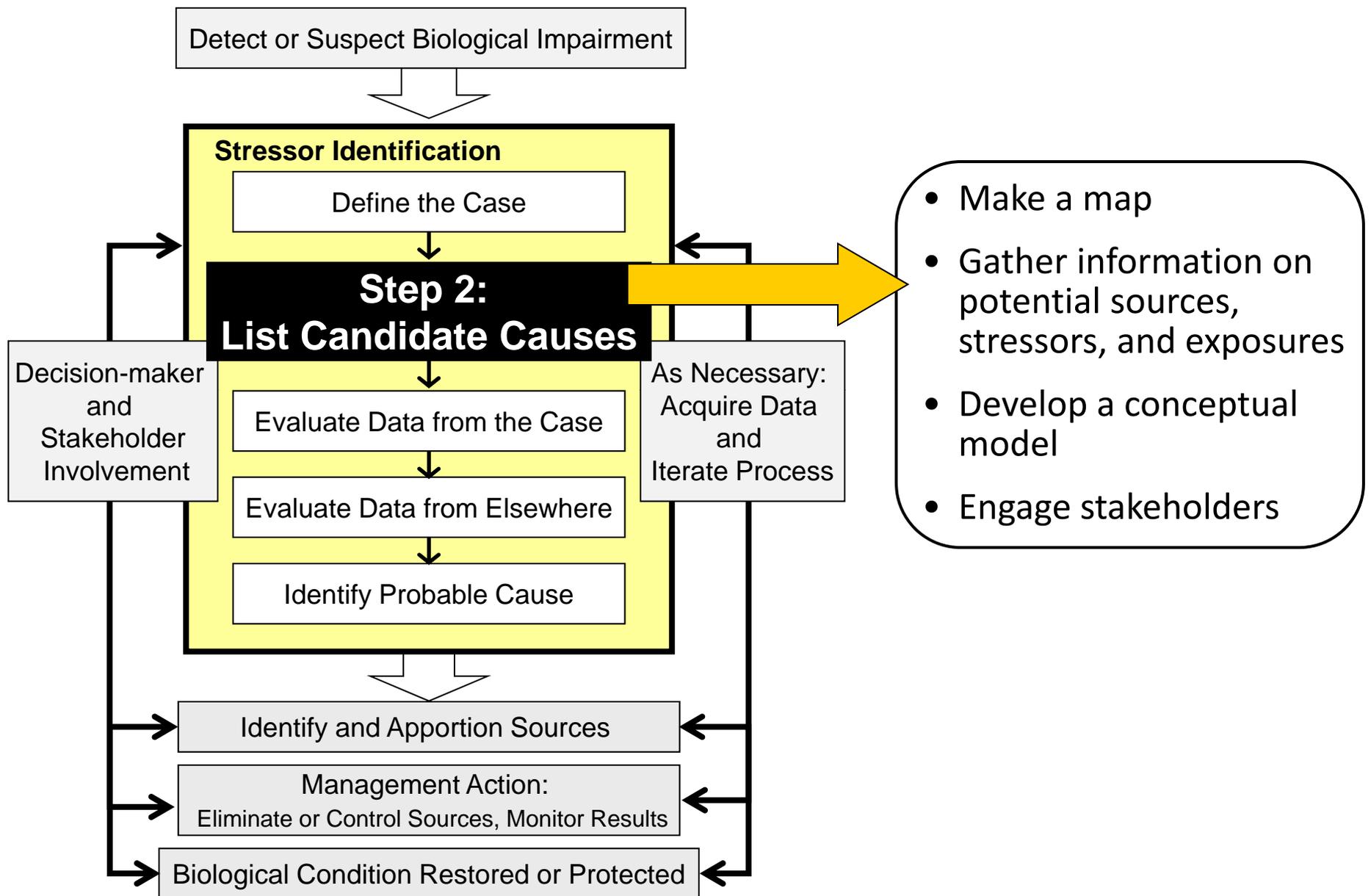
Identify and Apportion Sources

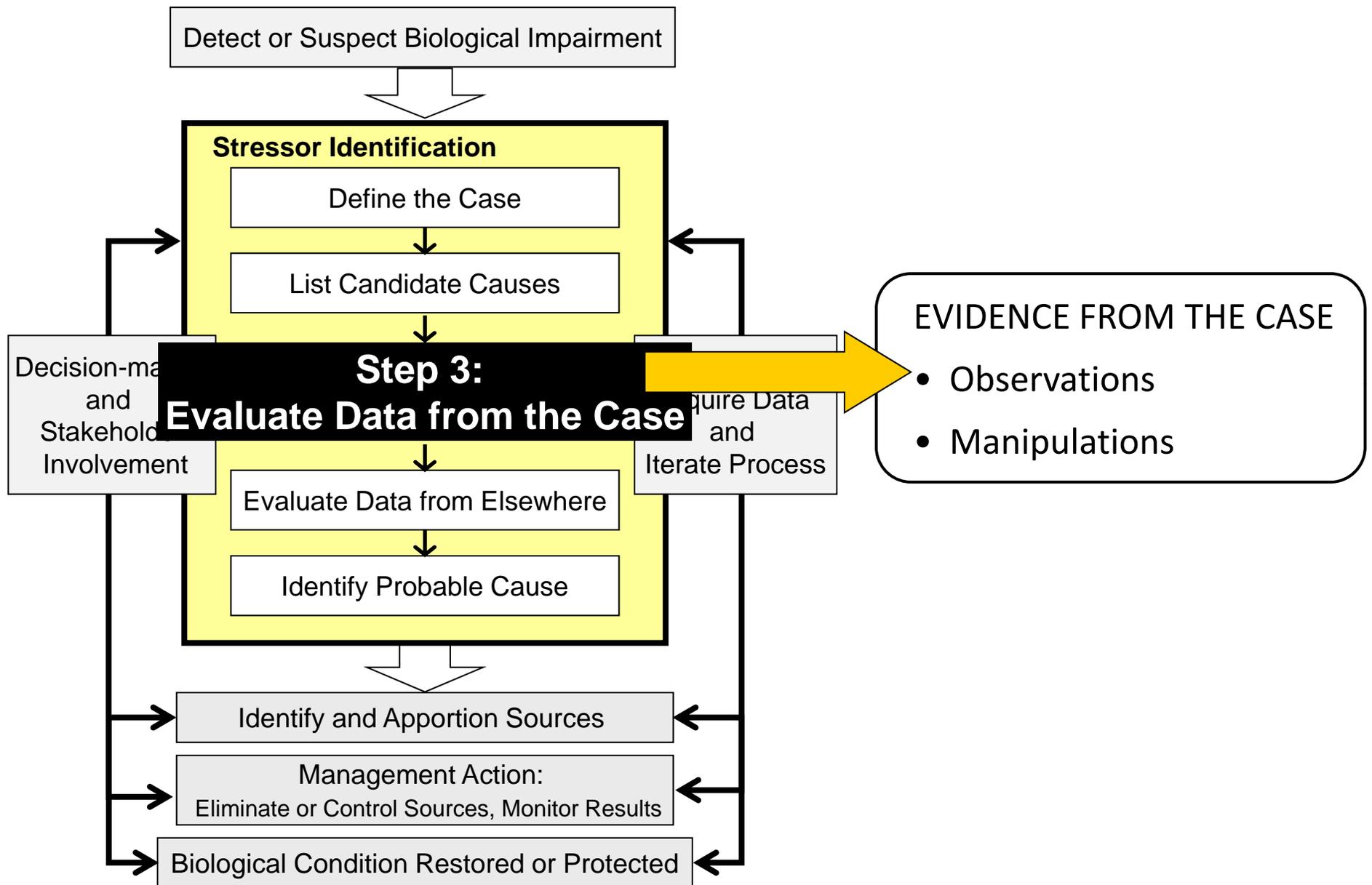
Management Action:  
Eliminate or Control Sources, Monitor Results

Biological Condition Restored or Protected

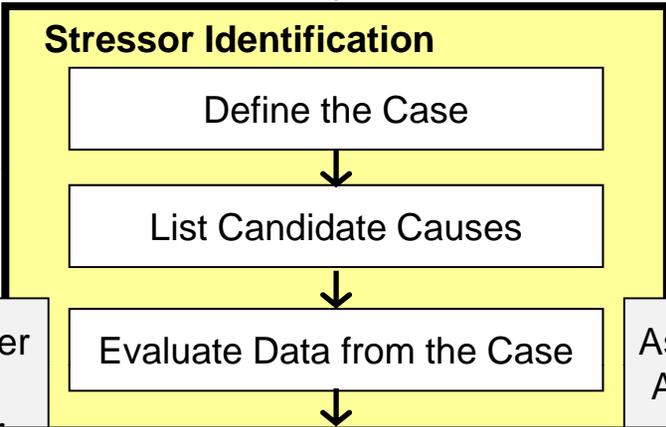
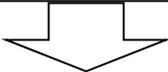








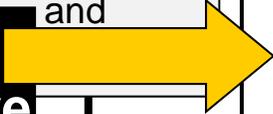
Detect or Suspect Biological Impairment



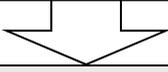
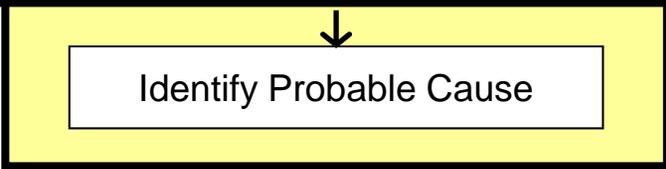
Decision-maker and Stakeholder Involvement

As Necessary: Acquire Data and

**Step 4: Evaluate Data from Elsewhere**



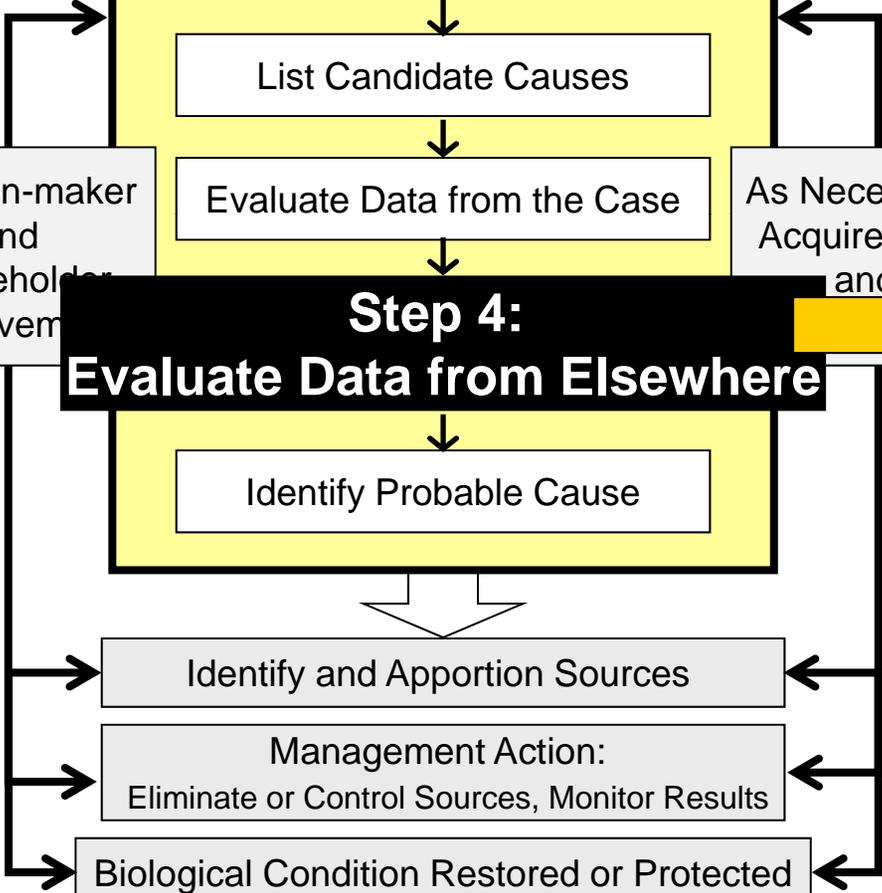
- EVIDENCE FROM ELSEWHERE**
- Observations
  - Manipulations
  - General Knowledge

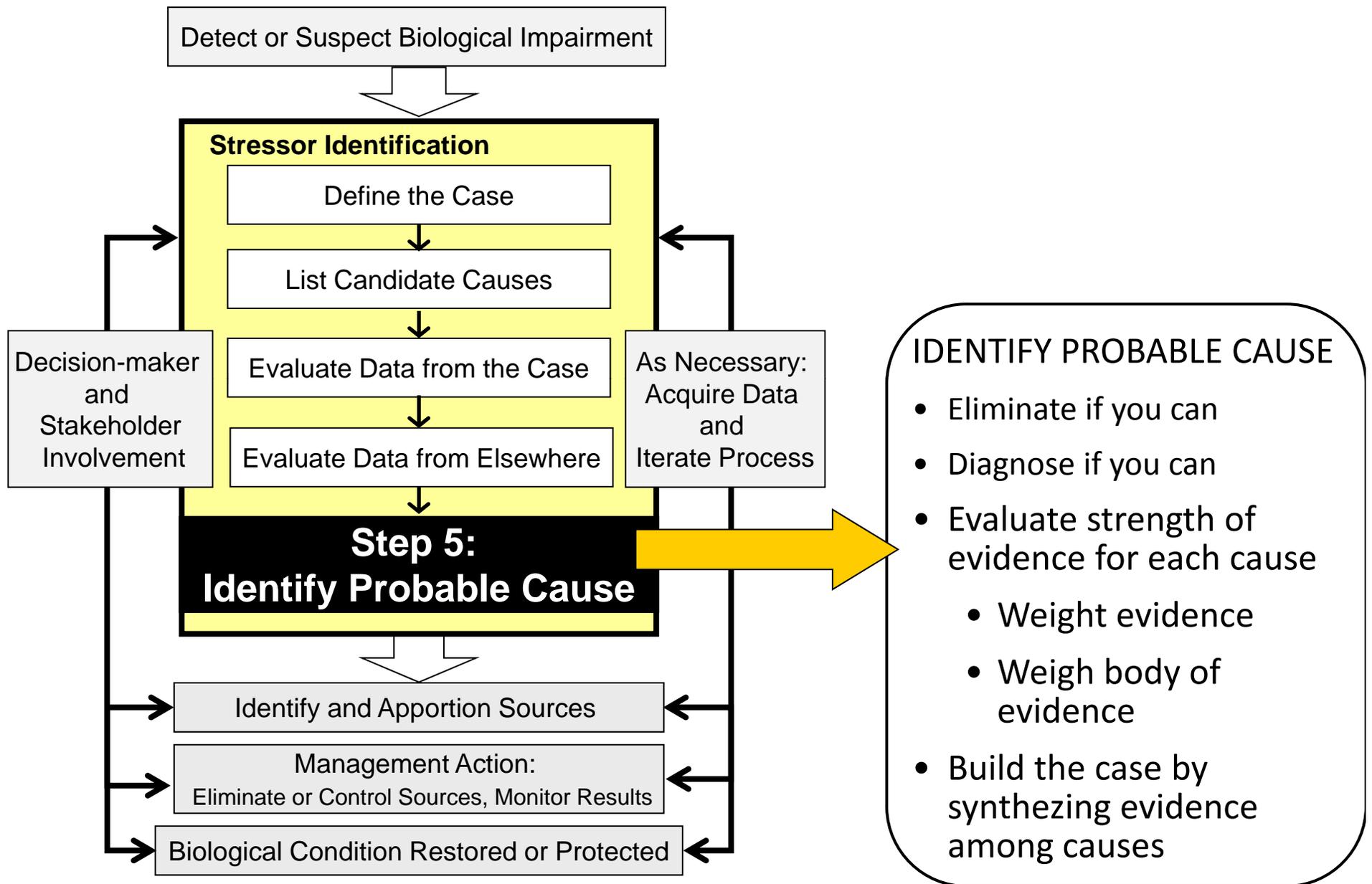


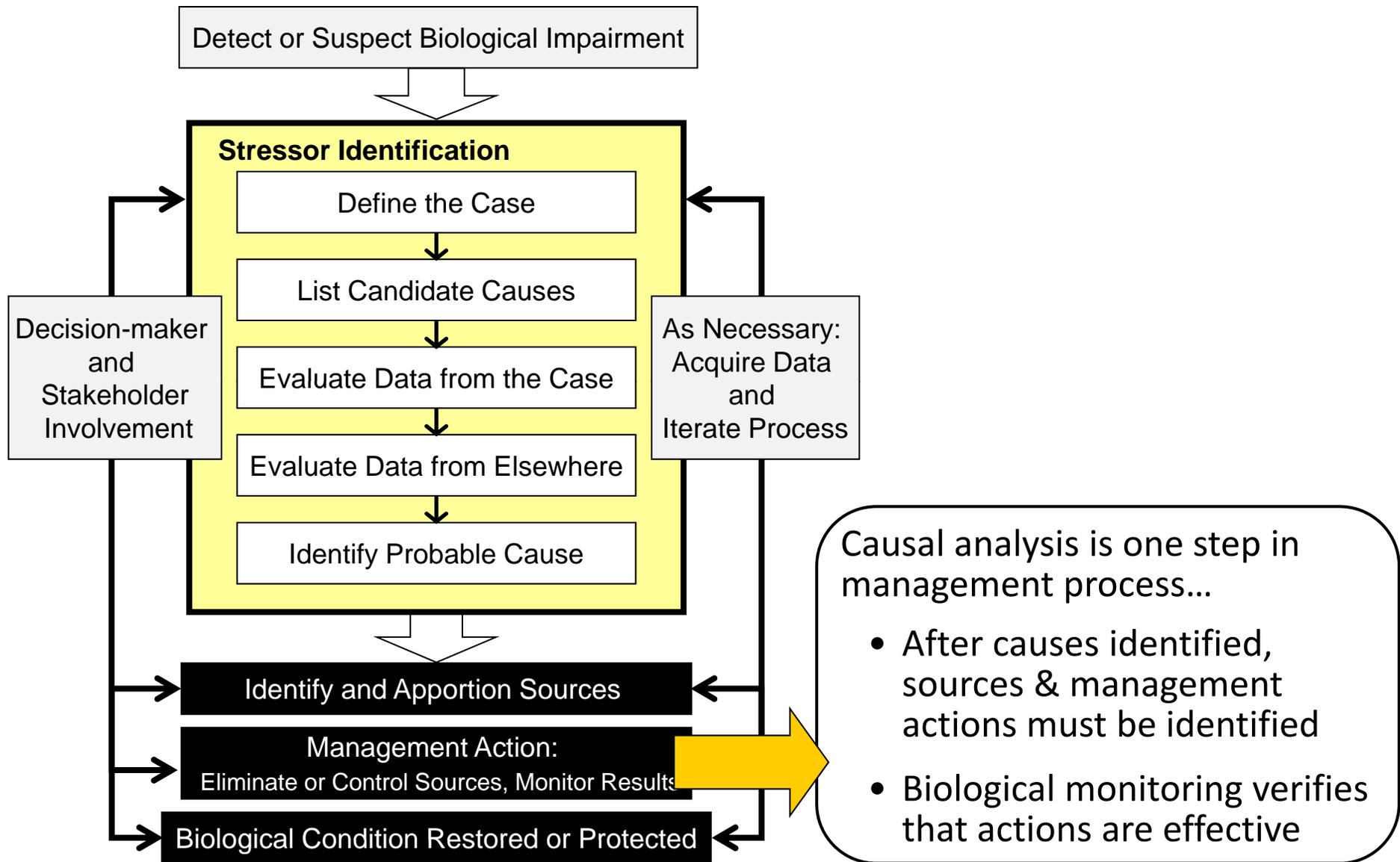
Identify and Apportion Sources

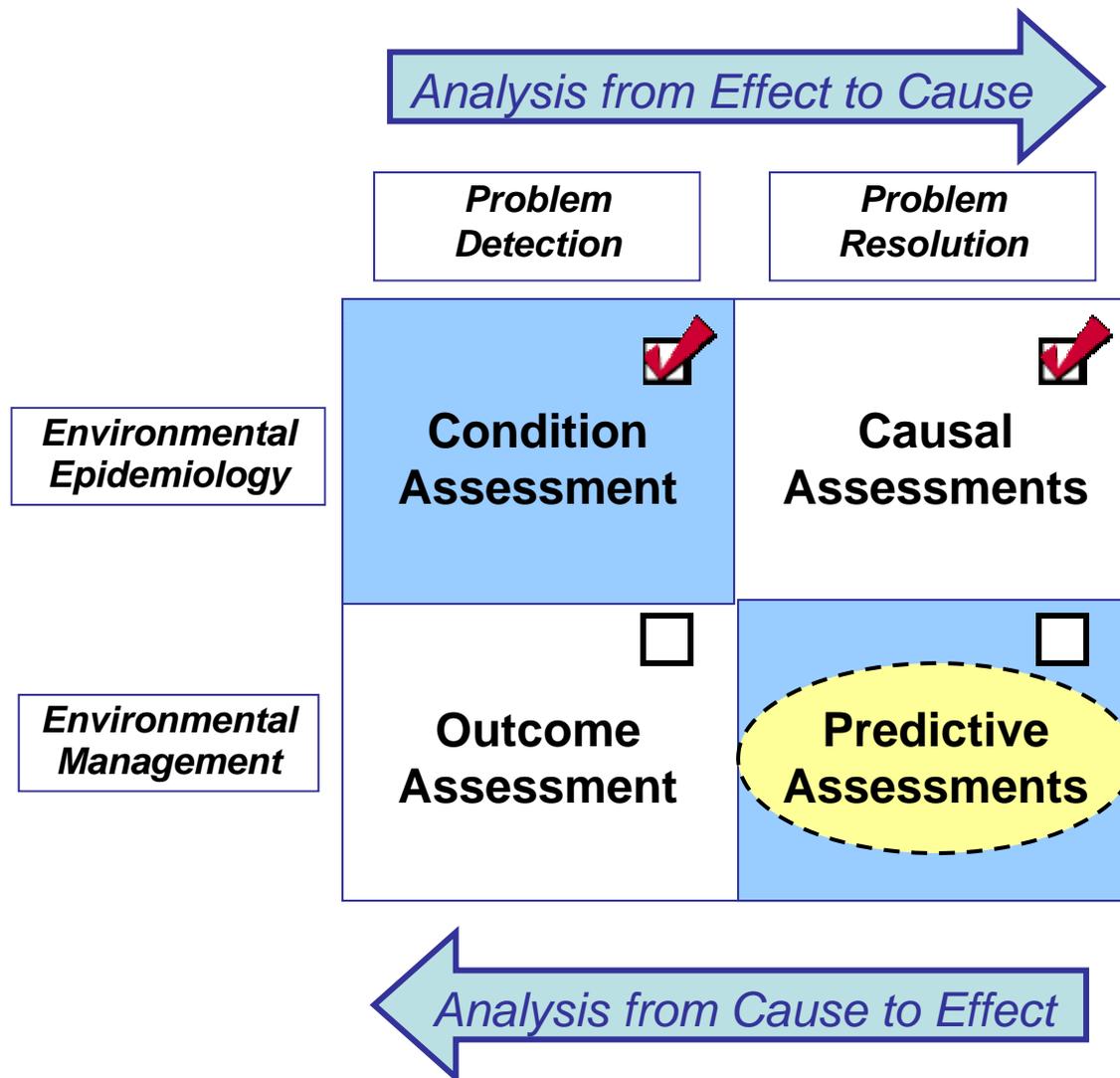
Management Action:  
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Biological Condition Restored or Protected









# RECAP

- Causal relationships can be expressed as agent, event, or process causation.
- There is a distinction between general and specific causation.
- Many environmental assessments deal with specific causation rather than generating new scientific knowledge and therefore have different inferential standards.
- The U.S. EPA process for causal assessment is based on a foundation of scientific philosophy and practical experience.