Relating Multiple Indicators to Beneficial Uses: Are We Making the Connections?

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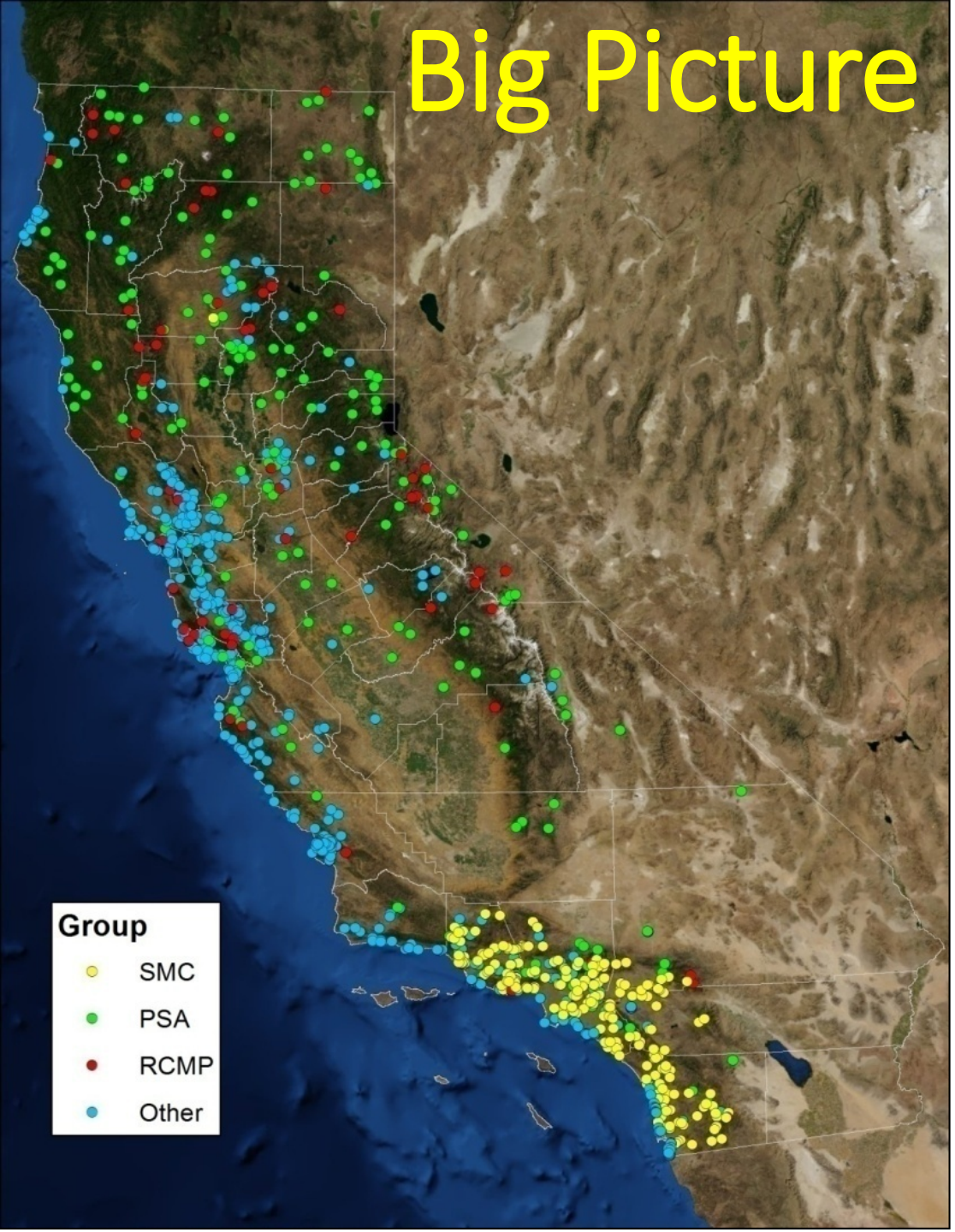
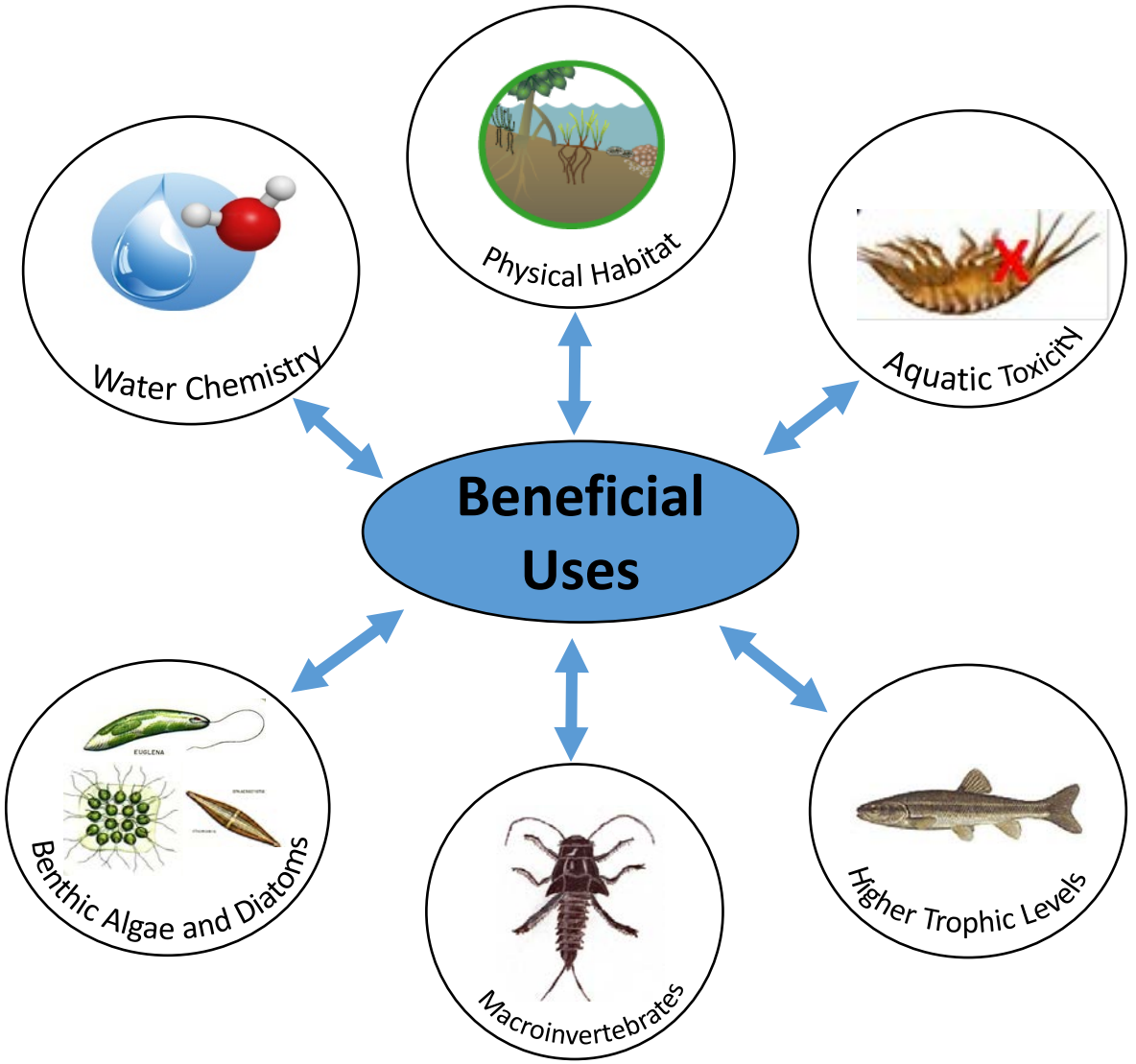
CA Bioassessment Workgroup

November 18, 2014

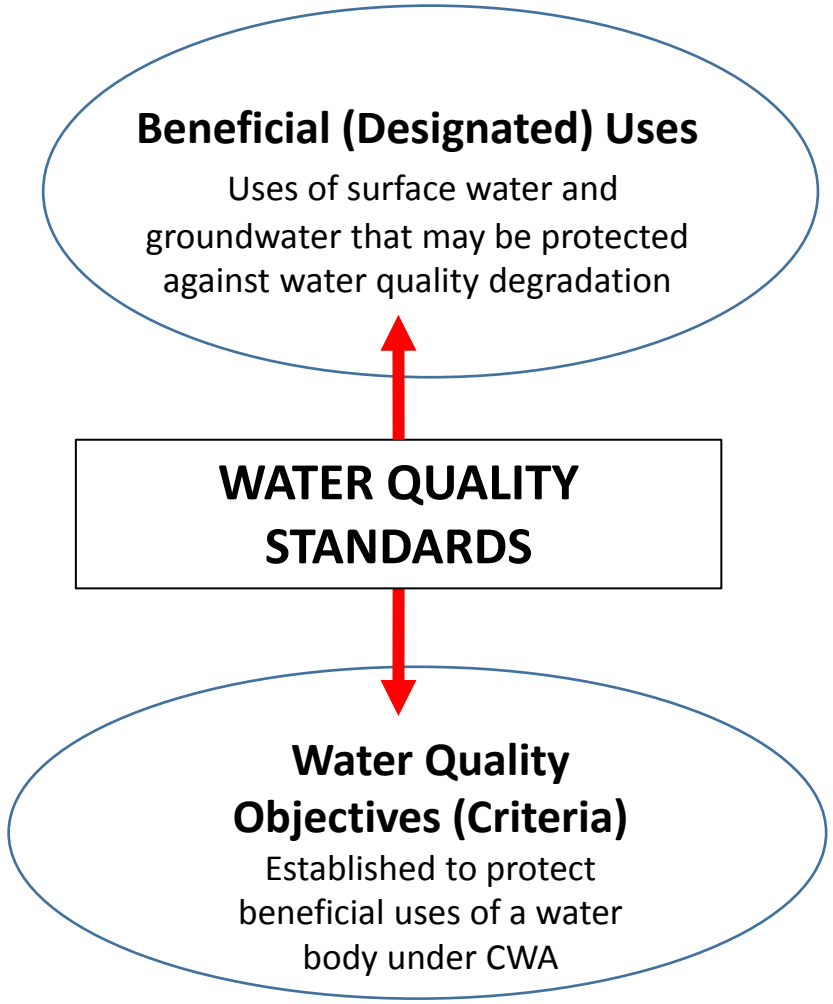
Special Session on Multi-Indicator Integration

Big Picture


Group
SMC
PSA
RCMP
Other


Beneficial Uses
Water Chemistry
Physical Habitat
Aquatic Toxicity
Benthic Algae and Diatoms
Macroinvertebrates
Higher Trophic Levels

Beneficial Use Primer



23 beneficial use definitions developed by SWB and recommended for use in Regional Basin Plans

- **Human Uses**:
  - Water supply (Municipal/Domestic, Ag, Industrial Process/Service)
  - Groundwater recharge
  - Hydropower generation
  - Water Recreation
  - Navigation
  - Commercial/sport fishing
  - Aquaculture
  - Shellfish harvesting

- **Habitat Types and Locations**:
  - Warm/Cold freshwater
  - Inland saline
  - Estuarine
  - Marine
  - Wildlife Habitat
  - Preservation of Biological Habitats of Special Significance

- **Processes and Function**:
  - Migration (fish)
  - Spawning, reproduction, early development (fish)
  - Preservation of RTE species

What is Missing?

- A way for integrating information from traditional water quality indicators and translating that to an evaluation of BU attainment

- A way to identify additional indicators so that new indicator development is targeted and complementary to existing tools
  - do not want to duplicate efforts

- With these components in place, can begin to answer fundamental questions about the health of our waterbodies

    - More informed decisions with better information
    - Connection back to program-specific needs and goals (e.g., are we protecting beneficial uses)

Challenges to BU Assessment

- Most uses have narrative objectives
  - Do lend easily themselves to direct quantitative evaluation
- Definitions for the same use can differ by Regional Board
- Most uses are complex and integrative in nature
  - “Habitat” uses consider multiple taxa and trophic levels

We need to translate “data” to more integrative endpoints

Long-term Goals for a BU Tool

1. Procedure for integrating information from multiple lines of evidence
   - chemical, physical, biological, stressor datasets

2. Translation of assessment results for interpreting beneficial use attainment

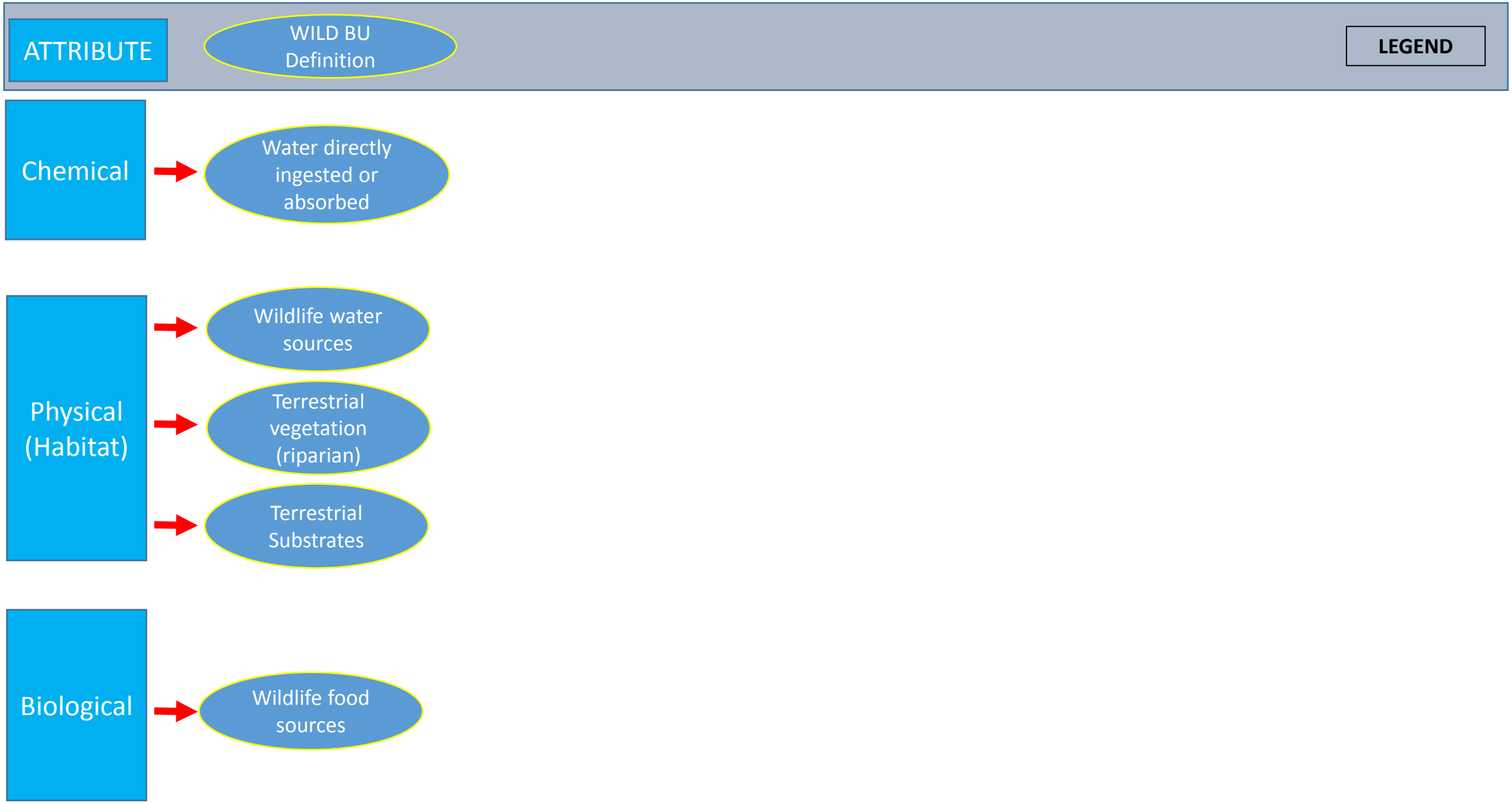
3. Develop a "decision-support system" for users to determine which organisms and response indicators are most appropriate for assessing BU attainment under various management scenarios

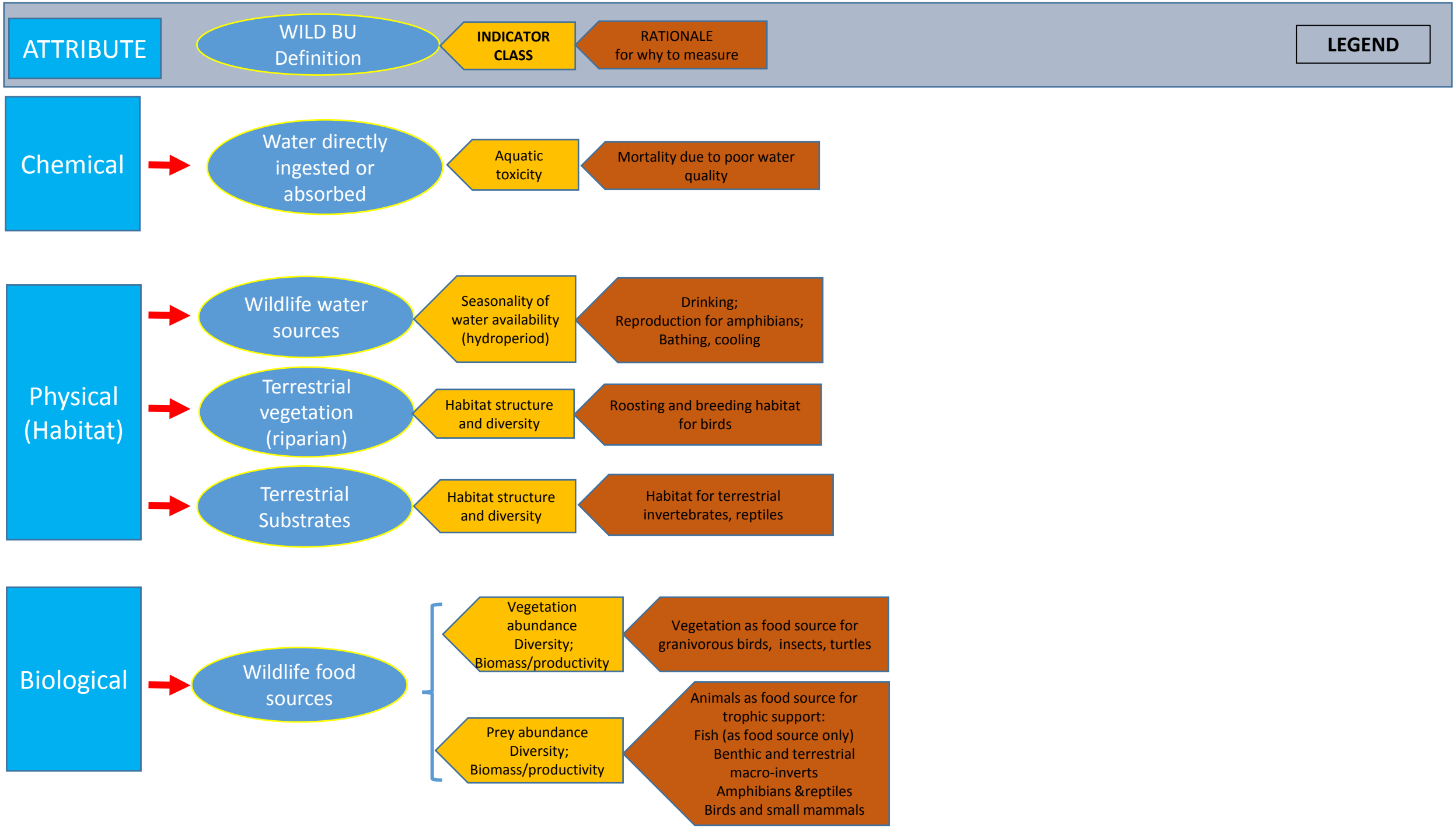
Requires a conceptual framework to guide this process

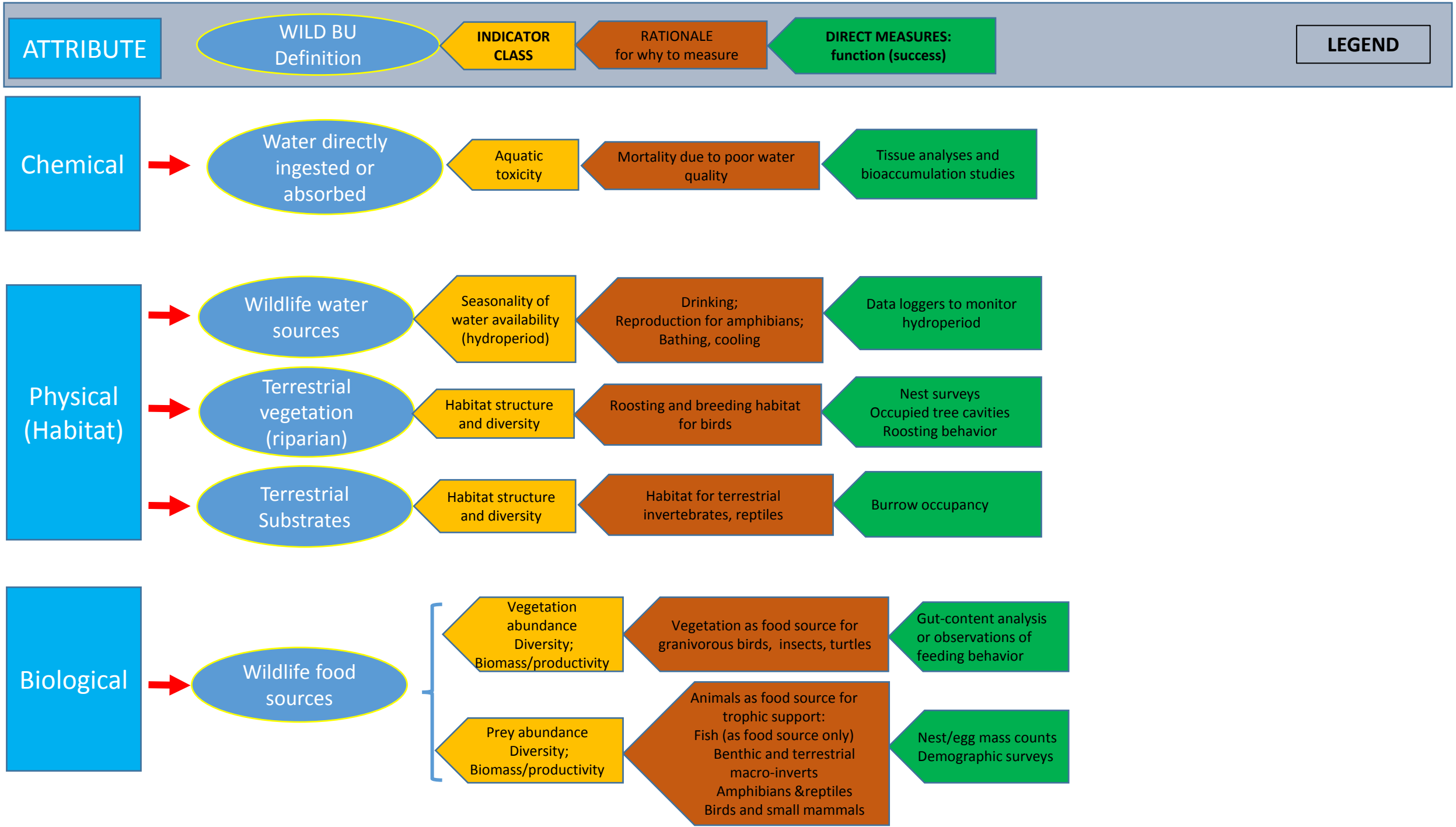
WILD and COLD BU Definitions

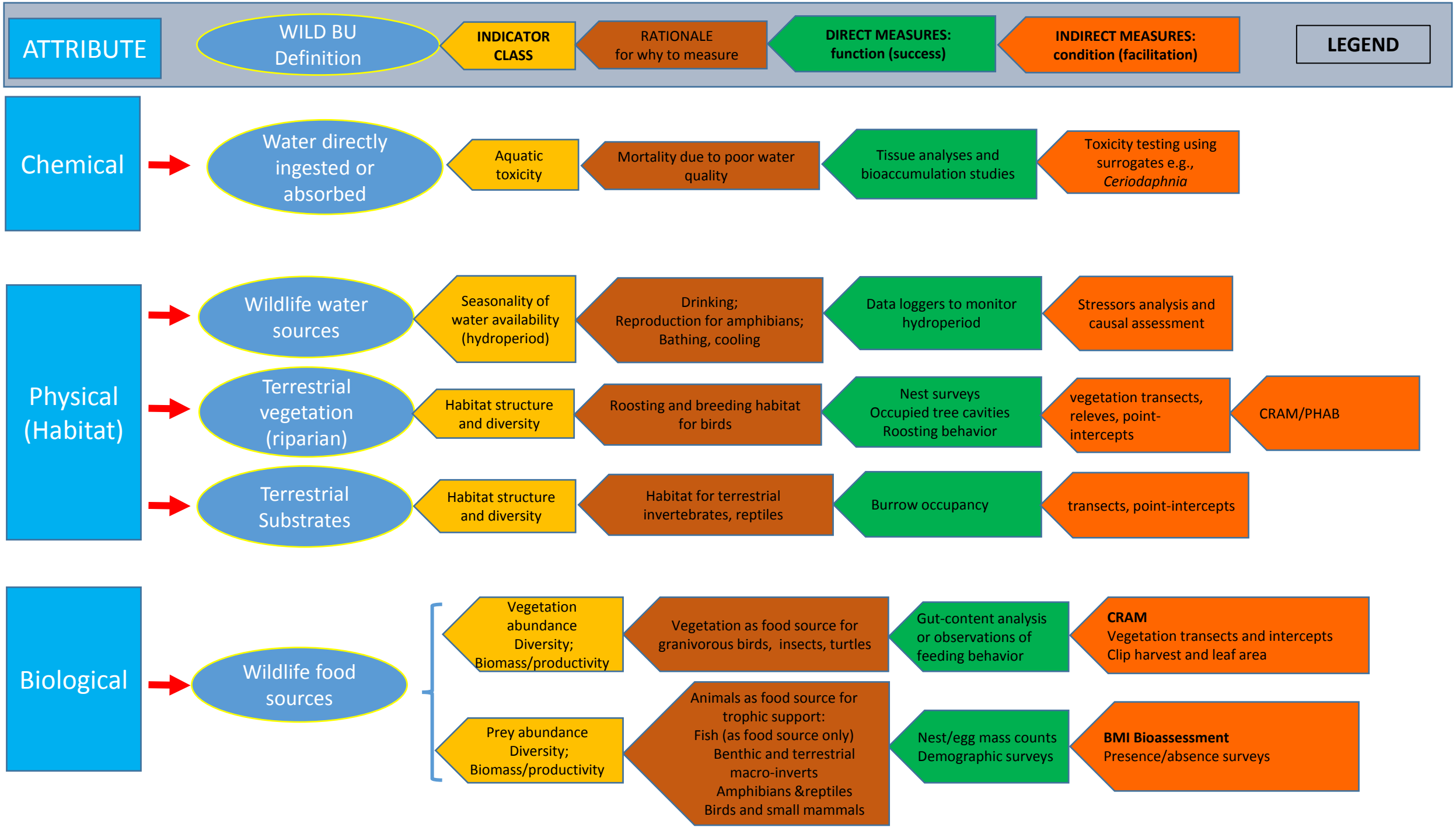
- WILD-Uses of waters that support terrestrial ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.

- COLD-Uses of water that support cold water ecosystems, including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.


ATTRIBUTE
WILD BU Definition
LEGEND
Chemical
Water directly ingested or absorbed
Physical (Habitat)
Wildlife water sources
Terrestrial vegetation (riparian)
Terrestrial Substrates
Biological
Wildlife food sources


ATTRIBUTE
WILD BU Definition
INDICATOR CLASS
RATIONALE for why to measure
LEGEND
Chemical
Water directly ingested or absorbed
Aquatic toxicity
Mortality due to poor water quality
Physical (Habitat)
Wildlife water sources
Seasonality of water availability (hydroperiod)
Drinking; Reproduction for amphibians; Bathing, cooling
Terrestrial vegetation (riparian)
Habitat structure and diversity
Roosting and breeding habitat for birds
Terrestrial Substrates
Habitat structure and diversity
Habitat for terrestrial invertebrates, reptiles
Biological
Wildlife food sources
Vegetation abundance Diversity; Biomass/productivity
Vegetation as food source for granivorous birds, insects, turtles
Prey abundance Diversity; Biomass/productivity
Animals as food source for trophic support:
Fish (as food source only)
Benthic and terrestrial macro-inverts
Amphibians &reptiles
Birds and small mammals


ATTRIBUTE
WILD BU Definition
INDICATOR CLASS
RATIONALE for why to measure
DIRECT MEASURES: function (success)
LEGEND
Chemical
Water directly ingested or absorbed
Aquatic toxicity
Mortality due to poor water quality
Tissue analyses and bioaccumulation studies
Physical (Habitat)
Wildlife water sources
Seasonality of water availability (hydroperiod)
Drinking; Reproduction for amphibians; Bathing, cooling
Data loggers to monitor hydroperiod
Terrestrial vegetation (riparian)
Habitat structure and diversity
Roosting and breeding habitat for birds
Nest surveys
Occupied tree cavities
Roosting behavior
Terrestrial Substrates
Habitat structure and diversity
Habitat for terrestrial invertebrates, reptiles
Burrow occupancy
Biological
Wildlife food sources
Vegetation abundance Diversity; Biomass/productivity
Vegetation as food source for granivorous birds, insects, turtles
Gut-content analysis or observations of feeding behavior
Prey abundance Diversity; Biomass/productivity
Animals as food source for trophic support:
Fish (as food source only)
Benthic and terrestrial macro-inverts
Amphibians &reptiles
Birds and small mammals
Nest/egg mass counts
Demographic surveys


ATTRIBUTE
WILD BU Definition
INDICATOR CLASS
RATIONALE for why to measure
DIRECT MEASURES: function (success)
INDIRECT MEASURES: condition (facilitation)
LEGEND
Chemical
Water directly ingested or absorbed
Aquatic toxicity
Mortality due to poor water quality
Tissue analyses and bioaccumulation studies
Toxicity testing using surrogates e.g., Ceriodaphnia
Physical (Habitat)
Wildlife water sources
Seasonality of water availability (hydroperiod)
Drinking; Reproduction for amphibians; Bathing, cooling
Data loggers to monitor hydroperiod
Stressors analysis and causal assessment
Terrestrial vegetation (riparian)
Habitat structure and diversity
Roosting and breeding habitat for birds
Nest surveys Occupied tree cavities Roosting behavior
vegetation transects, releves, point-intercepts
CRAM/PHAB
Terrestrial Substrates
Habitat structure and diversity
Habitat for terrestrial invertebrates, reptiles
Burrow occupancy
transects, point-intercepts
Biological
Wildlife food sources
Vegetation abundance Diversity; Biomass/productivity
Vegetation as food source for granivorous birds, insects, turtles
Gut-content analysis or observations of feeding behavior
CRAM
Vegetation transects and intercepts
Clip harvest and leaf area
Prey abundance Diversity; Biomass/productivity
Animals as food source for trophic support:
Fish (as food source only)
Benthic and terrestrial macro-inverts
Amphibians &reptiles
Birds and small mammals
Nest/egg mass counts Demographic surveys
BMI Bioassessment
Presence/absence surveys

COLD: CHEMICAL

ATTRIBUTE	RELEVANT WQ OBJECTIVE
CHEMICAL	Temperature pH Dissolved O_2 Biostimulation Suspended material Turbidity Oil and grease Sediment
	Metals Chemical constituents Toxic substances Pesticides Ammonia Bioaccumulation

ATTRIBUTE	RELEVANT WQ OBJECTIVE	ENDPOINT	MEASUREABLE COMPONENT
CHEMICAL	Temperature pH Dissolved O_2 Biostimulation Suspended material Turbidity Oil and grease Sediment	Effects on organism via water NOT directly ingested Impairment/mortality due to poor water quality	**Water quality and chemistry**
	Metals Chemical constituents Toxic substances Pesticides Ammonia Bioaccumulation	Effect on organism via water directly ingested or absorbed Impairment/mortality due to toxic conditions	**Aquatic life toxicity**

ATTRIBUTE	RELEVANT WQ OBJECTIVE	ENDPOINT	MEASUREABLE COMPONENT	RECEPTOR	RESPONSE INDICATOR	HABITAT SURROGATE
CHEMICAL	Temperature pH Dissolved O_2 Biostimulation Suspended material Turbidity Oil and grease Sediment	Effects on organism via water NOT directly ingested Impairment/mortality due to poor water quality	**Water quality and chemistry**	Diatoms and soft algae	Community condition: Richness, composition, and diversity measures	NA
				BMIs		
				Fish		
	Metals Chemical constituents Toxic substances Pesticides Ammonia Bioaccumulation	Effect on organism via water directly ingested or absorbed Impairment/mortality due to toxic conditions	**Aquatic life toxicity**	Diatoms and soft algae	Toxicity and pollution tolerance measures	NA
				BMIs		
				Fish		

ATTRIBUTE	RELEVANT WQ OBJECTIVE	ENDPOINT	MEASUREABLE COMPONENT	RECEPTOR	RESPONSE INDICATOR	HABITAT SURROGATE	EXAMPLE RECEPTOR-SPECIFIC METRICS	EXAMPLE METHOD
CHEMICAL	Temperature pH Dissolved O_2 Biostimulation Suspended material Turbidity Oil and grease Sediment	Effects on organism via water NOT directly ingested Impairment/mortality due to poor water quality	**Water quality and chemistry**	Diatoms and soft algae	Community condition: Richness, composition, and diversity measures	NA	Total taxa, # diatom/soft algae taxa ZHR metrics; CRUS; low TN, TP; eutrophic diatoms; sedimentation-tolerant diatoms; high Cu, DOC; acidophilic diatoms; diatom oxygen requirements Shannon-Wiener Index % Dominant taxon	Water probes, meters, thermometers, etc.
				BMIs			Total taxa, # EPT taxa, # Diptera % EPT, % Diptera, % Chironomidae % Dominant taxon	
				Fish			Total species, # native species # cold water native species	
	Metals Chemical constituents Toxic substances Pesticides Ammonia Bioaccumulation	Effect on organism via water directly ingested or absorbed Impairment/mortality due to toxic conditions	**Aquatic life toxicity**	Diatoms and soft algae	Toxicity and pollution tolerance measures	NA	ZHR metrics; CRUS; high Cu; teratology; density	Indicator organisms Tissue chemistry Toxicity bioassays Histopathology Proteomics/genomics
				BMIs			# intolerant taxa % tolerant taxa; % survival + reproduction of test organisms	
				Fish			% sensitive native individuals % tolerant individuals presence of growth anomalies	

COLD: PHYSICAL

ATTRIBUTE	RELEVANT WQ OBJECTIVE	ENDPOINT	MEASUREABLE COMPONENT
PHYSICAL (HYDROLOGY)	None identified in Basin Plans	Seasonality of cold water availability Mortality due to lack of water (desiccation)	**Water availability and quantity**
	None identified in Basin Plans	Presence of sufficient flow Diversity of flow regimes to support cold water benthos	**Flow velocity**
PHYSICAL (HABITAT)	Settleable Material Floating material	Attachment sites for benthic alga	**Epifuanal substrate and cover**
		Attachment sites for sessile BMIs locate food hide from predators concealment from prey repositories for egg masses	
		locate food control internal temperatures hide from predators concealment from prey repositories for egg masses	
	Exotic vegetation	Stream shading for cold water habitat	**Vegetative**

ATTRIBUTE	RELEVANT WQ OBJECTIVE	ENDPOINT	MEASUREABLE COMPONENT	RECEPTOR	RESPONSE INDICATOR	HABITAT SURROGATE
PHYSICAL (HYDROLOGY)	None identified in Basin Plans	Seasonality of cold water availability Mortality due to lack of water (desiccation)	**Water availability and quantity**	Diatoms and soft algae BMIs Fish	Community condition: Richness, composition, and diversity measures	Hydroperiod measures
	None identified in Basin Plans	Presence of sufficient flow Diversity of flow regimes to support cold water benthos	**Flow velocity**	Diatoms and soft algae BMIs Fish		Flow measures
PHYSICAL (HABITAT)	Settleable Material Floating material	Attachment sites for benthic alga	**Epifuanal substrate and cover**	Diatoms and soft algae	Community condition: Richness, composition, and diversity measures BMIs only: Habit measures (mode of locomotion)	Quality and abundance of instream substrates and cover
		Attachment sites for sessile BMIs locate food hide from predators concealment from prey repositories for egg masses		BMIs		
		locate food control internal temperatures hide from predators concealment from prey repositories for egg masses		Fish		
	Exotic vegetation	Stream shading for cold water habitat	**Vegetative**	Diatoms and soft algae BMIs Fish	Community condition: Richness, composition, and diversity measures	Quality of riparian zone and abundance of riparian zone vegetation

ATTRIBUTE	RELEVANT WQ OBJECTIVE	ENDPOINT	MEASUREABLE COMPONENT	RECEPTOR	RESPONSE INDICATOR	HABITAT SURROGATE	EXAMPLE RECEPTOR-SPECIFIC METRICS	EXAMPLE METHOD
PHYSICAL (HYDROLOGY)	None identified in Basin Plans	Seasonality of cold water availability Mortality due to lack of water (desiccation)	**Water availability and quantity**	Diatoms and soft algae BMIs Fish	Community condition: Richness, composition, and diversity measures	Hydroperiod measures	Total taxa/species, # taxa/species % dominant taxon	Stream gauge Data logger in situ stream discharge methods
	None identified in Basin Plans	Presence of sufficient flow Diversity of flow regimes to support cold water benthos	**Flow velocity**	Diatoms and soft algae BMIs Fish		Flow measures		Stream gauge Width: depth ratios Thalweg measurements in situ current velocity
PHYSICAL (HABITAT)	Settleable Material Floating material	Attachment sites for benthic alga	**Epifuanal substrate and cover**	Diatoms and soft algae	Community condition: Richness, composition, and diversity measures BMIs only: Habit measures (mode of locomotion)	Quality and abundance of instream substrates and cover	Particle size classes % fines % embeddedness organic woody debris Instream habitat complexity stream bank erosion potential measures of channel morphology % Clinger taxa (BMIs)	Physical habitat assessment methods (e.g. PHAB, CRAM Physcial Structure)
		Attachment sites for sessile BMIs locate food hide from predators concealment from prey repositories for egg masses		BMIs				
		locate food control internal temperatures hide from predators concealment from prey repositories for egg masses		Fish				
	Exotic vegetation	Stream shading for cold water habitat	**Vegetative**	Diatoms and soft algae BMIs Fish	Community condition: Richness, composition, and diversity measures	Quality of riparian zone and abundance of riparian zone vegetation	% canopy cover Number of plant layers Plant vertical structure	PHAB: Riparian vegetation characterization PHAB: canopy cover (densiometer)

COLD: BIOTIC

ATTRIBUTE	RELEVANT WQ OBJECTIVE	ENDPOINT	MEASUREABLE COMPONENT
BIOTIC	None identified in Basin Plans	High biomass and productivity of cold water species	**Biomass and productivity**
	Population and community ecology	High reproduction/recruitment of cold water species	**Reproductive Success**
	Population and community ecology	Release of nutrients downstream from algae and shredding invertebrates Use of terrestrial material by caddis flies to build cases Buffering capacity of wide riparian zones to erosional sediment inputs Terrestrial vegetation as a primary source of nutrients to streams	**Trophic realtionships**

ATTRIBUTE	RELEVANT WQ OBJECTIVE	ENDPOINT	MEASUREABLE COMPONENT	RECEPTOR	RESPONSE INDICATOR	HABITAT SURROGATE
BIOTIC	None identified in Basin Plans	High biomass and productivity of cold water species	**Biomass and productivity**	Diatoms and soft algae	Density measures	NA
				BMIs		
				Fish		
	Population and community ecology	High reproduction/recruitment of cold water species	**Reproductive Success**	Diatoms and soft algae	Evidence of reproduction/recruitment	NA
				BMIs		
				Fish		
	Population and community ecology	Release of nutrients downstream from algae and shredding invertebrates Use of terrestrial material by caddis flies to build cases Buffering capacity of wide riparian zones to erosional sediment inputs Terrestrial vegetation as a primary source of nutrients to streams	**Trophic realtionships**	Diatoms and soft algae	Community structure and feeding measues	NA
				BMIs		
				Fish		

ATTRIBUTE	RELEVANT WQ OBJECTIVE	ENDPOINT	MEASUREABLE COMPONENT	RECEPTOR	RESPONSE INDICATOR	HABITAT SURROGATE	EXAMPLE RECEPTOR-SPECIFIC METRICS	EXAMPLE METHOD
BIOTIC	None identified in Basin Plans	High biomass and productivity of cold water species	**Biomass and productivity**	Diatoms and soft algae	Density measures	NA	Chlorophyll-a Ash-free dry mass % algal cover	Bioassessment: Algae
				BMIs			Relative abundance (#/ sample)	Bioassessment: BMI
				Fish			Catch per unit effort	Electrofishing (catch per unit effort)
	Population and community ecology	High reproduction/recruitment of cold water species	**Reproductive Success**	Diatoms and soft algae	Evidence of reproduction/recruitment	NA	reproductive structures on relevant soft algae; presence of diatoms of varying sizes	Microscopic analysis of specimens, tallies
				BMIs			# semi-voltine taxa % semi-voltine	Bioassessment: BMIs
				Fish			# and spread in salmonid age classes	Egg mass counts Demographic surveys
	Population and community ecology	Release of nutrients downstream from algae and shredding invertebrates Use of terrestrial material by caddis flies to build cases Buffering capacity of wide riparian zones to erosional sediment inputs Terrestrial vegetation as a primary source of nutrients to streams	**Trophic realtionships**	Diatoms and soft algae	Community structure and feeding measues	NA	nutritional index/palatability/easy of handling of taxa comprising the community	Bioassessment: algae
				BMIs			Functional feeding groups (% scrapers, shredders, collectors, etc.)	Bioassessment: BMIs
				Fish			% omnivore plus herbivore individuals % insectivore individuals	Fish surveys Gut-content analysis Observations of feeding behavior

Next Steps

- Convene ad hoc technical committee to guide tool development process
- Facilitate discussion with stakeholders-solicit input
- Develop matrices for other relevant BUs
  - e.g., Estuarine, Migration

Special Workshop (4-5:30 pm today)

- Is this the right approach? Are we on track?
- Is the structure appropriate and effective?
- Does this make an effective translation between assessment endpoints and programmatic needs?
- Identify members for technical workgroup


Thank you!
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