



Development of Climate Change Indicators and Metrics

Summary of “Value-Added” Scoring and Draft Indicator Suite

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Today's Goals

1. Summarize the indicator development and scoring process.
2. Review input, aggregate results, and top vote-getters from the “value-added” scoring exercise.
3. Discuss a draft suite of indicator topics.
4. Request workgroup feedback that will help us select a final suite of indicator topics to feed into an implementation plan.

Project Objectives

Track progress toward the climate resiliency goal and outcomes in the 2014 Watershed Agreement:

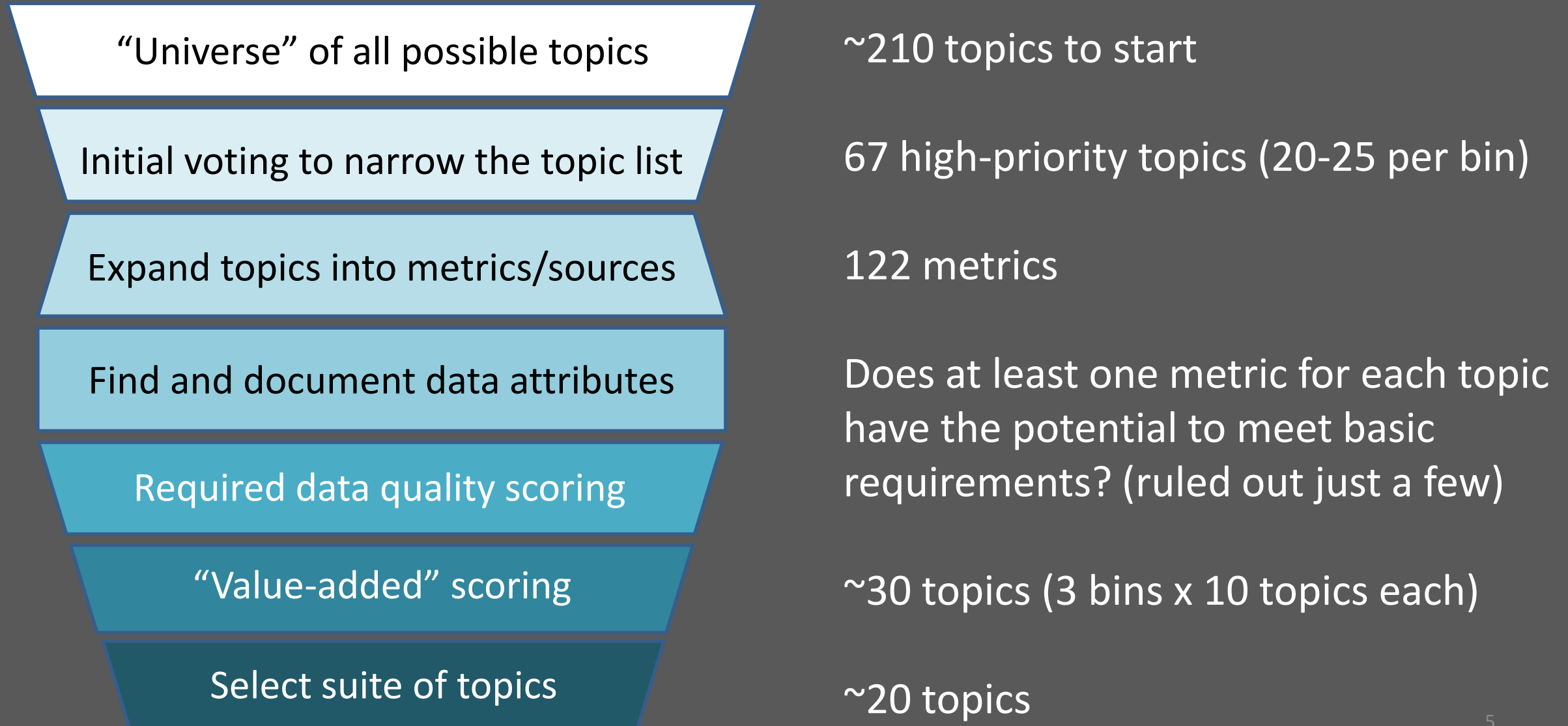
- **Goal:** Increase the resiliency of the Chesapeake Bay watershed, including its living resources, habitats, public infrastructure, and communities, to withstand adverse impacts from changing environmental and climate conditions.
- **Monitoring and Assessment outcome:** Continually monitor and assess the trends and likely impacts of changing climatic and sea level conditions on the Chesapeake Bay ecosystem, including the effectiveness of restoration and protection policies, programs and projects.
- **Adaptation outcome:** Continually pursue, design, and construct restoration and protection projects to enhance the resiliency of Bay and aquatic ecosystems from the impacts of coastal erosion, coastal flooding, more intense and more frequent storms and sea-level rise.

Indicator Development Process

| Step | Timeframe |
|--|------------------------|
| Establish framework (categories, definitions, criteria) | May 2017 |
| Compile lists of potential topics and data sources | May-June 2017 |
| Evaluate candidate topics against the criteria | June-October 2017 |
| Gather feedback and prioritize candidate topics | October-Nov. 2017 |
| Flesh out sources and specific metrics for indicator topics; develop implementation plan | Dec. 2017-January 2018 |
| Develop the top three to six indicators | March-April 2018 |
| Compile final results | May-July 2018 |



Indicator Selection by the Numbers



Indicator
Development
(continued)

“Universe” of all possible topics

Initial voting to narrow the topic list

Expand topics into metrics/sources

Find and document data attributes

Required data quality scoring

“Value-added” scoring

Select suite of topics

Implementation plan;
choose best metric(s)

Develop indicators as
resources allow

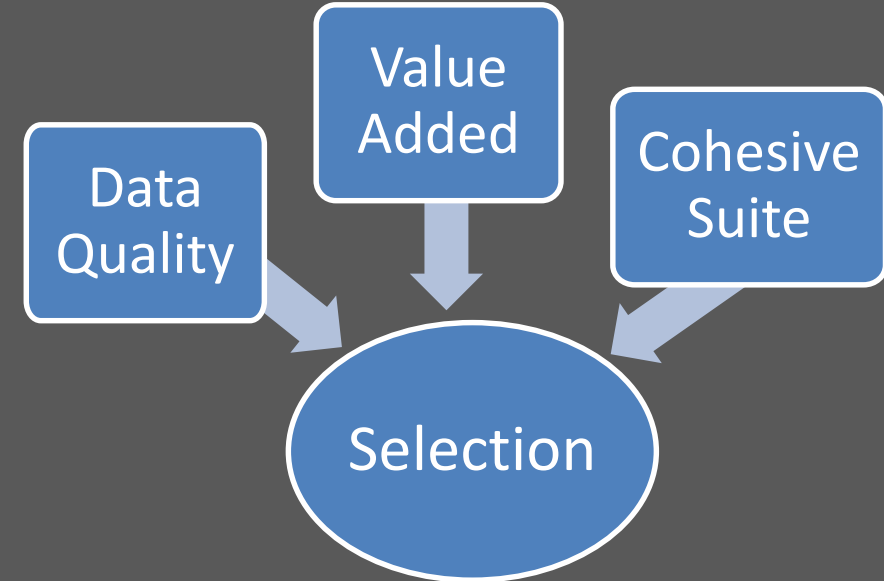
Summary of Scoring Steps

| Scoring Step | Who Votes | Use |
|------------------------------------|--|--|
| 1. Initial value voting | Workgroups and other stakeholders | Narrow the list of topics to research and score in more detail (done) |
| 2. Required data quality criteria | ERG data team | Eliminate topics that do not have a viable present or future indicator |
| 3. Value-added scoring | Workgroups, other stakeholders, CBPO project team, ERG | Select topics that are strong contenders for the final suite |
| 4. Suite criteria | CBPO project team, ERG | Select a cohesive final suite of topics |
| 5. Desirable data quality criteria | ERG data team | Select the best data source(s) for each of the selected topics, if more than one option is available |

The Desired End Result

A suite of indicators that...

- Meet basic criteria for indicator quality
- Use the best available data
- Add value in achieving the project objectives (based on diverse input)
- Achieve synergies together (whole is greater than sum of parts)



The Desired End Result (continued)

- All indicators in the suite must at least be feasible, but...
- Suite selection is independent of:
 - Current status (existing vs. proposed indicator)
 - Level of effort to construct
- Resource requirements will be considered in the implementation plan

In other words, the suite represents the **indicators we want**.
Resources will determine the **indicators we get**.

Assessing “Value Added”

- Six criteria recommended during 10/16/17 CRWG workshop:

| Criterion | How scored | Number of inputs |
|---|-------------------|------------------------------------|
| Rate of change | High/Moderate/Low | 9 (mostly individuals) |
| Significance of consequences | High/Moderate/Low | 9 (mostly individuals) |
| Significant advancement in our understanding of climate | Yes/No | 9 (mostly individuals) |
| Known new need | Yes/No | 15 (individuals, goal teams, etc.) |
| Relevance to CBP management actions (Bin #3 only) | Yes/No | 15 (individuals, goal teams, etc.) |
| Relevance to climate resiliency goal and outcomes (“climate relevance”) | High/Moderate/Low | 6 (core project team) |

Top Vote-Getters in Bin #1: Physical Climate Trends



| Points | Topic |
|--------|--|
| 87.25 | sea level change |
| 77.75 | heavy precipitation: extreme one-day precipitation events (etc.) |
| 77.20 | water temperature: Bay |
| 73.00 | streamflow metrics (high flow, low flow, peak volume) |
| 71.17 | water temperature: streams |
| 70.29 | air temperature: hot extremes |
| 69.96 | acidity: Bay |
| 64.66 | total precipitation |
| 64.20 | CO2 concentrations in air* |
| 62.90 | air temperature: mean |

* Does not meet the required indicator criteria, based on initial review

Top Vote-Getters in Bin #2: Ecological or Societal Impact



| Points | Topic |
|--------|---|
| 81.28 | wetland extent / coastal land loss / conversion |
| 76.39 | flooding: rivers / upstream |
| 73.04 | wetlands' physical buffering capacity, wave attenuation, protection against storm surge, etc. |
| 73.00 | infrastructure damage (value lost?) due to flooding |
| 67.31 | algal blooms: extent, frequency, duration |
| 66.94 | flooding: coastal (at least minor or nuisance-level) |
| 66.51 | submerged aquatic vegetation community composition |
| 65.92 | length of growing season |
| 61.96 | property at risk; changes in flood insurance maps |
| 61.42 | range boundary shifts and population centroid shifts: birds |

Top Vote-Getters in Bin #3: Progress Toward Resilience



What does "land use" mean to us?

- Original intent
- Possibilities

| Points | Topic |
|--------|--|
| 92.20 | "living" vs. hardened shoreline extent |
| 76.67 | acres of protected wetland, protected natural lands, or aquatic reserves; conservation easements |
| 75.61 | wetland accretion rates vis-à-vis sea-level rise |
| 72.76 | better siting and design of water-related BMPs |
| 72.43 | acres of restored habitat (wetlands, oyster beds, etc.) |
| 71.52 | designated wetland migration corridors |
| 71.27 | tree canopy (urban) |
| 69.63 | legislation or regulations to protect shorelines, the Bay, or wetlands -- including living shoreline regulations |
| 68.87 | green infrastructure (e.g., bioswales, rain gardens, permeable pavement, green roofs) |
| 66.17 | land use |

Observations from Value-Added Voting

- Final report will capture these observations and more
- Scoring requires personal judgment
 - As much as we tried to define a rubric, subjective judgment is inevitably required
 - Good reason to get scores from as diverse a group of stakeholders and experts as possible
- We clarified some criteria in our own minds
- Which criteria were scored most consistently across voters?
 - **Climate relevance** was most consistent (lowest standard deviation)
 - **Significant advancement** and **known new need** were least consistent

Observations from Value-Added Voting (continued)

- Different bins may require different interpretations of criteria
 - Also, some criteria may be naturally more conducive to certain bins
 - Good reason to compare results *within* bins more than *across* bins
- Some people are better positioned to judge certain criteria
 - Programmatic criteria
 - Subject matter expertise
 - Wide knowledge of existing data
 - Some people omitted certain columns, and that's okay

Observations from Value-Added Voting (continued)

- No rubric is perfect
- Some criteria inevitably more important than others
 - But opinions vary...
 - Dependence
- Any big misses?
 - Did we overlook “fish health/populations”? Might we have scored it differently with a better title or better context? (See Wainger et al. [2017])

Selecting a Cohesive Suite

- Objective criteria
 - Some suggested by this workgroup
 - Additional gap-filling through project team discussions
- More holistic considerations
 - How the indicators relate to each other

Suite Considerations Suggested by the CRWG

- **Weaving a thread** between trend/impact/response (storytelling), but without sacrificing standalone value
- **Actionable** for this group, where we can offer support
- Broader focus beyond the shoreline, including **watershed-level** resiliency activity (prioritize broader scope over size of resiliency effort)
- **Diversity**, with eye to communication value
- **Prioritize societal value and human health** components
- Consider the **coordination** of the expansion of metrics

Refined Criteria

1. Balance across bins

- Aim for at least 25% (five indicators) from each bin
- Recognize that some indicators straddle bins

2. Balance of tidal and nontidal/watershed-wide

- Aim for no more than 2/3 tidal or 2/3 nontidal

3. Balance of ecological and societal/human concerns

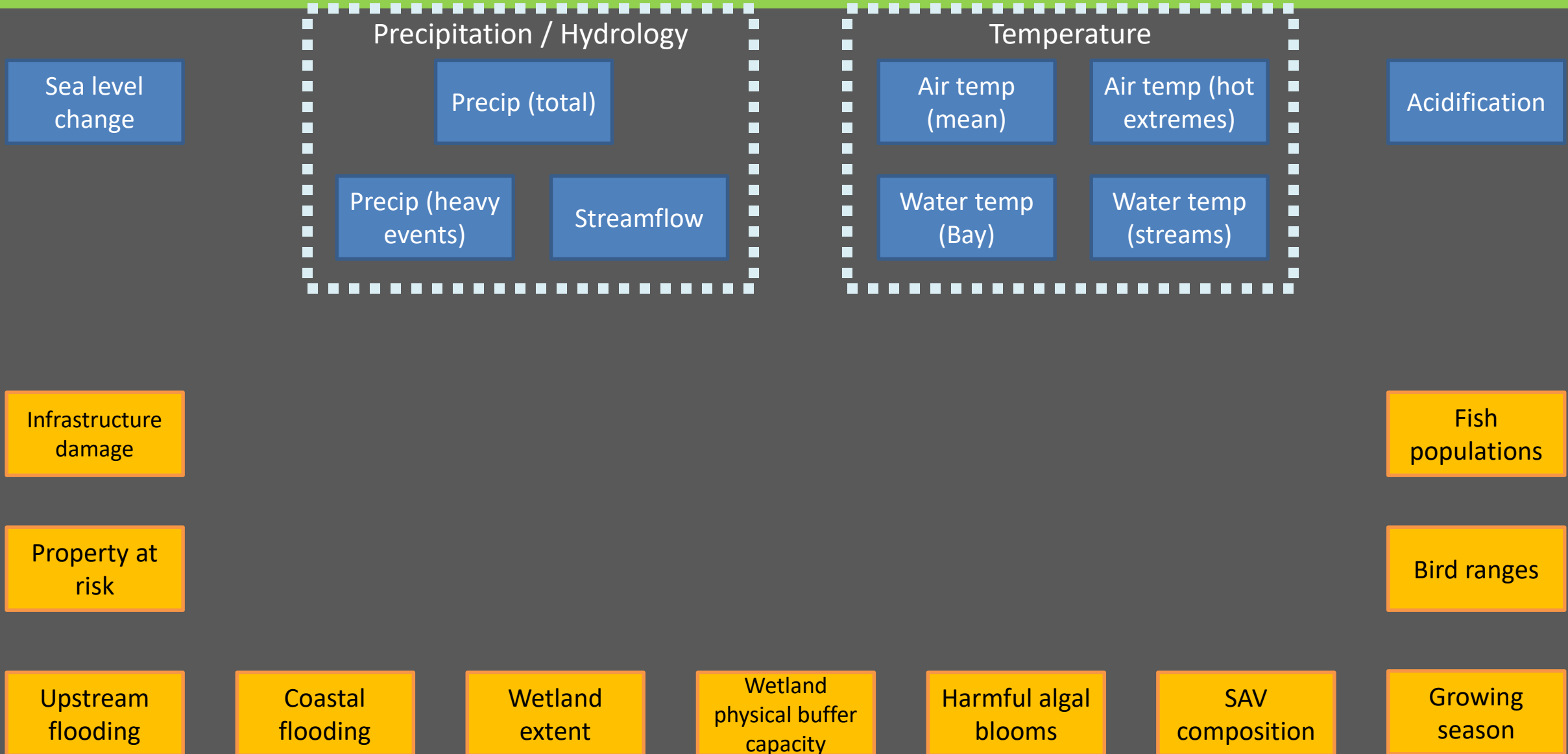
- CRWG member(s) suggested a focus on societal/human
- Climate resiliency goal and outcomes refer to living resources, habitats, and ecosystems

4. Balance between breadth (diversity) and depth (connections or “threads”)

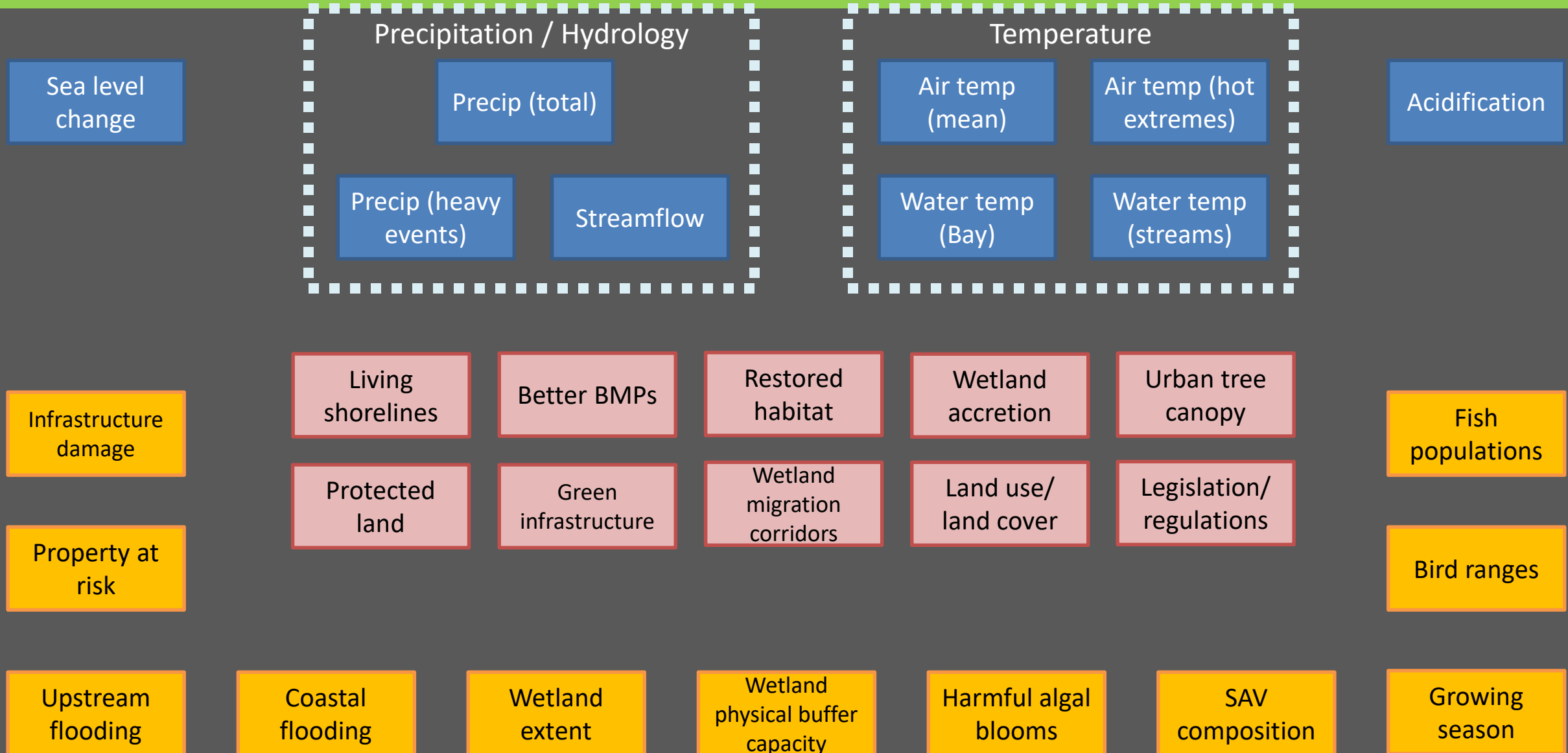
- Cover all key climate change stressors (temperature, precipitation, sea level, acidity)
- Cover many types of systems and issues; avoid duplication
- Include some indicators that have causal linkages and work together to tell a story, particularly across the three bins

5. Topics that scored highly on all “value-added” criteria and have high communication value (possible tiebreaker)

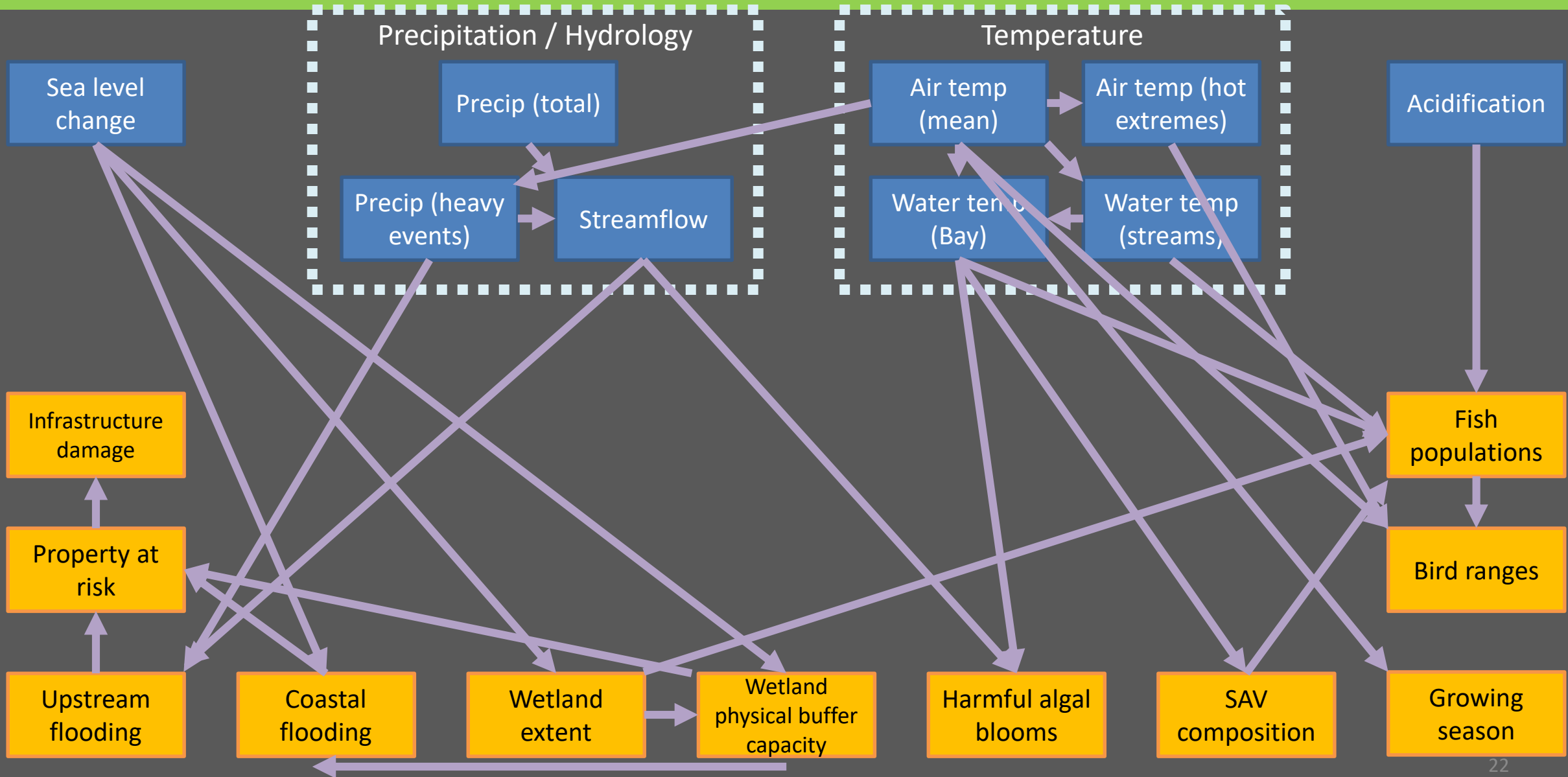
Stressors and Impacts



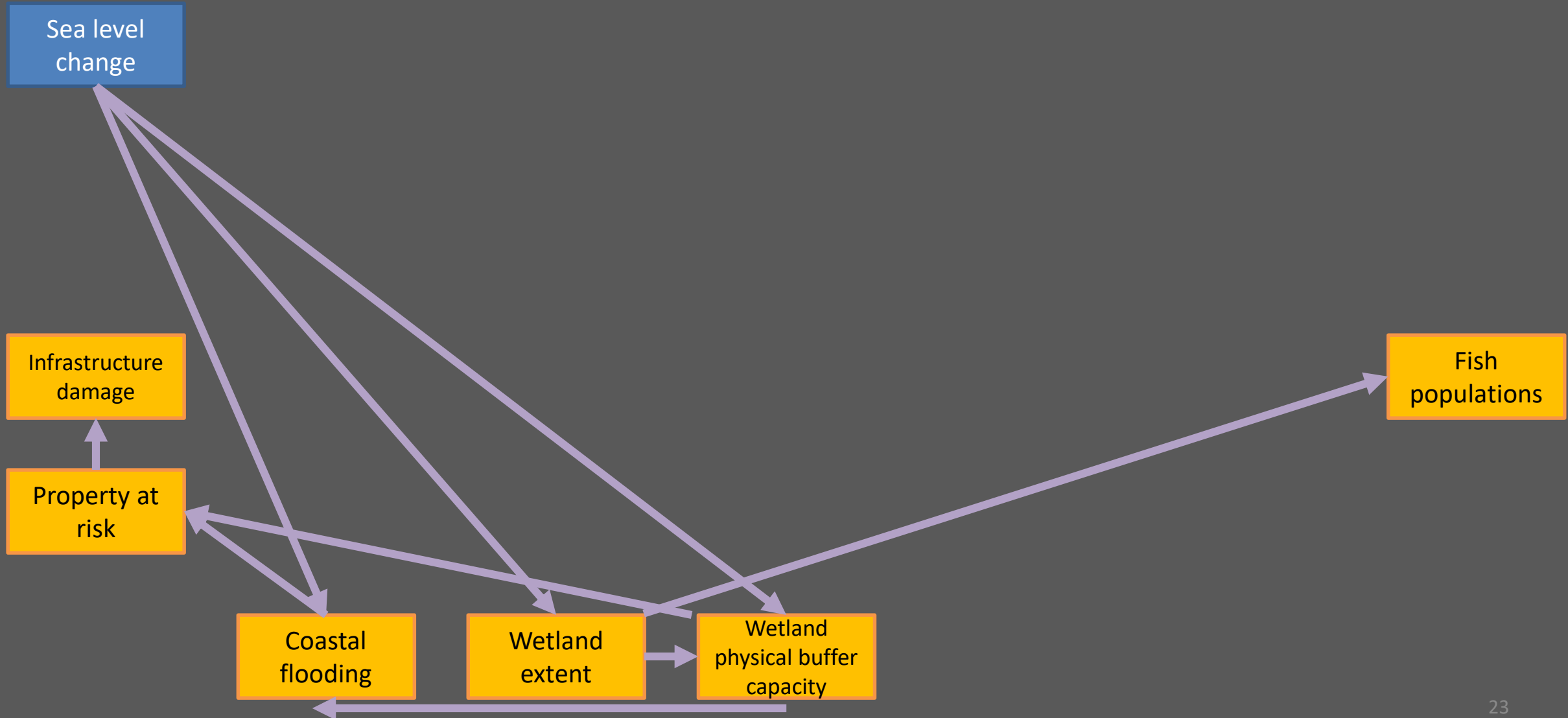
Stressors and Impacts, With Resilience/Responses Added



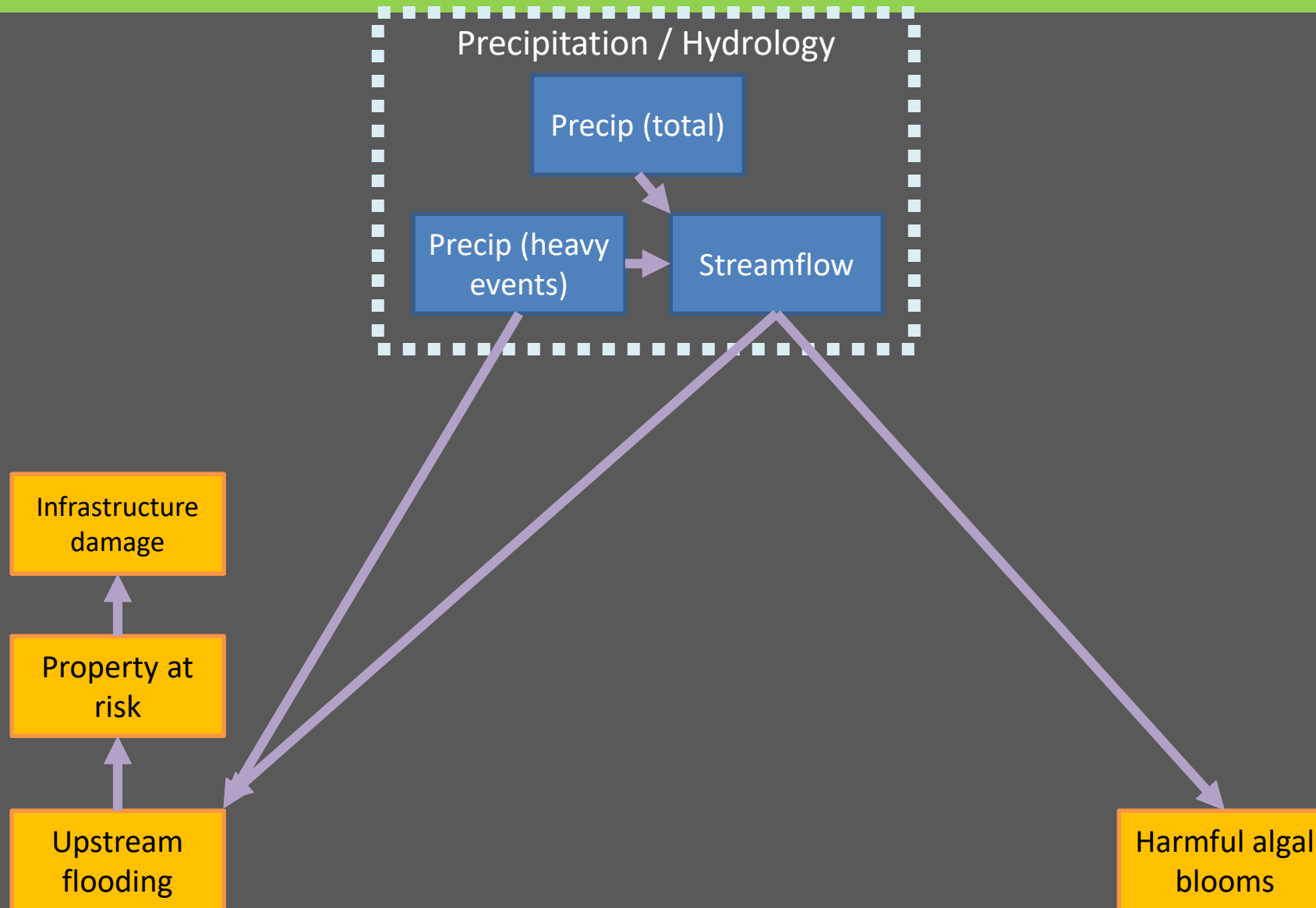
Connections Between Stressors and Impacts



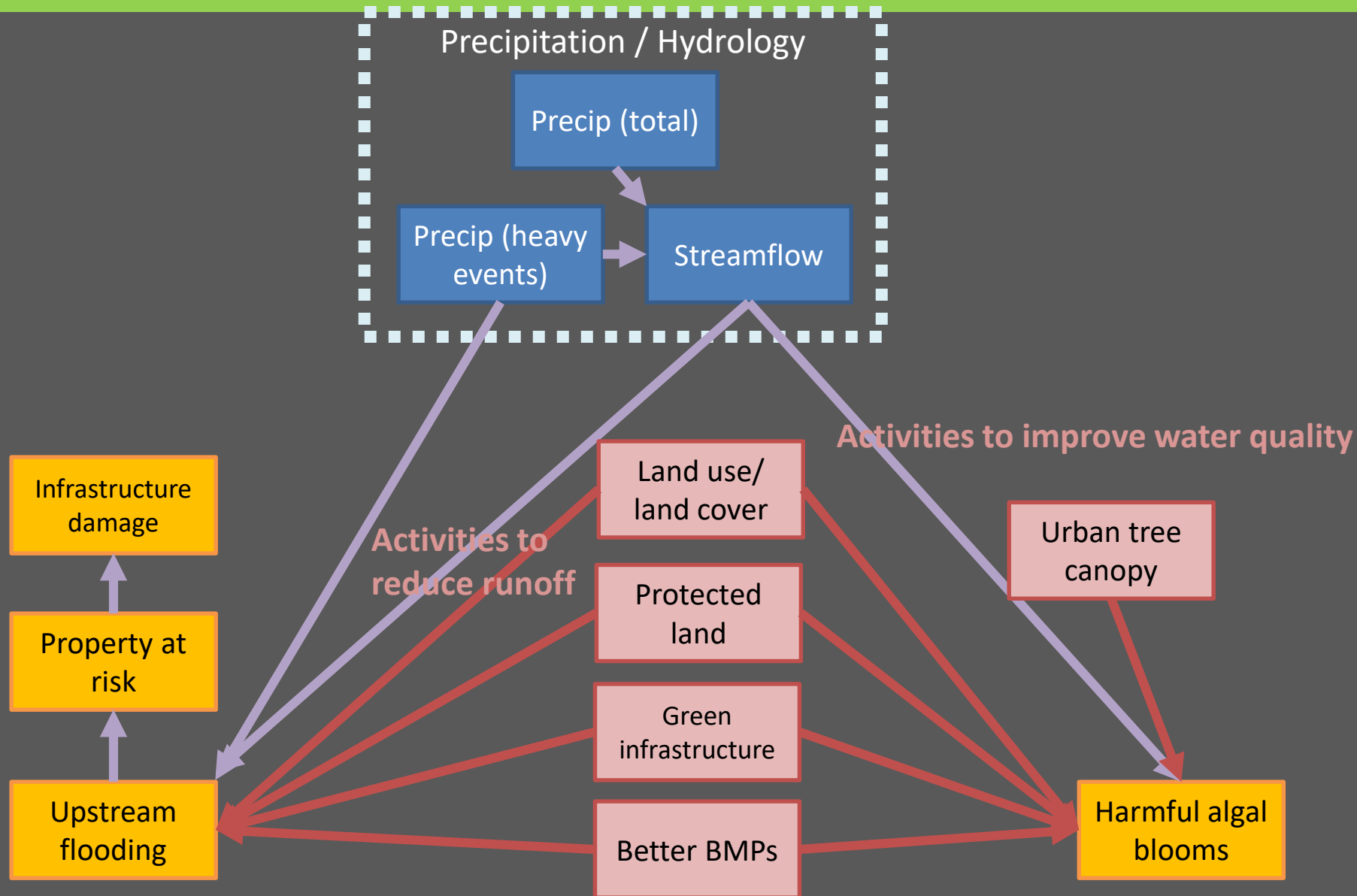
Strong Storylines: Sea Level/Wetlands/Coastal Flooding



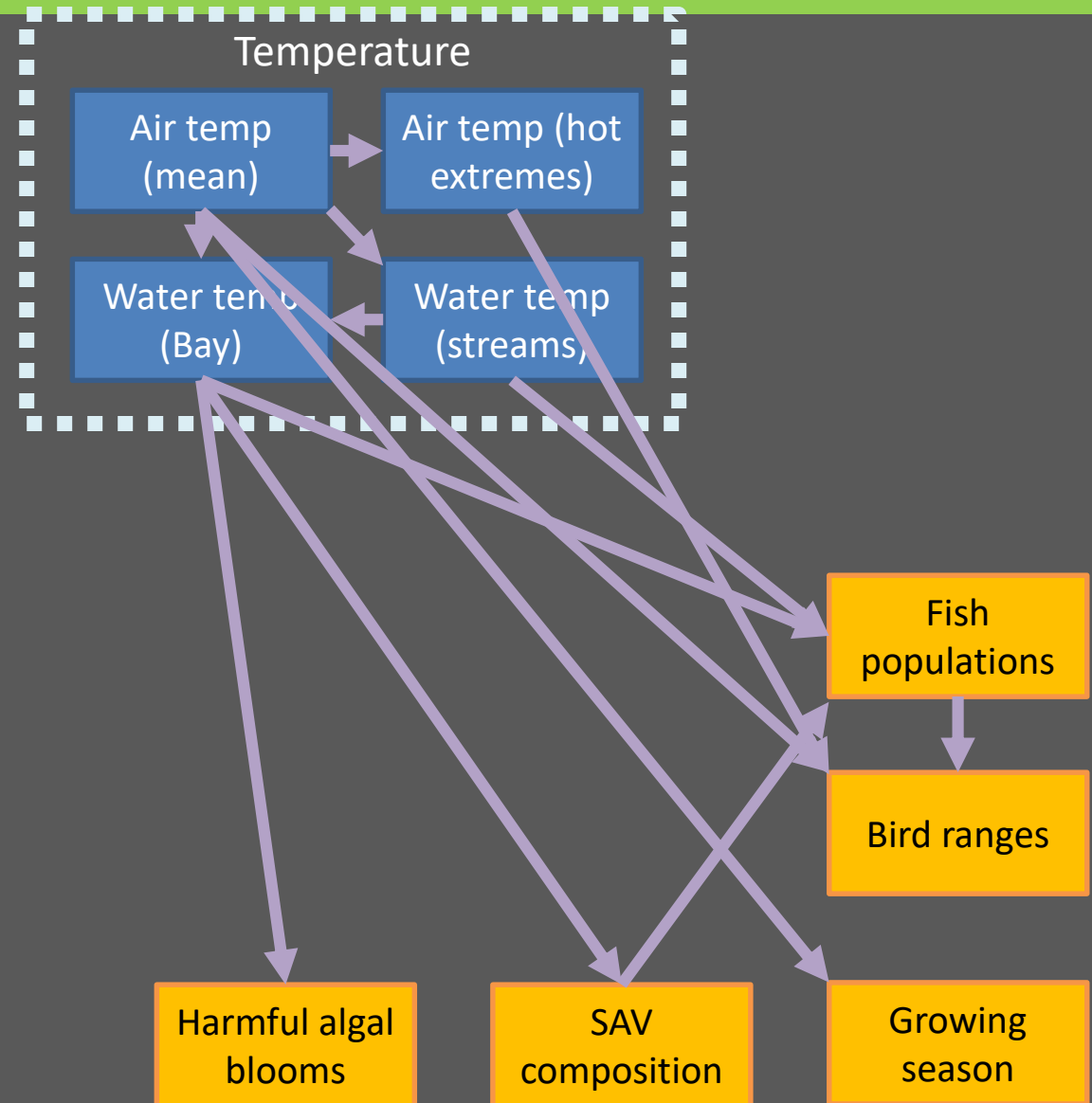
Strong Storylines: Precipitation and Streamflow Effects



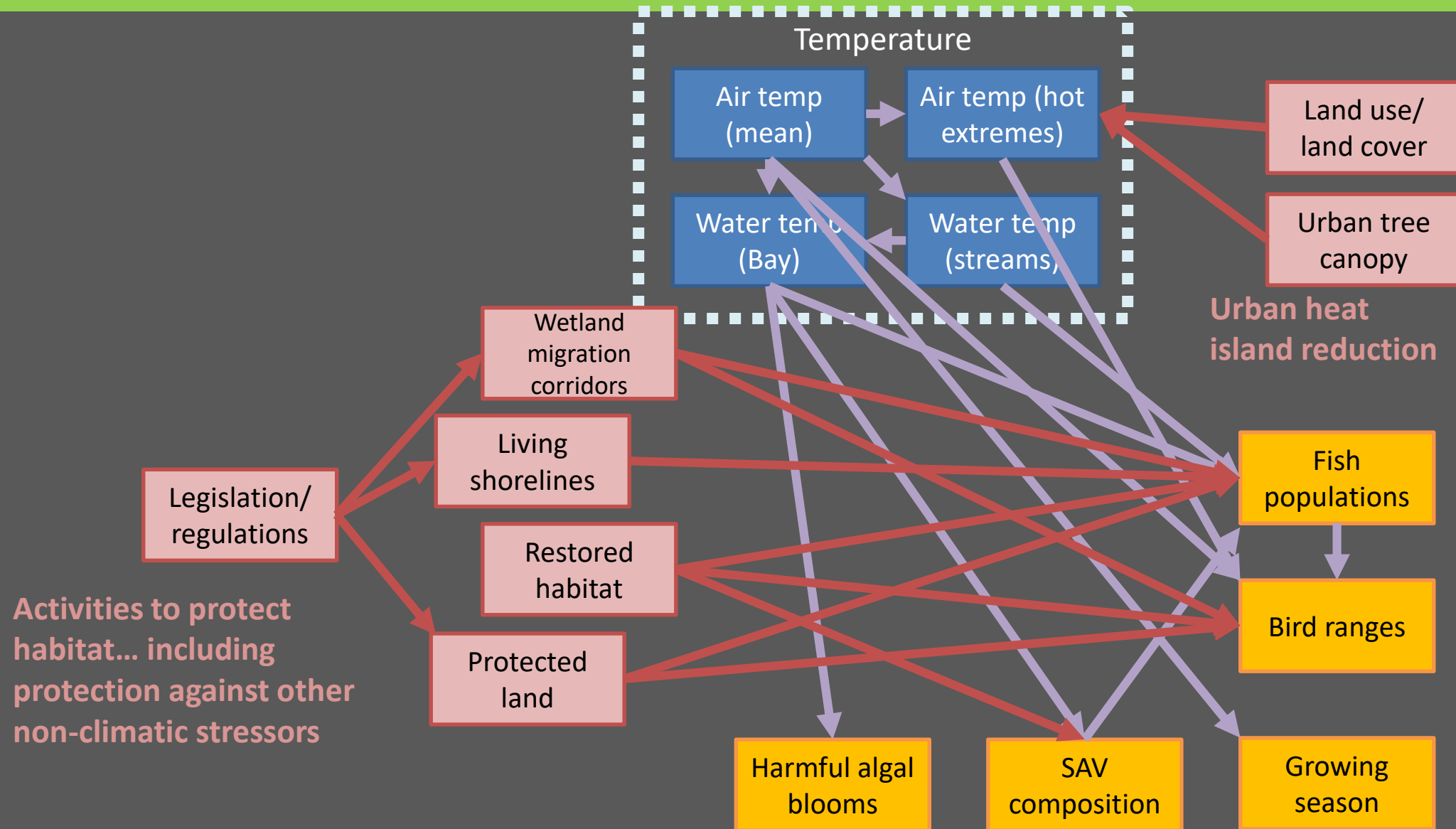
Resilience/Response to Precipitation and Streamflow Effects



Strong Storylines: Temperature Effects



Resilience/Response to Temperature Effects



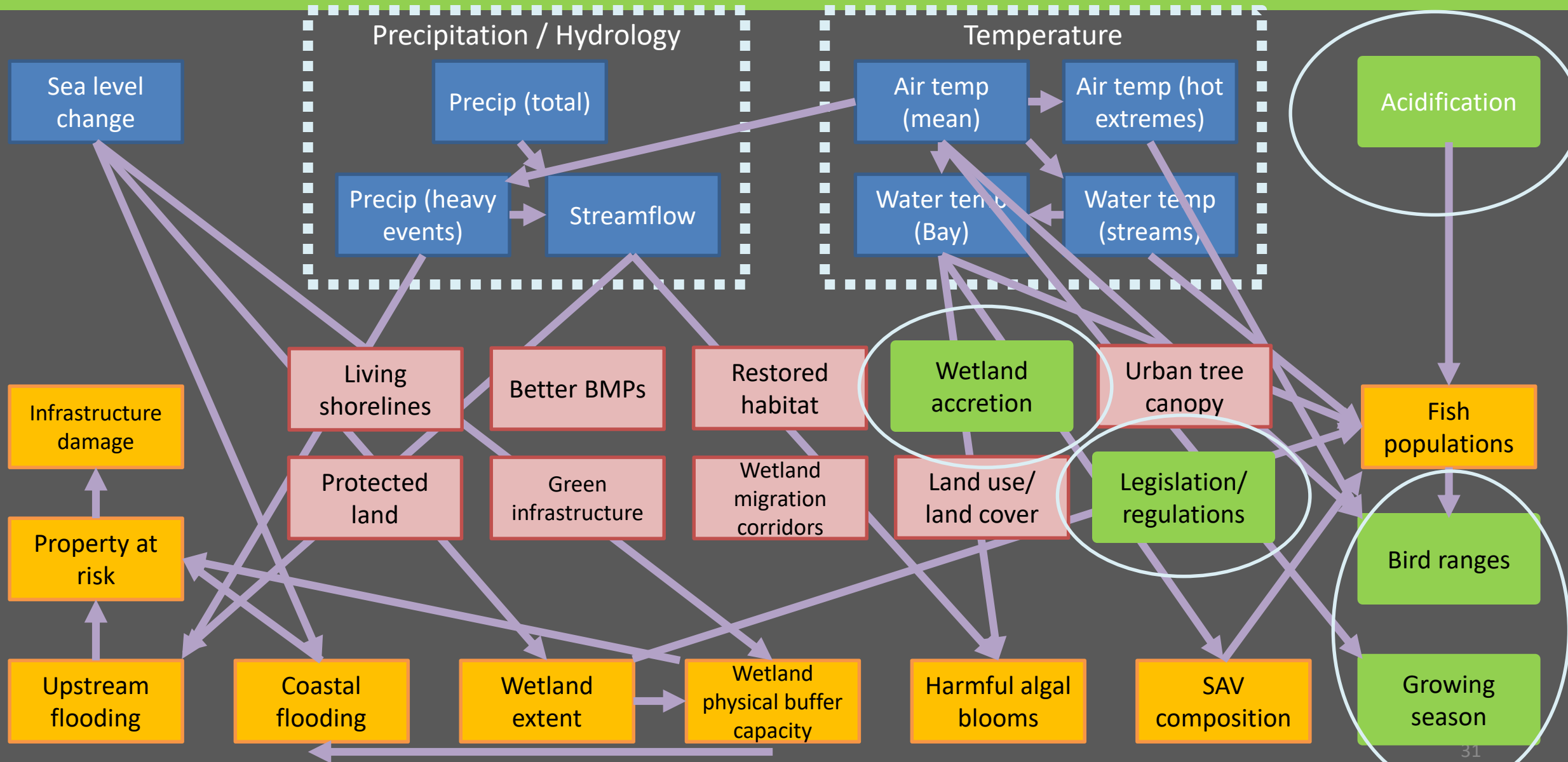
Good News: Storylines Provide Diversity and Balance

- Sea level/wetlands/coastal flooding
 - Ecological and societal impacts
 - Effects are tidal/within the Bay
- Precipitation and streamflow effects
 - Mostly societal effects in this indicator suite, but HABs relate to ecological effects of poor water quality
 - Mostly upstream/watershed-level effects
- Temperature effects
 - Mostly ecological impacts in this indicator suite, except for (implied) human health impact of urban heat islands
 - Tidal/Bay and upstream/watershed-level effects

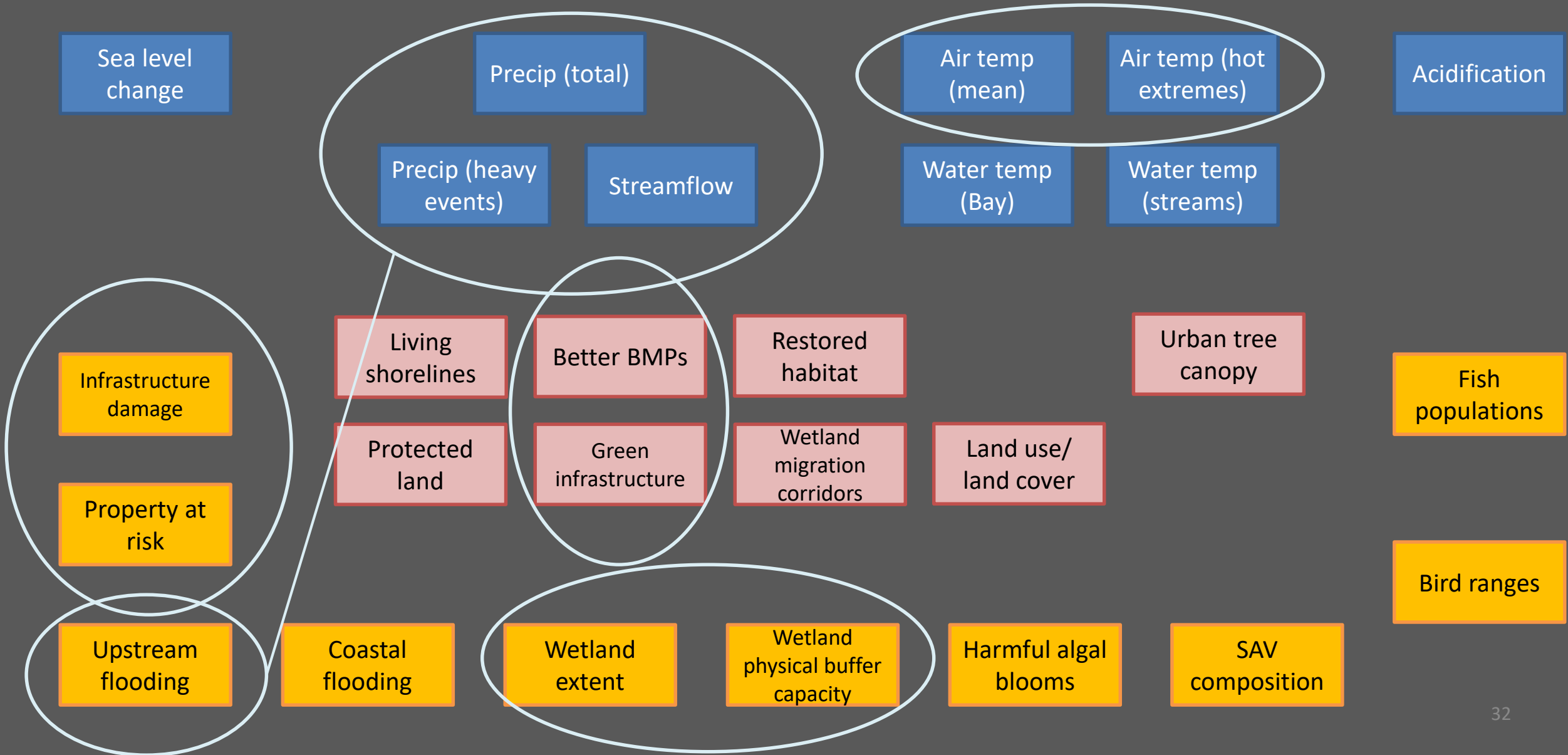
How to Get a Stronger, More Focused Suite

- Eliminate the least relevant topics
 - Those with the fewest connections
 - Those that we are least able to address programmatically
 - Those that we are least able to measure
- Eliminate or combine duplicate topics
 - Could one indicator be a proxy for another?
 - Can have an indicator with multiple metrics

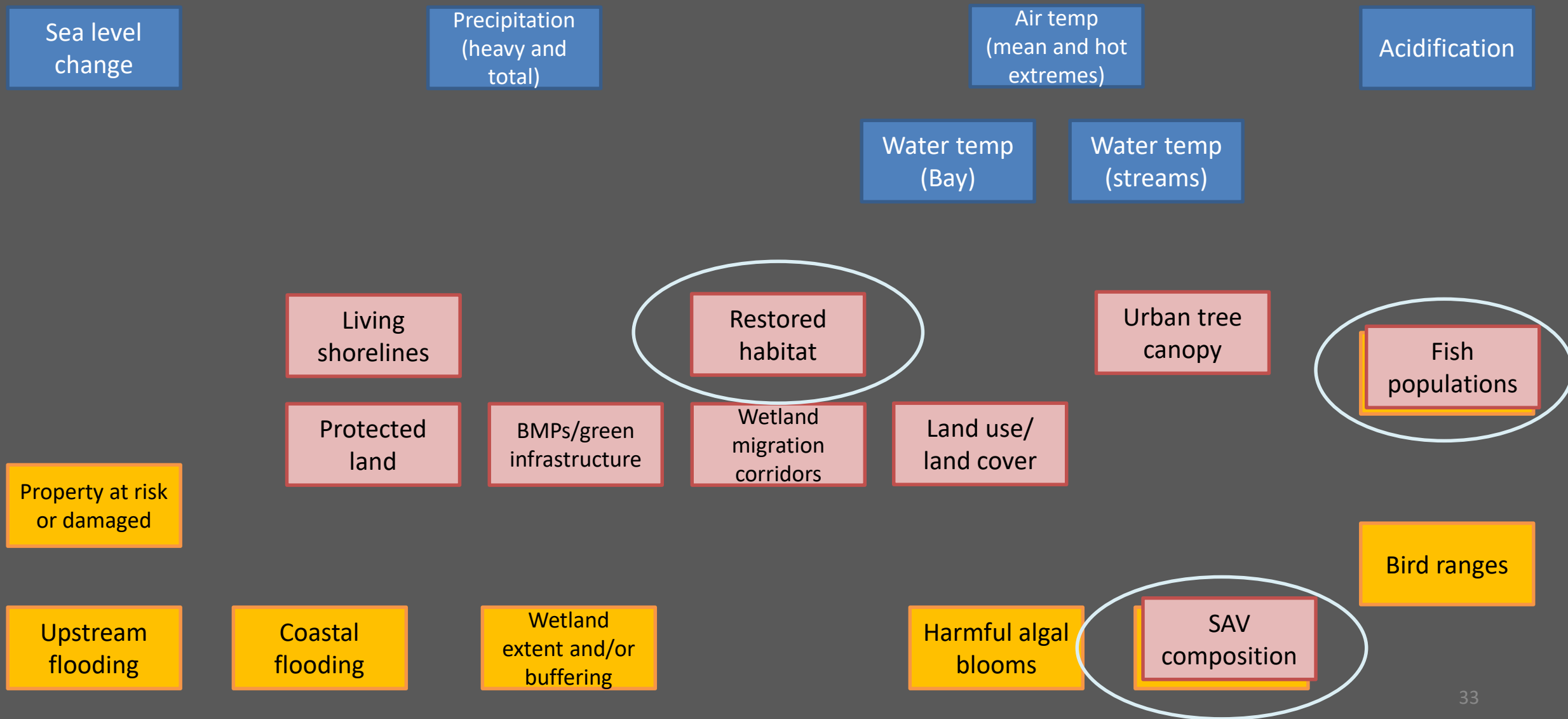
Weakest or Least Connected Topics



Possible Duplicates or Proxies



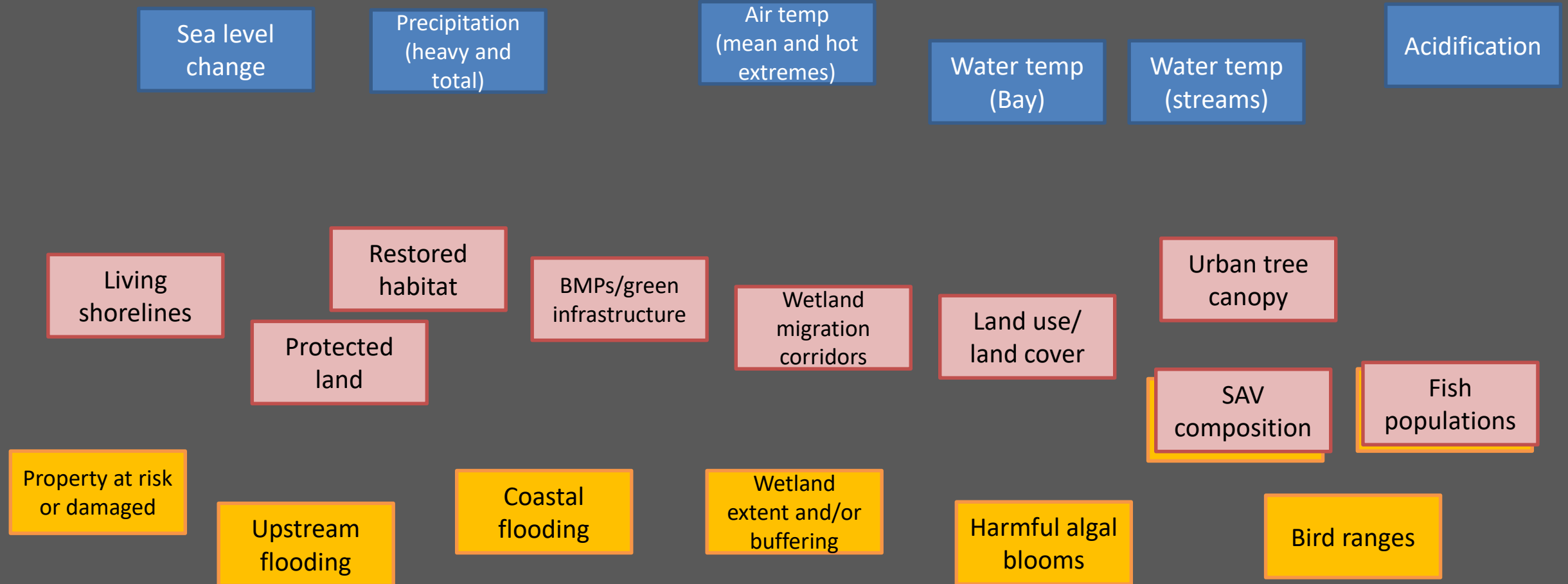
Suggestions to Reduce Further?



Revisit the Criteria: How Did We Do?

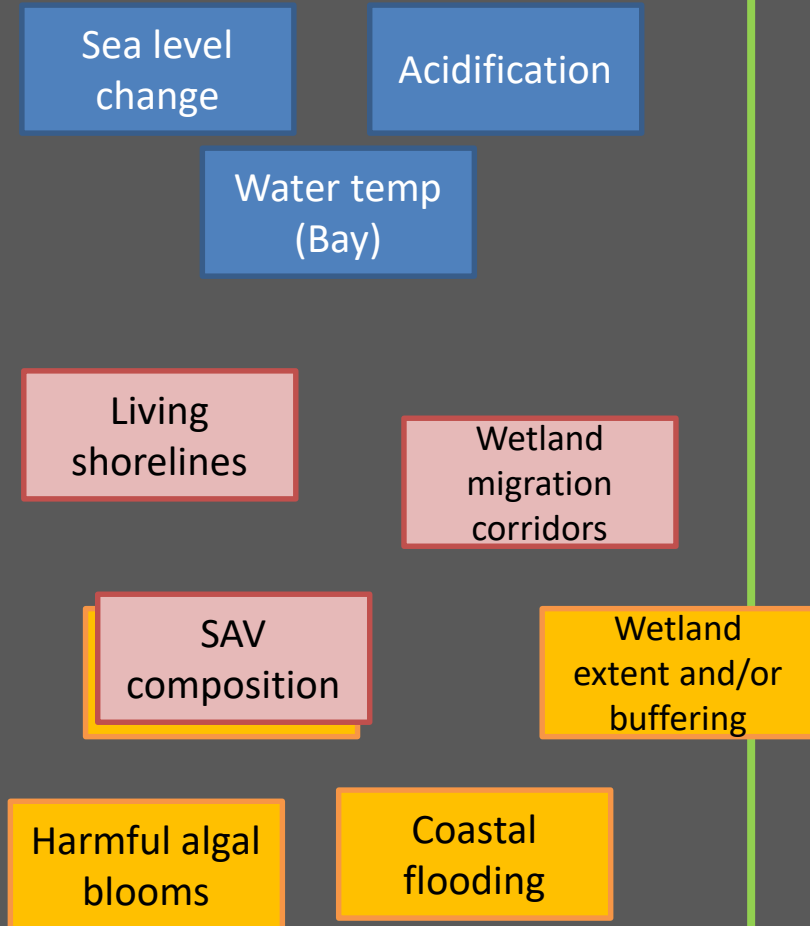
1. **Balance across bins**
2. **Balance of tidal and nontidal/watershed-wide**
3. **Balance of ecological and societal/human concerns**
4. **Balance between breadth (diversity) and depth (connections or “threads”)**
5. **Topics that scored highly on all “value-added” criteria and have high communication value** (possible tiebreaker)

1. Balance Across Bins

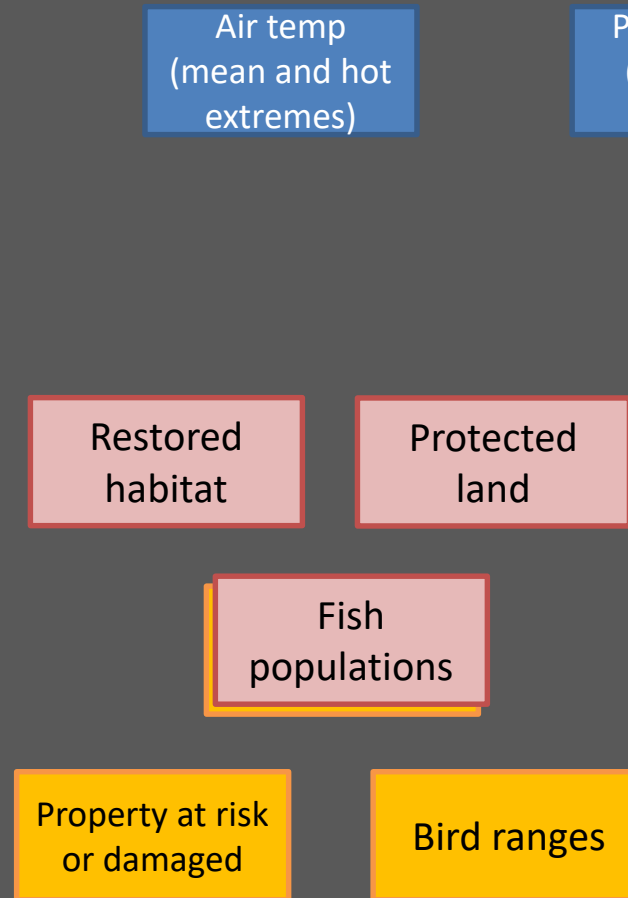


2. Balance of Tidal and Nontidal

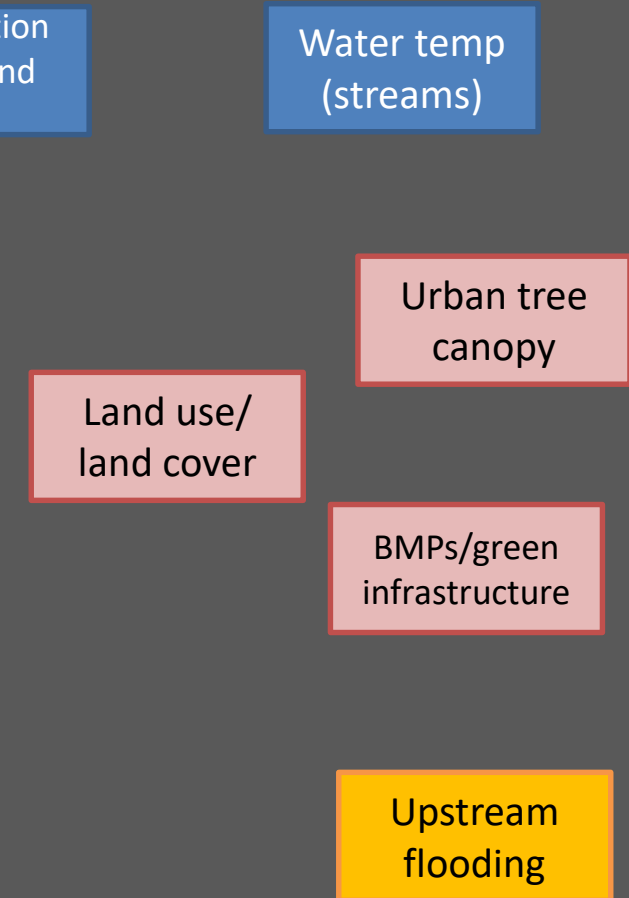
Mainly tidal / Bay



Mix of tidal/nontidal

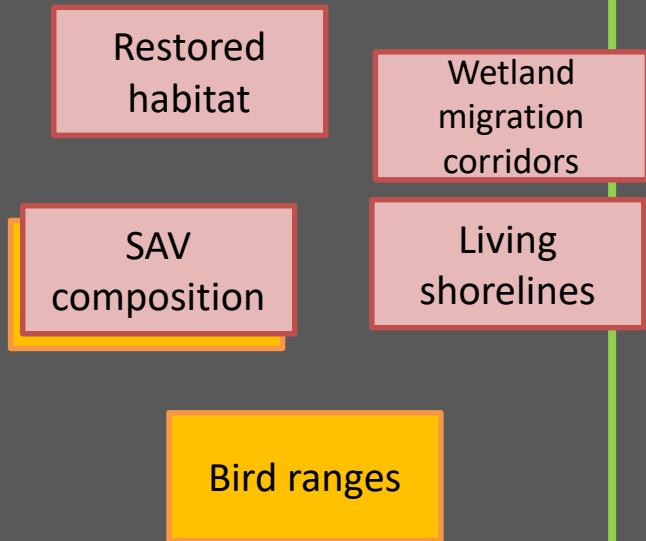


Mainly nontidal/upstream

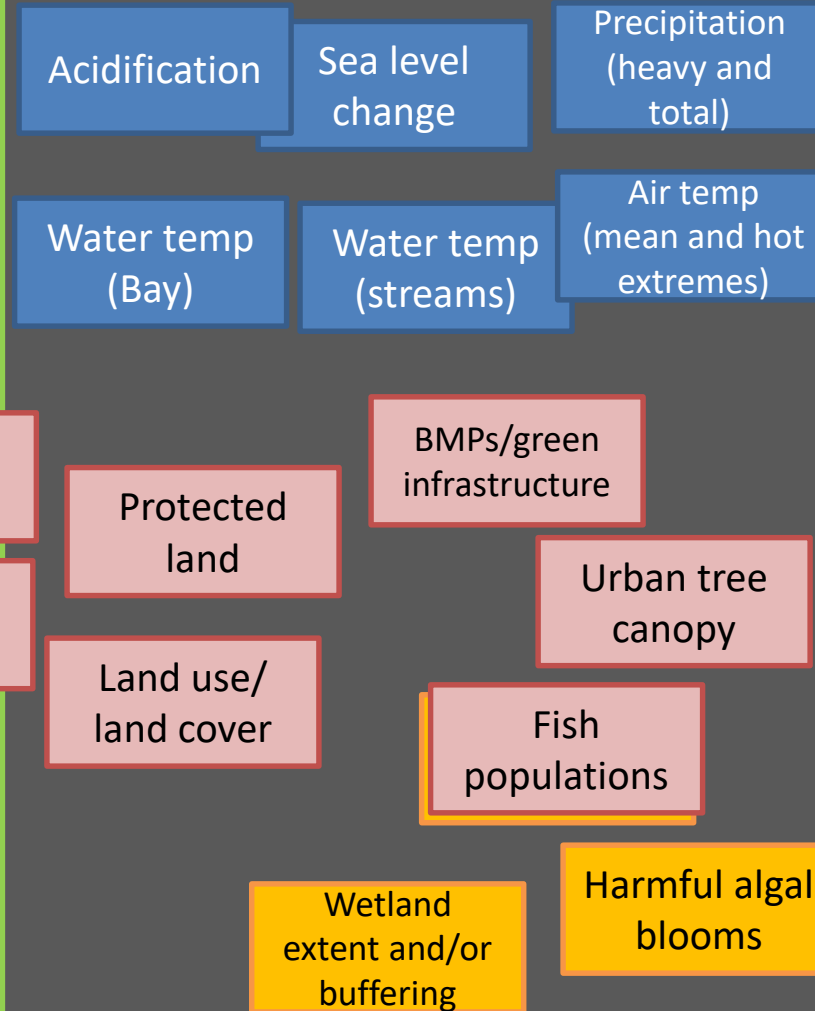


3. Balance of Ecological and Societal

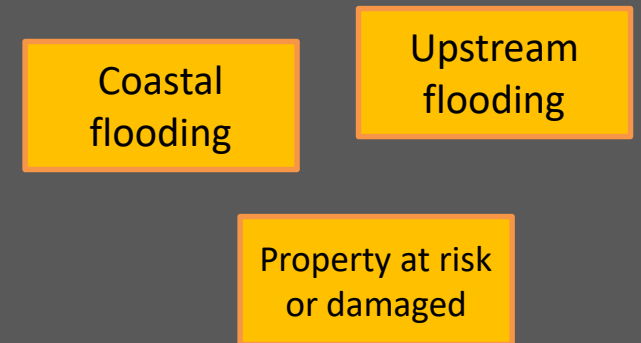
Mainly ecological



Mix of ecological/societal



Mainly societal



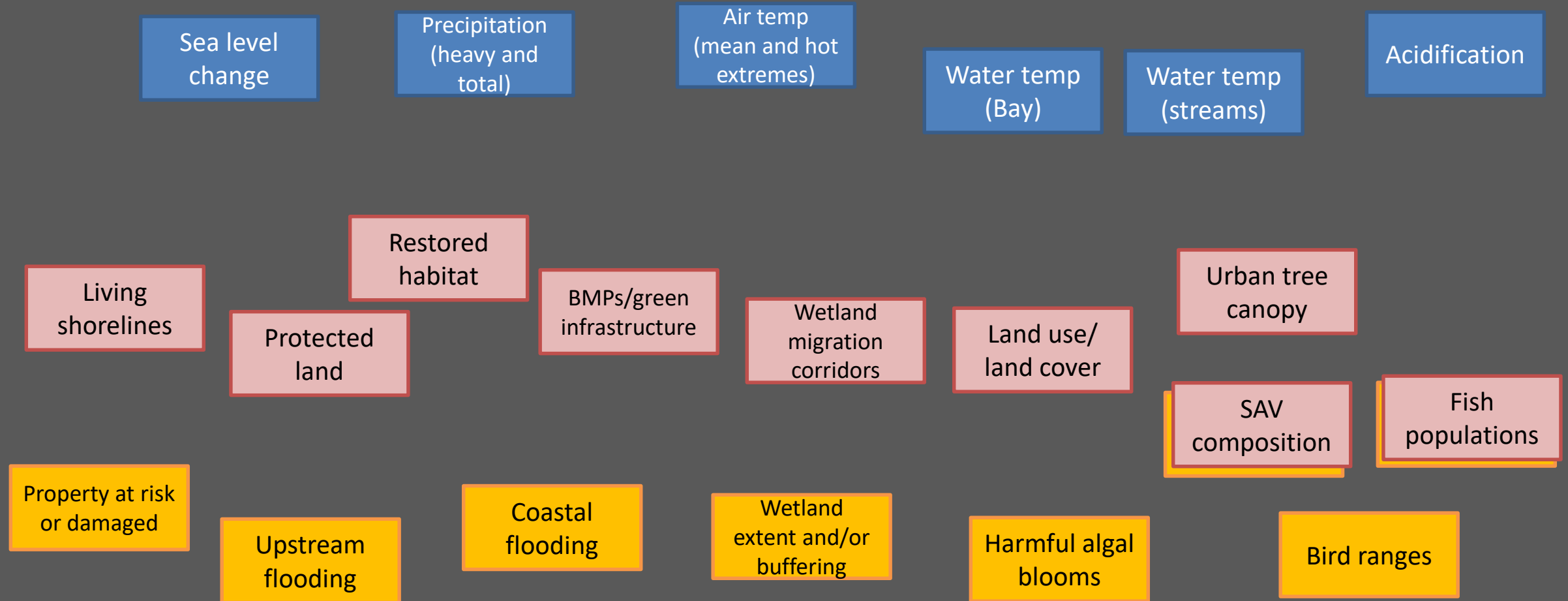
4. Balance Between Breadth and Depth

- We cover the four major climate stressors
 - Temperature, precipitation, sea level, and acidification
- We reduced duplication
- We have three major storylines with causal connections
 - Sea level/wetlands/coastal flooding
 - Precipitation and streamflow effects
 - Temperature effects
- We have indicators that relate to other (implied) storylines
 - Example: extreme air temperatures and human health

5. High-Scoring, High-Communication-Value Topics

- Only 4 of 21 had low scores on any criteria
- Connections to several other Chesapeake goals and outcomes:
 - Water quality
 - Healthy watersheds
 - Vital habitat
 - Sustainable fisheries
 - Land conservation
- Compelling stories to communicate
- In short, there's a lot of potential!

Feedback on the Suite?



Next Steps

1. Compile feedback from today's conversation
2. Refine suite and develop summary report with documentation for the steps we've completed
3. Apply desirable data criteria to identify best data source(s) and metric(s) for each topic
 - a. Coordinate with other workgroups on their areas of expertise
 - b. Identify where it's best to link to an existing indicator
4. Develop implementation plan
5. Proceed with targeted indicator development, etc.



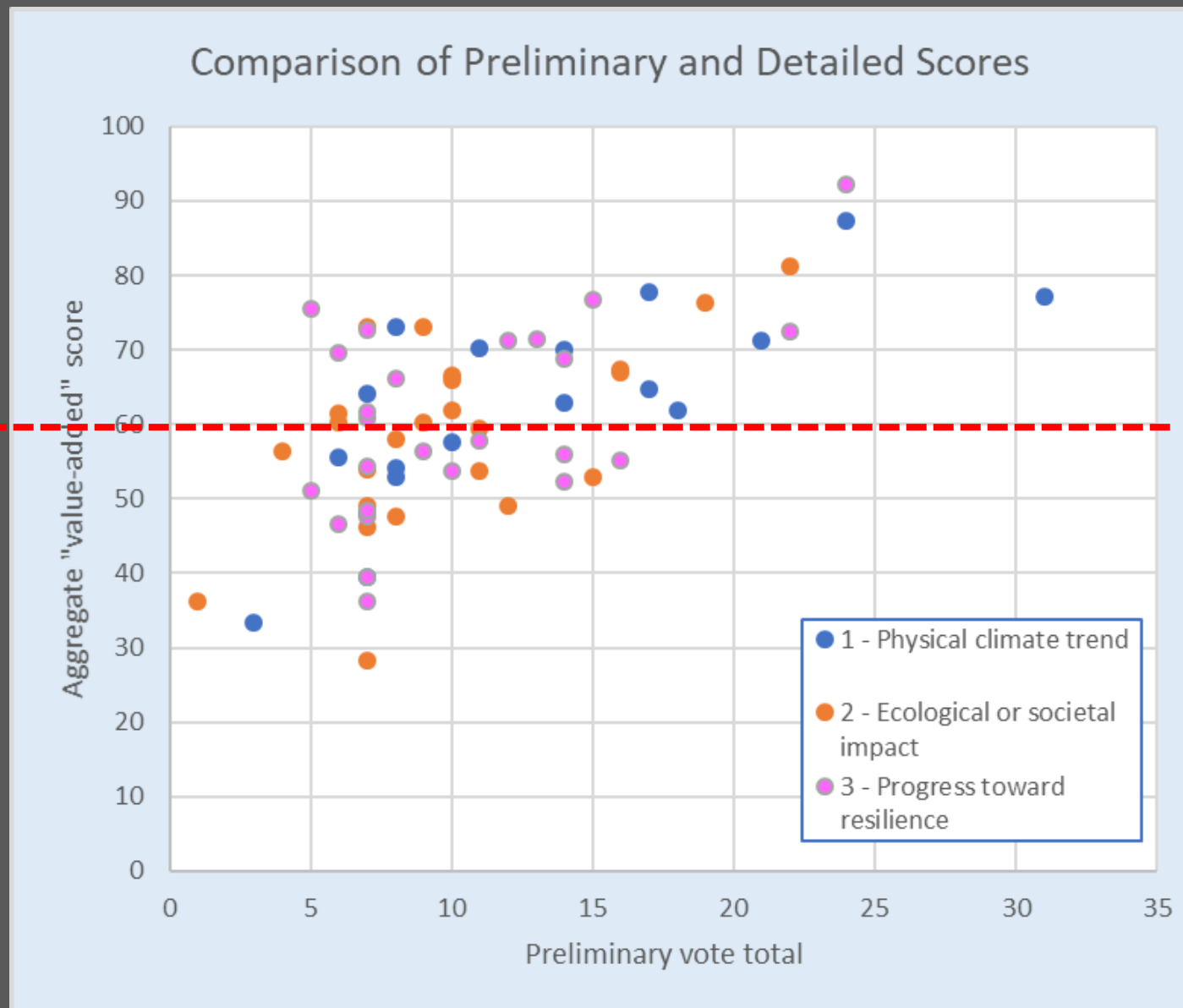
Thank you!

Aggregation of Scores

- Primary approach:
 - Convert individual scores to numbers (0,1,2 – expanded to 0,50,100)
 - Unweighted average of all six criteria, for now
 - Unweighted average of all contributors, for now
- Alternatives considered:
 - Use “climate relevance” as an exclusion criterion
 - More sophisticated weighting
- How would these alternatives affect results?

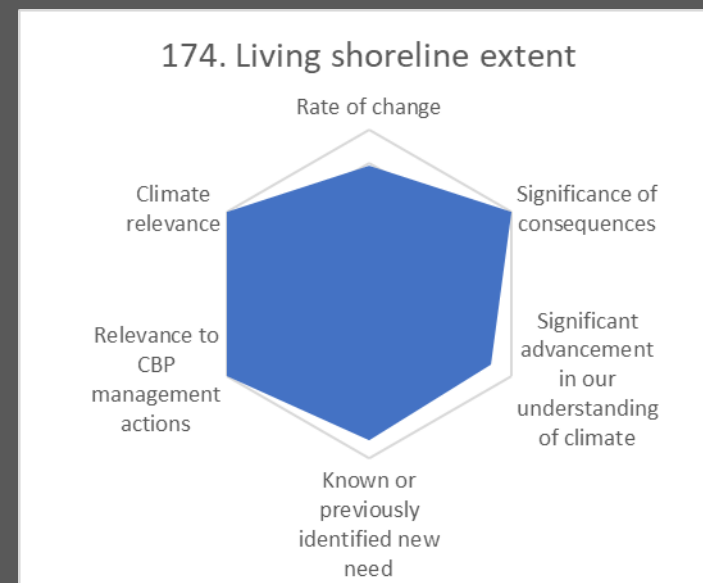
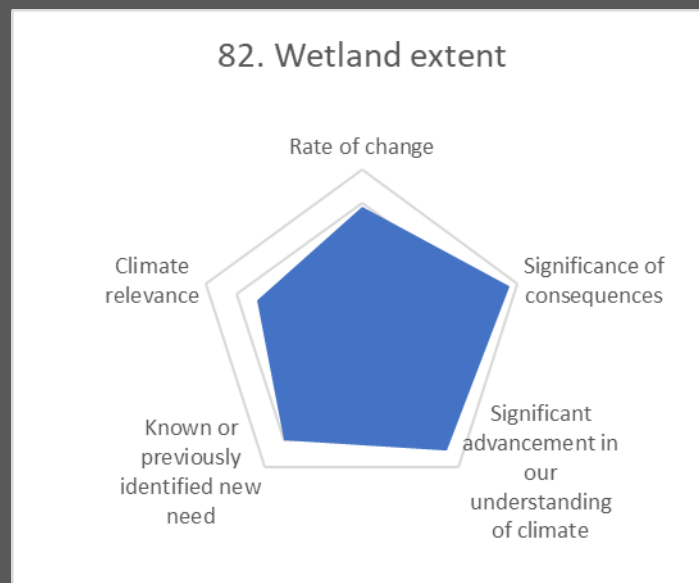
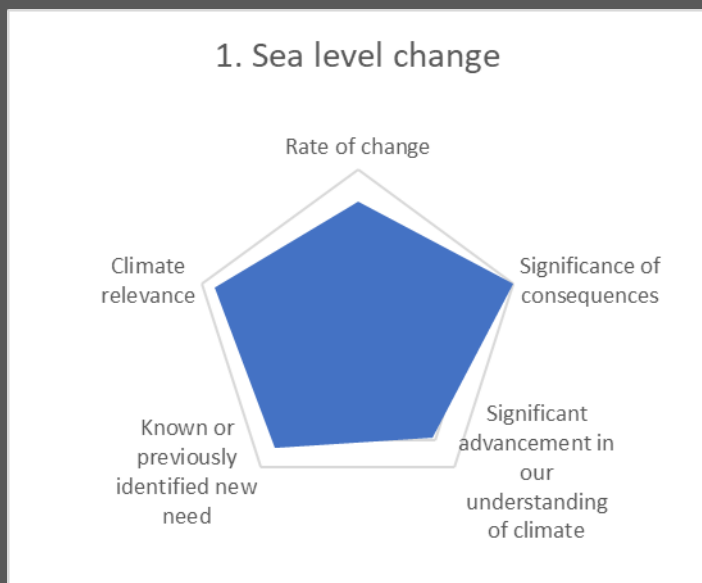
Initial Assessment of Results

- Do the results reflect what we'd expect?
 - Comparison with our original gut-level votes
 - Reactions to the leading vote-getters in each bin?



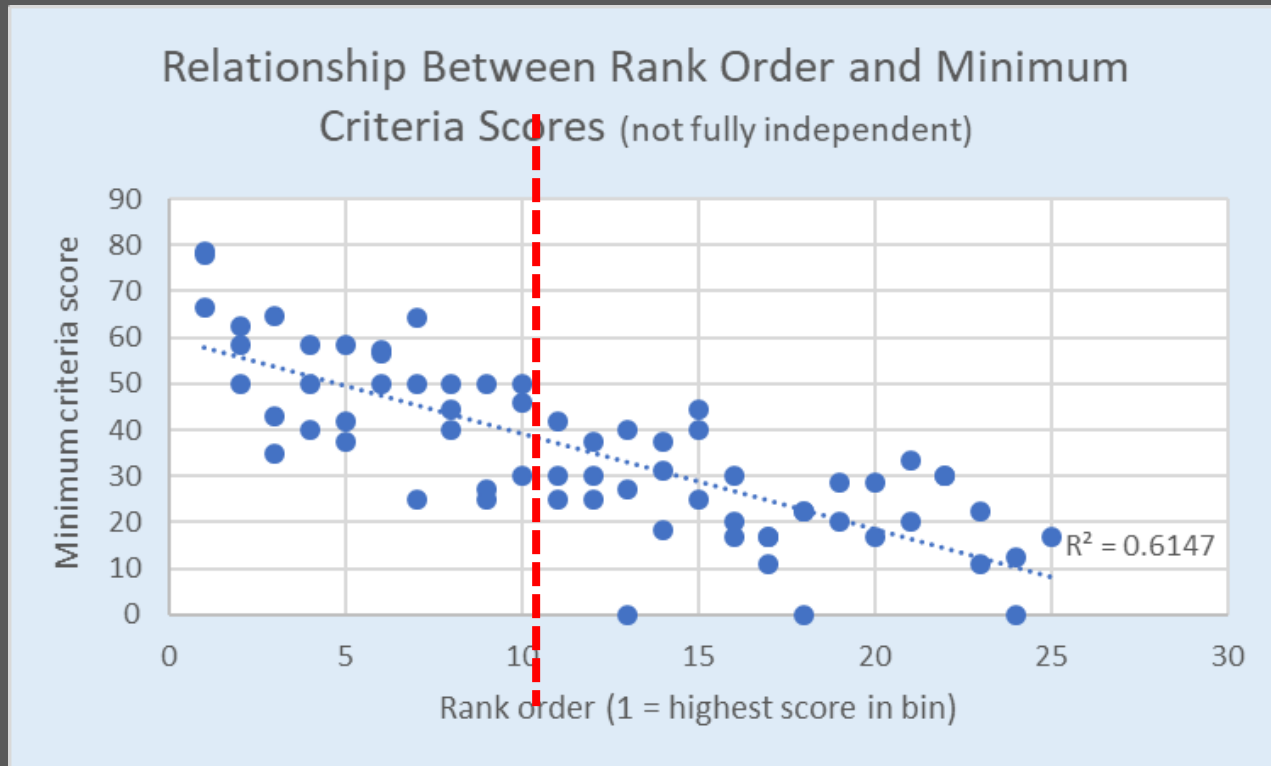
Initial Assessment of Results

- Did our process reward well-rounded indicators?
 - Top scorers in each bin:



Initial Assessment of Results

- Did our process reward well-rounded indicators?
 - How many winners scored poorly in any areas?



Is this good or bad, or does it really matter?