Chesapeake Bay Program
Science. Restoration. Partnership.

STREAM HEALTH WORKGROUP APRIL 2025 MEETING

Friday, April 18, 2025, from 10:00 AM - 12:00 PM ET

Click here to join the meeting

Meeting ID: 239 163 249 666; **Passcode:** js3KF2F3;
or **call in (audio only)** 202-991-0477; **Phone conference ID:** 710 147 031#

Link to Meeting Materials

Table of Contents:

ATTENDEES:

- Rosemary Fanelli, USGS
- Melissa Harrison, PA DEP
- Alison Santoro, MD DNR/SHWG Co-chair
- Kelly Maloney, USGS
- Greg Noe, USGS and STAC
- Scott Stranko, Maryland DNR
- Leila Duman, Maryland MB Member
- Emily Young, ICPRB
- Mark Southerland, Tetra Tech
- Denise Clearwater, MD Dept. of the Environment
- Claire Buchanan, ICPRB
- Sandy Davis, U.S. Fish and Wildlife Service
- Joe Berg, Biohabitats
- Gina Hunt, Habitat GIT Chair
- Derrick McDonald, Pa DCNR Bureau of Forestry
- Melinda Daniels - Stroud Water Research Center
- Louise Finger, VA DWR
- Rory Coffey, Tetra Tech
- Kristin Saunders, UMCES
- Jennifer Palmore, VA DEQ
- Arianna Johns VA DEQ
- Cassie Davis, NYS DEC
- Sadie Drescher, Chesapeake Bay Trust
- Scott Heidel, PA DEP
- Katheryn Barnhart, R3 EPA Water Division
- Anne Hairston-Strang, MD DNR Forest Service
- Labeeb Ahmed, USGS CBPO
- Everald A McDonald, PA DEP
- Elizabeth Mckercher, VA DEQ
- Anna Killius, CBC
- Jessica Shippen, TJSWCD
- Anne Coates
- Peter Claggett
- Garrett Stewar, DC DOEE
- Angel Valdez, MDE
- Brock Reggi, VA DEQ
- Nancy Roth, Tetra Tech
- Marilyn Yang, CRC
- Kara Kemmerer, MDE
- Martha McCauley, EAEST
- Bonnie Bick, Mattawoman Watershed Society
- Sarah McDonald, USGS
- Chris Ruck, Fairfax County
- Keith Bollt, EPA
- Chris Spaur, USACE
- Sara Weglein, MD DNR/SHWG co-chair
- Nick Staten, CRC/SHWG Staffer

10:00 WELCOME, ROLL CALL, & ANNOUNCEMENTS (10 minutes)

Speakers: Alison Santoro and Sara Weglein

Announcements will include updates on:

Upcoming Meetings:

- The Habitat Goal Implementation Team Spring Meeting will be on **April 29th 10 AM - ~12:00 PM** and will be **fully virtual**
- The Next Stream Health Workgroup Meeting will be on **Friday, June 20, 2025 from 10:00am - 12:00pm**
    - Mark Southerland will provide an update on the GIT Funding project:

2024 GIT Funding: *Phase 3B – Data Review and Development of Multi-Metric Stream Health Indicators – Physicochemical Metric Analysis*

- *Project team has a draft QAPP and have conducted expert interviews*

10:10 2022 GIT Funding - Presentation of Preliminary Results:

Literature review and meta-analysis of existing stream ecosystem metrics known to be affected by climate change and stream restoration practices **(15 minutes)**

Speaker: Melinda Daniels

Slides: See Appendix I: Slides - 2022 GIT Funding - Presentation of Preliminary Results - Melinda Daniels

We searched the scientific literature for restoration studies reporting metrics relevant to climate change mitigation. The goal of our project is to provide guidance to support integration of climate mitigation/adaptation strategies into current stream restoration maintenance/upgrades and future stream restoration regulation, siting, design, and/or construction practices. Our review collates the extant knowledge of restoration effects on climate-relevant stream ecosystem metrics and attempts to rank the relative effectiveness of specific practices.

Inquiry process example:

1. Search Stream Restoration + Climate Change: **Many thousands of results**
2. Added modifiers such as including the word “wood”: **~2000 results**
3. Hours of screening studies: **16 results that were promising**

4. Applying all criteria of this study which was documenting or monitoring a stream restoration project involving wood where metrics relevant to climate change were actually measured: **2 studies applied to those criteria**

Inquiry Process generally:

1. Broad Search in Scopus/WoS/Google Scholar ->
2. Non climate resiliency projects excluded ->
3. Records screened in depth ->
4. Records downloaded and data is extracted into categories:
    a. Reviews
    b. Empirical
    c. Modeling

Preliminary Findings:

1. Very little literature contains quantifiable measures of restoration effectiveness with regard to climate resiliency metrics.
2. 80 papers were identified that focused on river restoration and increased climate resiliency
    a. Note:
    Almost half of those studies were reviews that are very useful for guiding policy and presenting potential solutions, but do not highlight the effectiveness of restoration strategies that have been implemented

    This study had no geographic limitation, only a handful of papers focused on the Chesapeake Bay Watershed.

Results: Empirical

- A ranking system was developed to evaluate the actions that were the most effective.
- The categories that scored the highest, that is the ones that improved conditions the most, were “beaver dam analog” installations, and multiple approach projects (ex. NCD, wood, riparian vegetation).
    - Note:
    Beaver dam analog projects may vary from project to project, and
    multi approach projects could have different contents depending on the project.
    Therefore, this ranking should be interpreted with the understanding that uniformity in the literature is limited.

Results: Modeling

- Note:
Modeling literature is dominated by stormwater BMPs which were not addressed in this literature search. This study focuses on river restoration projects, not stormwater restoration projects.
Every model is different and therefore it is unclear if they are really directly comparable.

- Did not create a ranking table because of the lack of uniformity of modeling studies.
- Bulk of modelling literature focused on hydrological metrics of high flow but it is difficult to assess how to compare them since their are all so unique.
- Initial observation: The more project types you implement the higher reductions in high peak flow, analogous to the empirical study multifaceted restoration finding.

Results: Conceptual/reviews

- Not overly relevant to quantitative assessment of restoration effectiveness.

The problem of a limited amount of empirical studies is common throughout the ecosystem services literature as well.

Additionally, in terms of empirical studies we only found one study that measured hydrologic metrics, peak flood reduction for example. The rest were focused on temperature and channel stability. There is a need for more empirical studies of hydrologic response to restoration.

Of note there has been a notable increase in publications in this area over the last several years as most of the empirical literature found for this study was from the last five to six years.

Preliminary conclusion: There is not a sufficient sample size to develop a meaningful rating for restoration techniques.

Joe Berg (Chat): How is floodplain reconnection defined? Many NCD projects really never accomplish floodplain reconnection on a meaningful frequency (e.g., multiple times per year rather than once every 1.5 years.

- Melinda Daniels: We defined it as a piece of literature that actually measured it. The studies of natural channel design, floodplain reconnection had data of the frequency of inundation of the floodplain surface from before and after the project was installed, and the stream hydrology data to go with that to compare the flow regime prior to the project to following the project. So that there was actually a, you know, a confident hydrologic assessment that yes, in fact, floodplain inundation had changed post project.

Denise Clearwater: When you looked through literature did you specify climate or just the key words of metrics of climate change

- Melinda Daniels: We started with both and it returned a very low number of papers, then we did just key metrics without mentioning climate, but still did not get more papers.

Denise Clearwater: Is there useful information in “segregate studies” such as impoundment studies on temperature?

- Melinda: Definitely, if you look at beaver dams there is a lot of studies on their benefits on stream temperatures regimes.

Joe Berg: Art Parola and his students did a study for CBT looking at floodplain restoration projections, 2D modeling to predict if restored floodplains will be stable with increased storm water with climate change. The thing they found was that floodplain reconnection projects were the resilient projects to climate change projections, the bigger the floodplain the more resilient.

- Sadie Drescher (Chat): Art's last summary on the work Joe just mentioned from Pooled Monitoring research is at: https://cbtrust.org/wp-content/uploads/2_Parola_ULRF_Pooled_Monitoring_Forum_230626_Final.pdf (the final report is under review and will be posted on our website in the next few weeks)

Chris Spaur: Is it worth having a chart on the side describing the terms we are using. ex. natural channel design; stream restoration is mainly based in geomorphology which can mean something very different that ecological restoration.

Rosemary Fanelli: About the empirical studies: at the end of rolling through those papers did you have an idea of an ideal study to standardize around? What would be your ideal number of years pre and post, what controls? Was there a specific study that struck you as a model paper?

- Melinda: I am drafting a paper on this very topic. There needs to be a uniform study design for monitoring projects. To me 3-5 year pre-project and 3-5 year post project would be satisfactory. There also needs to be multimetric assessments, abiotic in addition to biotic metrics are so important. Temperature is cheap and easy to measure and should be standard. If there is any sort of construction there should be pre-project and post project data whether that is the geomorphology, survey of the project, or even just repeat photography/aerial photography to understand how the system has been effected after installation.

Alison Santoro: What is the timeline for the final project

- Sadie Drescher: Early July

Other comments from the chat:

Alison Santoro: This is really important to have - identify what we don't know and guide new research projects.

- Kristin Saunders replying to Alison Santoro: Let's make sure to put the research needs into the strategic science and research framework database STAR manages!

Rosemary Fanelli: Do you have a sense of the ideal study design that could be adopted to fill that monitoring need?

Joe Berg: good point, very challenging!

Claire Buchanan: Thank you, Melinda! Great review

Sadie Drescher: Great presentation and thanks, Melinda (and Alison).

Louise Finger: Many variables are much more long-term (thinking size of planted trees being sufficient to shade the stream and reduce temperature). Very challenging to monitor at that time scale!

10:25 Draft Outcome and Output Language (1 Hour 35 Minutes)

Speakers: Alison Santoro and Sara Weglein

- **Summary of Concerns and Survey Responses - 15 min**
- **Updating Outcome Language and adding Outputs - 80 min**
  - **Decide** on high level language and measurable targets
  - Discuss how to incorporate Health Watershed's work as an output(s)

Continually improve and protect stream health and ecological integrity throughout the watershed based on sound science, coupled with land management, planning, and protection. (High Level Language)

- *Annually improve health and function of at least <X>% of stream miles each year. (Measurable Target)*

See Appendix II: Slides - Draft Outcome and Output Language - Alison Santoro and Sara Weglein

Proposed: Keep "continually improve and protect".

- ***No objection***

Elizabeth Mckercher: If we're going to say protect here it seems redundant to say it again at the end.

Continually improve and protect stream health and ecological integrity throughout the watershed based on sound science, coupled with land management, planning, and protection. (High Level Language)

- *Annually improve health and function of at least <X>% of stream miles each year. (Measurable Target)*

Elizabeth Mckercher: What is the definition of stream health vs ecologically integrity? Uncertain whether stream health and ecological integrity is mutually exclusive or not.

- *Gina Hunt: We need to better define these terms because if we do not know the public won't either.*
- *Claire Buchanan: Stream Health (ecological integrity) would be good then cover your basis*
- *Chris Spar: We want a link to living things when we talk about healthy streams.*
- *Joe Berg: We often get caught up in thinking of stream health as the biological context only, but a stream is so much more than benthic invertebrates and fish. I think ecological integrity is more meaningful that stream health is.*
- *Jennifer Palmore: My view is multipronged. The term stream health I do not love, it is very vague, we are not talking about specific uses of the stream. What are we trying to accomplish? Is it safe for recreation, is it safe for fishing, wildlife? Etc. Are we only focusing on the aquatic life uses? I am not sold on ecological integrity either because it excludes some other uses of streams like fish passage. Stream health is not definable. Opposite of the smart goals we are trying to synthesize.*
- *Denise Clearwater: Biology is the top of the pyramid. I think we should be careful with looking at other metrics because we run the risk of tradeoffs the lower in the pyramid we go.*

Alison Santoro: I see a couple options in the chat:

Claire Buchanan's comment:
"A thought: if the Outcome is still "stream Health Outcome", could the first sentence be "continually improve and protect stream ecological integrity throughout..." and thereby imply that stream health means stream ecological integrity?"

and

Greg Noe's comment:
"..stream health, including their living resources, functions, and ecosystem services for people, ..." ?

Gina do you feel there is a preference to a lot of metrics like Greg's comment or use a more broad term?

- *Gina Hunt: I like what greg put in the chat "..stream health, including their living resources, functions, and ecosystem services for people, ...", but I did hear*

reservations with the stream health term and I don't think ecological integrity fits as well.

Elizabeth Mckercher: This is an outcome that the jurisdictions are going to agree to, I honestly think including their living resources, functions and ecosystems is more outcome oriented than "for the benefit of".
How do those apply as an outcome as I guess is what I'm saying. How do those relate back to what we would do and?

Alison Santoro:
At this point that's kind of how we do things and we are not quite there yet. That is not what we are tasked to do.

Chris Spaur:
I just wanted to say I think an approach on just functions can lead us down the road of doing projects that provide almost no meaningful benefits and that's happened historically, you know initially decades ago. The idea was that, hey, if habitats degraded and you go in there and you somehow fix it with a geomorphology project, you're going to of course see improvement in biotic integrity. That, of course, proved to be completely wrong in many settings. So that would be an example. Another example is a lot of the focus just on the geomorphology side can produce the same end point where you adjust the geomorphology, but really you haven't benefited aquatic life nor people.So I think the functions alone can really lead us down a non benefit road unless it's clarified.

Alison Santoro:
I think that having ecological integrity and living resources in there will mitigate a lot of that concerns and I'm really sorry we do need to move on, so if there are additional concerns please email.

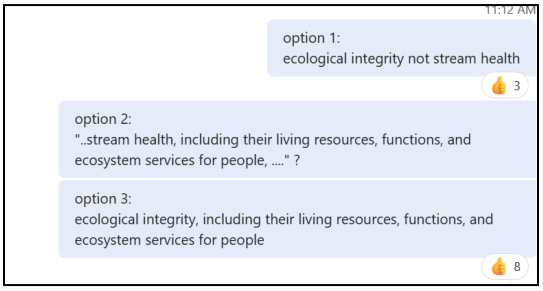

Figure 1. *Voting results for the three main options discussed*

More from Chat:

Brock Reggi: ecological stability?

Chris Spaur: I do NOT like including term "function" without clarifying which functions.

Greg Noe: Outcomes are general, and operational definition and metrics for functions can be included in the outputs/targets??

Joe Berg: Living resources should extend beyond fish and macroinvertebrates, so amphibians, wetland species, FIDS, etc.

Chris Spaur: Concur with living resources and ecological integrity!

Continually improve and protect stream health and ecological integrity throughout the watershed based on sound science, coupled with land management, planning, and protection. (High Level Language)

- *Annually improve health and function of at least <X>% of stream miles each year. (Measurable Target)*

    - *Q: Do we include tidal streams? or just non-tidal streams?*

    - *Alison santoro:*

      We could specify in the high level language:
      ex.
      *Continually improve and protect **non-tidal** stream health and ecological integrity throughout the watershed based on sound science,*

      OR

      We could specify in the targets:
      ex.
      … (High Level Language)
        - *Annually improve health and function of at least <X>% of **non-tidal** stream miles each year. (Measurable Target)*

      Leaning towards option 2.

<u>More from Chat:</u>

Claire Buchanan: There is a benthic macroinvertebrate IBI for tidal streams and all salinities of the Bay.

Joe Berg: I think "throughout the watershed" is fine and speaks to areas upstream of the stream-lets not let perfect get in the way of progress.

Gina Hunt: "protect nontidal stream health..."

Kristin Saunders: If you think there is a change the program may at some point include work beyond non-tidal, I would leave it as throughout the watershed

Keith Bollt: Good point, most people can't define "watershed". That said, I still like watershed

Kristin Saunders: yes, leave yourself room

Continually improve and protect stream health and ecological integrity throughout the watershed *based on sound science, coupled with land management, planning, and protection. (High Level Language)*

- *Annually improve health and function of at least <X>% of stream miles each year. (Measurable Target)*
    - *Q: should we leave in "sound science" since that is subjective?*
    - *Anne Hairston-Strang: Leave it, we can all agree we want to use sound science*
    - ***Decision: Put a pin in sound science for now***

More from Chat:

- *Rosemary Fanelli: latest science?*
- *Claire Buchanan: "...using science-based land management, planning and protection."?*
- *Joe Berg: agree, with sound science*
- *Sandra Davis: I liked the sound science addition - last chat*

Continually improve and protect stream health and ecological integrity throughout the watershed *based on sound science, coupled with land management, planning, and protection. (High Level Language)*

- *Annually improve health and function of at least <X>% of stream miles each year. (Measurable Target)*

- *Keith Bollt (chat): Conserve and protect are used interchangeably but they have very different meanings*
    - *Kristin Saunders: It is true that conservation and protect are used interchangeably, but some think protection means long term protection without public access. Local leaders and officials don't like the term because we use a broad range of conservation strategies. There is a spectrum of conservation strategies including land use planning. I recommend replacing the second protection with conservation.*

- ***Decision: Change protection to conservation***

- ***Decision: Change coupled with to informed by***

- *Alison Santoro: Please if there is any heartburn please email us.*

More from chat:

- *Joe Berg: protection is static and generally infeasible*
- *Denise Clearwater: "...applied with land management, planning, restoration, and protection."*
- *Joe Berg: protection is often conflated with preservation*
- *Keith Bollt: Agree 100 percent Kristin, thanks for capturing well put! I also suggest using the word "conserve"*
- *Sara Weglein: I like adding conservation. Protection of streams is included in the first part, we're proposing to achieve it through land management, planning, and conservation.*
- *Joe Berg: "coupled with" leaves room for other than science science-based decisions*
- *Sara Weglein: "in conjunction with"*
- *Martha McCauley: "what about 'and incorporating'?"*
- *Keith Bollt: "to inform"*

- *Jennifer Palmore: "using science-based tools, such as land management, planning, and conservation."*

- *Keith Bolt: "using sound science to inform"*

- *Chris Spaur: Delete "coupled onward..." replace with something like "with integrated consideration of the stream in its drainage basin context."*

    Alison Santoro: This may be too confusing for this public facing document.

- *Denise Clearwater: "based on sound science to inform conservation actions."*

- *Keith Bollt: Agree Joe. That might be baked into the cake, in the best case scenario, science informs decisions in human-designed systems but doesn't supply the answer itself.*

Measurable targets:
See Appendix II: Slides - Draft Outcome and Output Language - Alison Santoro and Sara Weglein

Annually improve health and function of at least <X>% of stream miles each year. (measurable target)

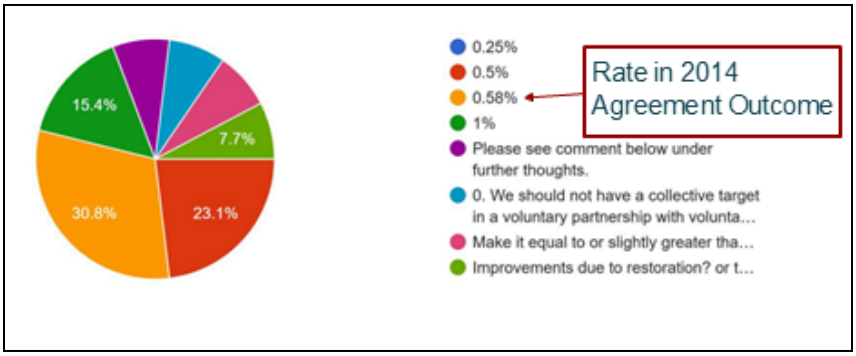

Figure 2. *Preference for the annual rate of improvement in stream health bay-wide for the updated outcome*

- ***Decision: Remove Annually***

- *Claire Buchanan: Chessie BIBI is every 6 years because the states have rotating collection periods. Putting it all together a 6 year interval captures all the states. However there are many other parameters we could work with. I suggest saying "when possible" or "regularly" that way its left up to the individual parameters. We could use the healthy watershed report and start using metrics outlined in that. We need to sit down with Peter and go through the health watershed report to discuss metrics.*

- *Alison Santoro: This would need to be one of the targets labeled as "under construction" and probably wouldn't be ready for public comment.*

Improve health and function of at least 3% (OR 3.5%) of stream miles each 6 years. (measurable target)

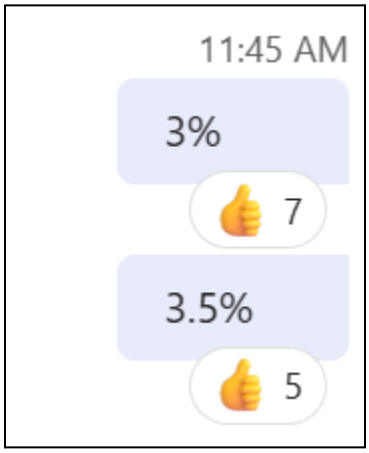

Figure 3. *Results from polling the rate of improved stream miles in 6 years*

- *Alison Santoro: 3.5% is about what our 2014 goal was and 3% is a little less than that.*
- *Denise Clearwater: It is typical if you're on pace to meeting a goal then the next iteration should be a little higher. Additionally with the new increased emphasis on living resources we should go higher.*
- *Claire Buchanan: I would caution against that because COVID affected our monitoring cycles so we will not be as confident for the upcoming data. I would also caution in understanding that a group like SAV was making great progress and was looking they were going to meet their goal and then one season wiped out so much SAV and we felt similar effects in stream health. I would even go less than 3%.*

  <u>More from chat:</u>

  - *Joe Berg: I feel a target of less than 1% annually is an embarrassingly low standard-don't pick a low number we know we can meet-be aspirational and adjust our approach, not our goal if we don't meet it!*
    - *Anne Hairston-Strang: We should have an achievable goal understanding we have some headwinds incoming*
  - *Keith Bollt: I put 0 because successes and failures are created by partners but not the partnership, and therefore without significantly more decision-making authority, it's not going to be a SMART partnership outcome. Totally understand the challenges Alison, we're going through the same thing with Toxics, and the Management Board has not picked up on this nuance. Not a hill I'm going to die on as an interested party 🙂*

- *Chris Ruck: Much of the low-hanging fruit (streams) have already been completed. It gets more difficult as we need to work with private homeowners, etc.*

- *Joe Berg: still 85% of our 1st and 2nd order streams are buried or piped.*

Improve health and function of at least 3% (OR 3.5%) of stream miles each 6 years. (measurable target)

- *Alison Santoro: We could keep "and function" or tie it to a specific indicator but I am reluctant to do that in case we have better science than the Chessie BIBI in a few years.*

- *Claire Buchanan: Ecological Integrity?*

  More from chat:

  - *Joe Berg: health AND function gets past the concern function gets precedence*

  - *Mark Southerland: Stick with ecological integrity in targets too*

Continually improve and protect stream health and ecological integrity…

- *Annually increase the stream miles protected by 1% per year or 10% over 10 years (new measurable target)*

- *Alison Santoro: I had a question about this because our streams are already protected under federal and state regulations. So what would protect mean in this case? We can workshop this but do we want to include this?*

- *Denise Clearwater: I would say no, streams are regulated, which is different than being protected. Under Covenant or easement is information we could get and report on.*

- *Anne Hairston-Strang: There is another metric we're tracking in the Bay Program on land conservation. If there was routine analysis that we could be doing that would be assessing stream sections that are influenced by that land conservation/protection measure we could incorporate that.*

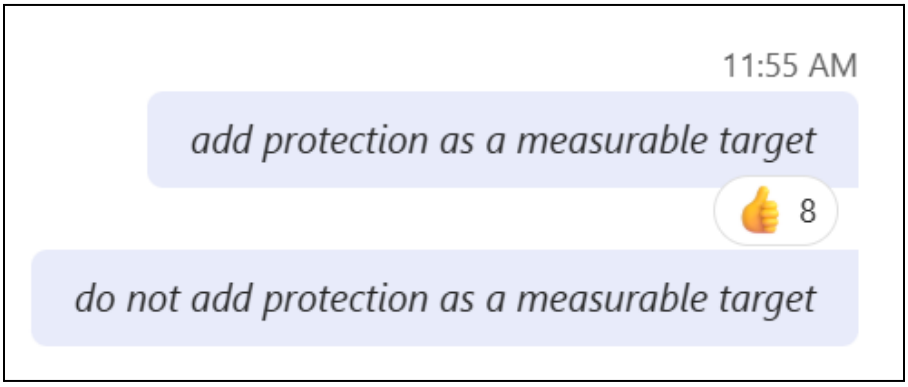

Figure 4. *Results of polling whether to add protection as a measurable target.*

More from chat:

- *Joe Berg: health AND function gets past the concern function gets precedence*
- *Brock Reggi: some language of stream evolutional changes due to environmental conditions might help with deflecting hard line out comes*
- *Anne Hariston-Strang: Tie to land protection measure?*

Measurable Targets and Activities

- Development of multi-metric stream health indicators to complement the Chessie BIBI. (81.3%)
- Advocate implementation of restoration practices directly tied to improving instream biological conditions. (50%)
- Improve scientific understanding and predictions of stressors to the stream ecosystem at the spatial scale of individual stream reaches to assist in the choice of restoration approaches. (56.3%)

Figure 5. Potential new targets that had >50% participant's support.

- *Gina Hunt: Advocating seems more an action. We would need jurisdictional opinions on how to make this measurable and time bound. Scientific understanding is an action. How do you make this quantifiable and measurable?*
- ***Decision: Add development of multimetric stream health indicators as a target but make it time bound.***

- *Gina Hunt: For those that put those actions in the survey. Some are probably better suited in the management strategy, but if you can make that action a metric via making it measurable and time bound, please send them to us.*

  More from chat:

  - *Joe Berg: I think about a multi-metric indicator to be derived from an approach to combat the urban stream syndrome (e.g., peak discharge, loss of baseflow, etc.)*

  - *Denise Clearwater: There is increased emphasis on living resources-why not add advocating for this, especially since they are more likely to improve if it part of the project objective (per STAC report)?*

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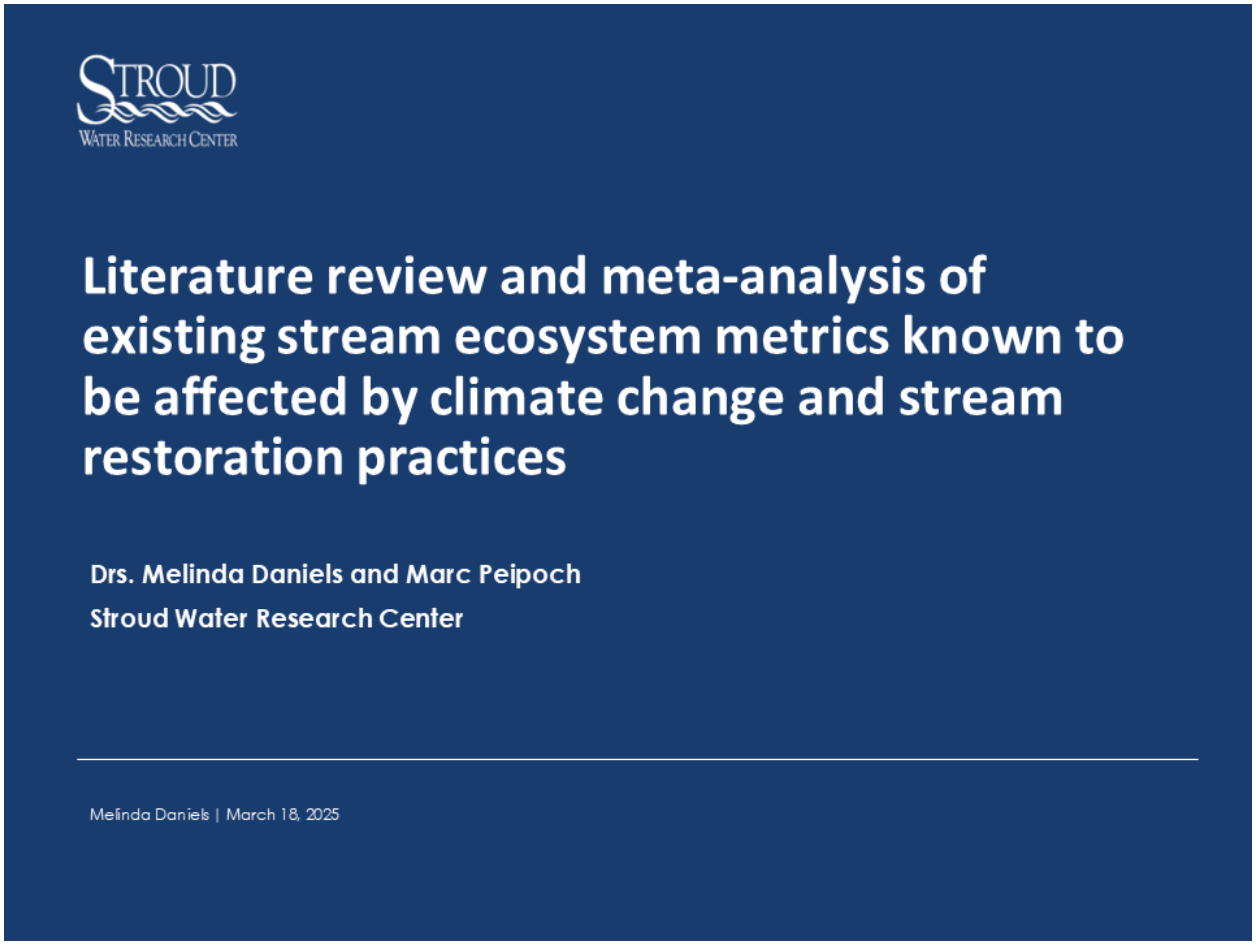
12:00 – MEETING ADJOURNED.

Appendix I: Slides - 2022 GIT Funding - Presentation of Preliminary Results - Melinda Daniels



Climate Resiliency Metrics and Search Terms

Hydrology (peak Q, high flow, baseflow, etc.)

Temperature (daily max, thermal refugia, heat stress, etc.)

Dynamic Equilibrium (Stability, bank erosion, sediment, etc.)

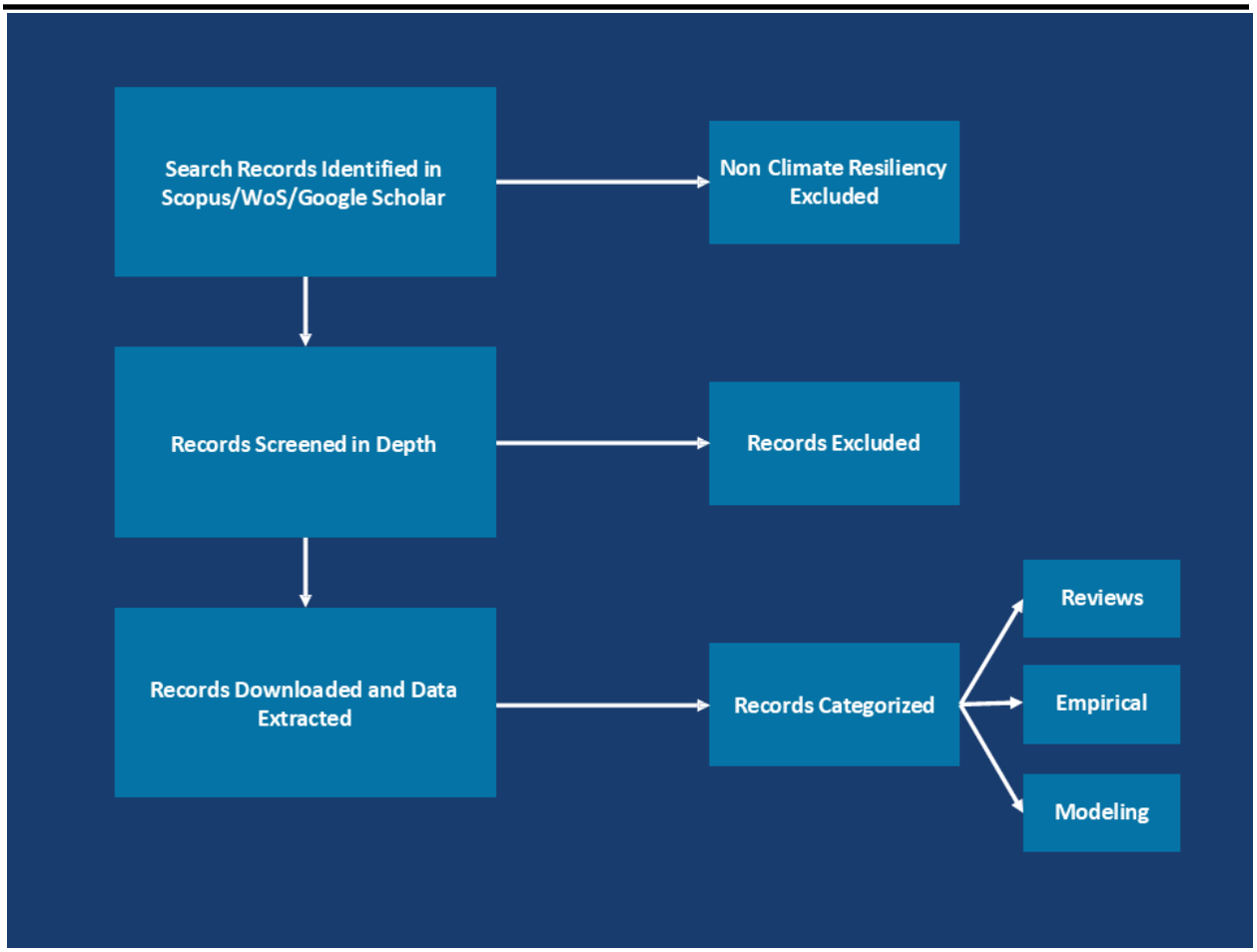
Restoration Techniques (floodplain connection, wood addition, channel reconfiguration, re-meandering, reforestation, etc.)

STROUD WATER RESEARCH CENTER

Example Search Query

TITLE-ABS-KEY (stream restoration AND climate AND change) OR (river restoration AND climate AND change) AND (wood)

- 2025 documents found
- 16 selected for in depth review
- 2 included


Search Records Identified in Scopus/WoS/Google Scholar
Non Climate Resiliency Excluded
Records Screened in Depth
Records Excluded
Records Downloaded and Data Extracted
Records Categorized
Reviews
Empirical
Modeling

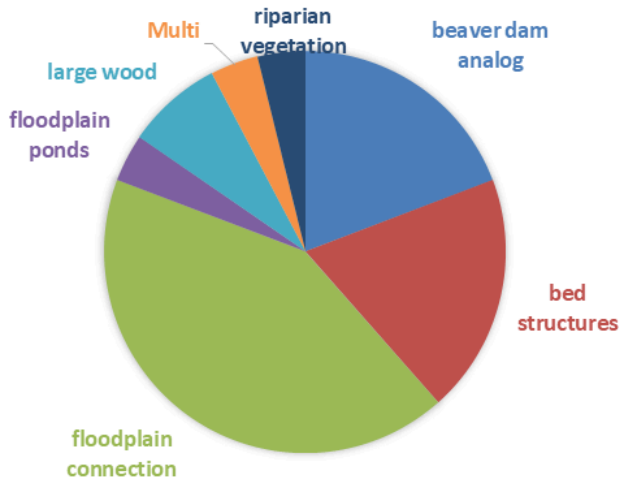
Results

Most reviewed studies did not present primary data regarding restoration effectiveness with regard to climate resiliency metrics

- Literature is dominated by impact or process studies that mention applications to restoration design or planning for future climate change
- 80 papers identified that focused on river restoration and increased climate resiliency
  - Conceptual/Reviews (39)
  - Modelling (17)
  - Empirical (24)

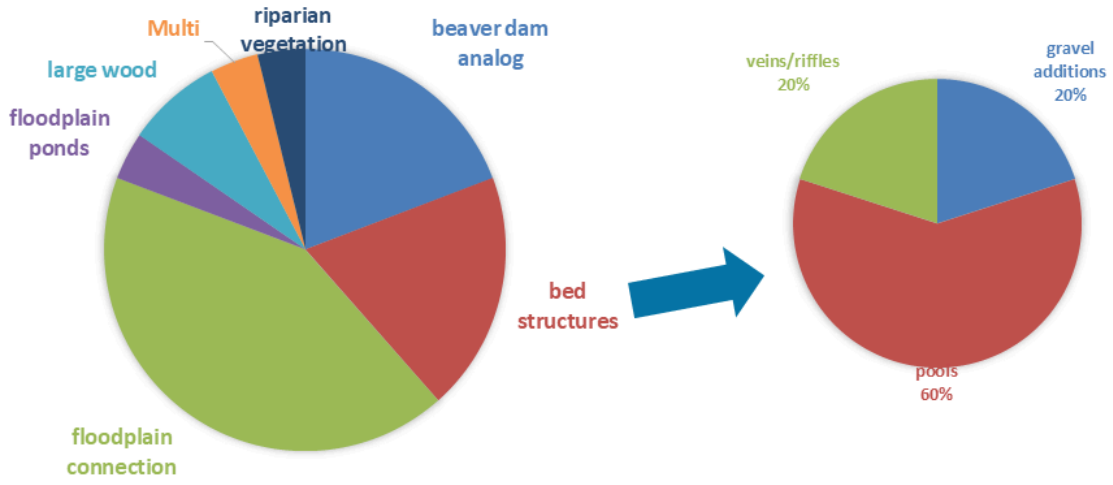
Results: Empirical (n=24)

Papers measuring field application of restoration approaches or techniques and evaluating measured change in metrics of resiliency



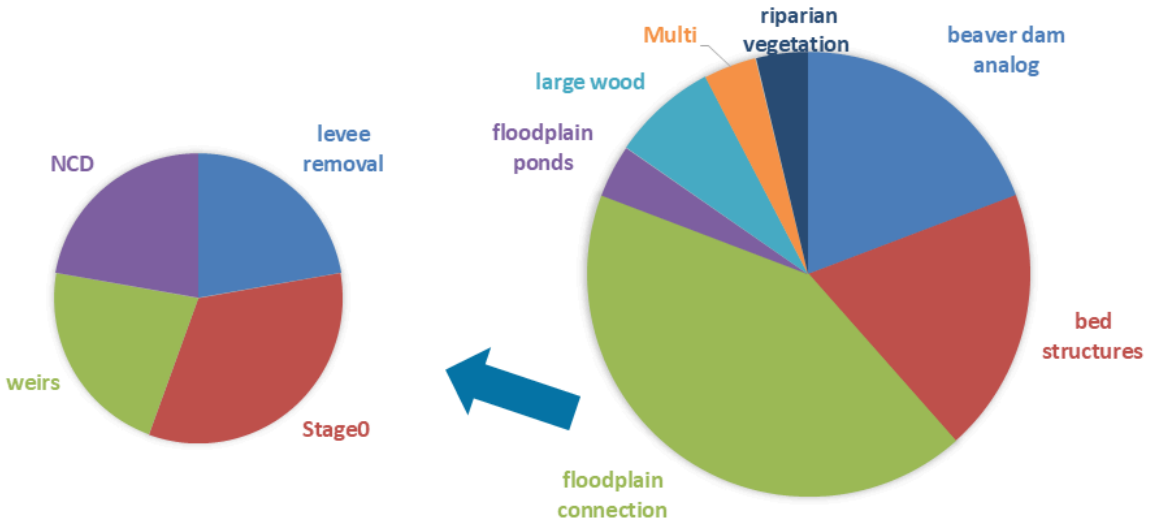
Results: Empirical

Papers measuring field application of restoration approaches or techniques and evaluating measured change in metrics of resiliency (n=25)



Results: Empirical

Papers measuring field application of restoration approaches or techniques and evaluating measured change in metrics of resiliency (n=25)



Results: Ranking Restoration Techniques

Category	Sub Category	HighQ (-)	LowQ (+)	Sediment (-)	Stability (+)	Temp (-)	Q Storage (+)	Connection (+)	Score
beaver dam analog						1			1
beaver dam analog		1	1				1	1	4
beaver dam analog				1		1			2
beaver dam analog							1		1
beaver dam analog						-1			-1
bed structures	veins/riffles			1					1
bed structures	pools					1			1
bed structures	gravel additions					0			0
bed structures	pools					1			1
bed structures	pools					1			1
floodplain connection	NCD						1	1	2
floodplain connection	NCD			1			1	1	3
floodplain connection	levee removal			1			1	1	3
floodplain connection	levee removal			1			1		2
floodplain connection	weirs						1	1	2
floodplain connection	weirs						1	1	2
floodplain connection	Stage0					-1			-1
floodplain connection	Stage0					-1			-1
floodplain connection	Stage0					-1	1	1	1
floodplain ponds						1			1
large wood						0			0
large wood							1		1
multi - NCD, wood, riparian vegetation					1	1	1	1	4
riparian vegetation				1	1				2

Beaver Dam Analog

Munir, T. M., & Westbrook, C. J. (2021). Beaver dam analogue configurations influence stream and riparian water table dynamics of a degraded spring-fed creek in the Canadian Rockies. *River Research and Applications*, 37(3), 330-342. doi:10.1002/rra.3753

Multi-technique Restoration

Hodge, B. W., Henderson, R., & Brehme, C. E. (2025). Restoration Effects on a Native Cutthroat Trout Stream. *River Research and Applications, 41*(3), 541-552. doi:10.1002/rra.4373

TABLE 1 | Summary of restoration treatments at Armstrong Creek, Colorado, as derived from the engineer's design and botanist's planting schema.

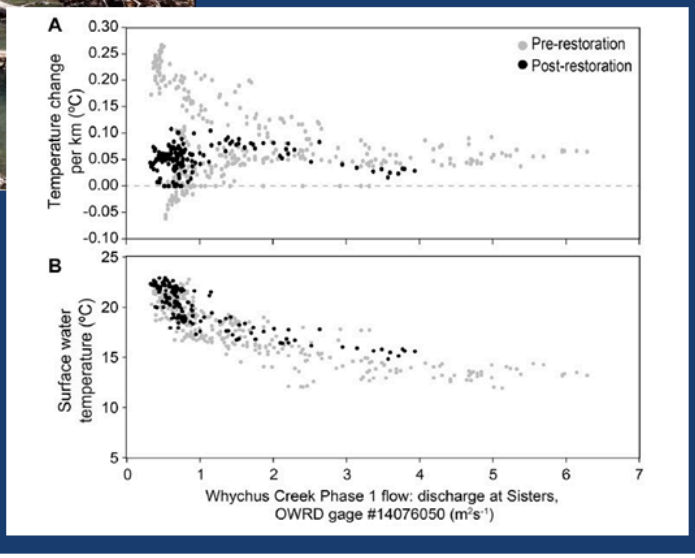
Restoration treatment	Unit	Restoration reach		
		Upper	Middle	Lower
Boulder grade control (two steps per)	Each	4	0	3
Channel reconstruction	M	0	0	211
Coir mat soil lift	M	13	0	0
Log drop (two steps per)	Each	5	0	11
Off-channel pond/wetland	Each	0	0	4
Point bar regrading	M	28	0	0
Riparian exclosure	% of reach	100	100	100
Sedge planting	Each	200	0	1700
Sod mat	M	107	0	216
Willow/alder planting	Each	200	0	1800
Wood toe w/sod mat[a]	M	27	0	168

Note: Willows *Salix* spp. were grown from locally harvested cuttings and Thinleaf Alder *Alnus incana* and sedges (Panicled Bulrush *Scirpus microcarpus and Carex spp.*) from locally harvested seeds.
[a]On Lower Reach wood toe structures, sod mats were replaced with sedge mats consisting of coir fiber and sedge plantings.

Results: Ranking Restoration Techniques

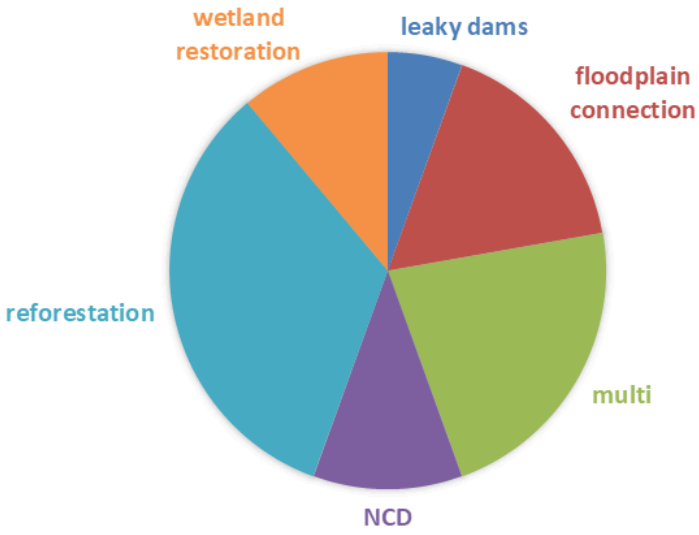
Category	Sub Category	HighQ (-)	LowQ (+)	Sediment (-)	Stability (+)	Temp (-)	Q Storage (+)	Connection (+)	Score
beaver dam analog						1			1
beaver dam analog		1	1				1	1	4
beaver dam analog				1		1			2
beaver dam analog							1		1
beaver dam analog						-1			-1
bed structures	veins/riffles			1					1
bed structures	pools					1			1
bed structures	gravel additions					0			0
bed structures	pools					1			1
bed structures	pools					1			1
floodplain connection	NCD						1	1	2
floodplain connection	NCD			1			1	1	3
floodplain connection	levee removal			1			1	1	3
floodplain connection	levee removal			1			1		2
floodplain connection	weirs						1	1	2
floodplain connection	weirs						1	1	2
floodplain connection	Stage0					-1			-1
floodplain connection	Stage0					-1			-1
floodplain connection	Stage0					-1	1	1	1
floodplain ponds						1			1
large wood						0			0
large wood							1		1
multi - NCD, wood, riparian vegetation					1	1	1	1	4
riparian vegetation				1	1				2

Flitcroft, R. L., Brignon, W. R., Staab, B., Bellmore, J. R., Burnett, J., Burns, P., . . . Wondzell, S. M. (2022). Rehabilitating Valley Floors to a Stage 0 Condition: A Synthesis of Opening Outcomes. *Frontiers in environmental science, 10*. doi:10.3389/fenvs.2022.892268



Results: Modelling (n=17)

Application of restoration approaches or techniques to a real or simulated fluvial ecosystem



- on-channel ponds and floodplain reconnection
- peatland reforestation, damming of gullies
- channel re-meandering and riparian veg
- on channel storage, hedgerow, forest, wetlands

STROUD WATER RESEARCH CENTER

Results: Modelling (n=17)

Application of restoration approaches or techniques to a real or simulated fluvial ecosystem

Category	Sub Category	HighQ (-)	LowQ (+)	Sediment (-)	Stability (+)	Temp (-)	Q Storage (+)	Connection (+)
leaky dams		10% reduction						
floodplain connection	stage0	up tp 37% reduction						increased 46%
floodplain connection	levee removal						yes	yes
floodplain connection		10-15% reduction						
multi	on-channel ponds and floodplain reconnection	15-30% reduction						
multi	peatland reforestation, damming of gullies	31-60%						
multi	channel re-meandering and riparian veg	14% reduction						
multi	on channel storage, hedgerow, forest, wetlands	8 to 30% reduction						
NCD	de-channelization	5 to 25% increase						
NCD	de-channelization						yes	yes
reforestation		8% reduction						
riparian reforestation						2.8 deg		
riparian reforestation		19% reduction						
riparian reforestation					80-90% reduction in sediment			
wetland restoration		up to 18% reduction	increase by 18%					
wetland restoration		8 to 30%						
woodland restoration		5 to 30%						

STROUD WATER RESEARCH CENTER

Table 2. Modeled representation of co-designed NFM opportunities.

NFM Feature	Modelled Representation
Woodlands (including hedgerows) **	Increased floodplain roughness—0.15 *n* value
Online storage	Online storage unit *
Offline storage	Reservoir unit *
Leaky barriers	Increased channel roughness—0.15 *n* value
River and floodplain restoration	Reservoir unit *, alter digital terrain model (DTM) + channel network
Track drainage alteration **	Junction function in the 1D network to divert
Buffer strips	Increased floodplain roughness—0.075 *n* value
Soil aeration, winter crops and zero tillage	Increased floodplain roughness—0.050 *n* value
Swales, ponds, bunds and sediment traps **	Edit DTM for runoff attenuation features (RAF)

Notes: * Built—in features in the software can be amended to represent area and volume. ** Only opportunities within the active 2D area (floodplain) are represented and tested.

Results: Conceptual/Reviews (n=39)

Conceptual resiliency papers or reviews of potential resiliency strategies, including suggested restoration approaches or techniques

Conclusions

Low number of quantitative empirical studies consistent with the larger river restoration ecosystem services literature

Ecosystem Services 46 (2020) 101206

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journal homepage: www.elsevier.com/locate/ecoser

Does river restoration increase ecosystem services?

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ARTICLE INFO

Keywords:
Peer-review
ES assessment
River ecosystems
Restoration effects
Study weighting
CICES

ABSTRACT

Rivers provide ecosystem services (ES) that benefit people, but worldwide, many rivers are severely degraded thus compromising service supply. River restoration aims at reversing this condition. We reviewed the scientific literature to synthesise published effects of restoration on ES and to identify which specific ES commonly benefit from or recede after river restoration. Most of the reviewed studies (n = 850) did not present insight into restoration effects on ES, but merely used ES terminology (n = 762; 89.6%), indicating that researchers often implicitly assume an increase of ES following restoration. Only a small fraction of studies reported qualitative (n = 53; 6.2%) or quantitative effects on ES (n = 35; 4.1%). From those 88 core studies, we found evidence for an increase of 12 ES. We observed little consistency in ES assessments, which impeded the comparability. Trade-offs between ES and decreasing ES after restoration were more frequently observed in models than in empirical studies. The studies also showed a strong bias toward the coverage of ecoregions and ecosystems. In the future, not only will further studies be needed to close the knowledge gap, but there is also a clear need to adapt existing legal frameworks which drive restoration, to define ES as a water management objective.

Conclusions

- Continuing lack of monitoring or evaluation of restoration techniques, particularly hydrologic metrics of flow regime
- Notable increase in publications in the last few years
- Absence of sufficient number of quantitative monitoring studies makes ranking restoration technique effectiveness challenging

Appendix II: Slides - Draft Outcome and Output Language - Alison Santoro and Sara Weglein

Through the Chesapeake Bay Watershed Agreement, *the Chesapeake Bay Program has committed to…*

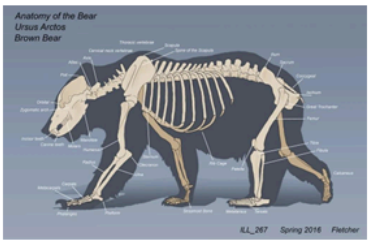
Goal: *Stream Health*

Outcome:

Continually improve stream health and function through the watershed. Improve health and function of ten percent of stream miles above the 2008 baseline for the watershed

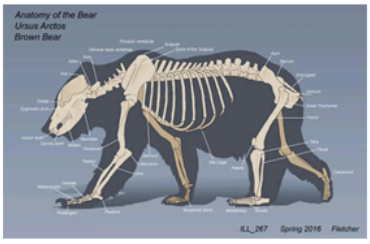
Building a Bear

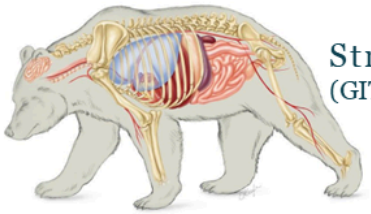
Agreement and Outcomes



Building a Bear

Agreement and Outcomes

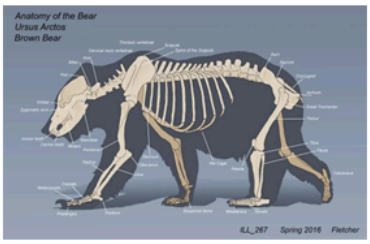


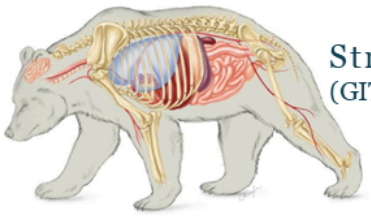


Structure (GITs, WGs?)

Building a Bear

Agreement and Outcomes



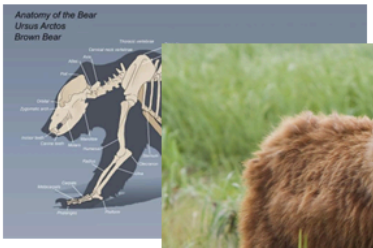


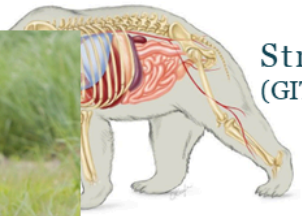
Structure (GITs, WGs?)

Management Strategies and Action Plans

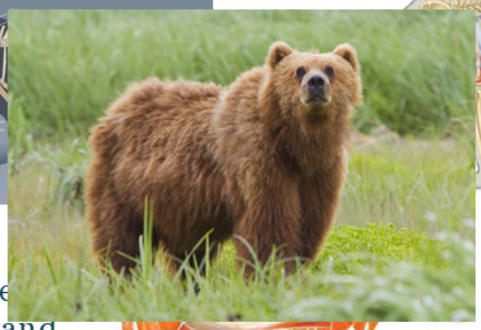
Building a Bear

Agreement and Outcomes





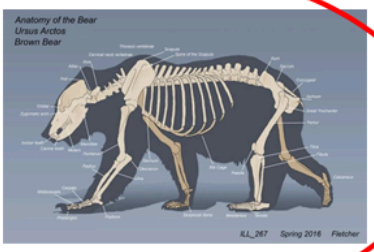
Structure (GITs, WGs?)



Management Strategies and Action Plans

Building a Bear

Agreement and Outcomes



We are here!

GOALS & OUTCOMES

The commitments contained in this section are the Goals and Outcomes that the signatories will work on collectively to advance restoration and protection of the Chesapeake Bay ecosystem and its watershed. The Goals articulate the desired high-level aspects of the partners' Vision. The Outcomes related to each Goal are specific, time-bound, measurable targets that directly contribute to achieving that Goal.

https://www.chesapeakebay.net/files/Chesapeake-Bay-Watershed-Agreement-Amended.pdf

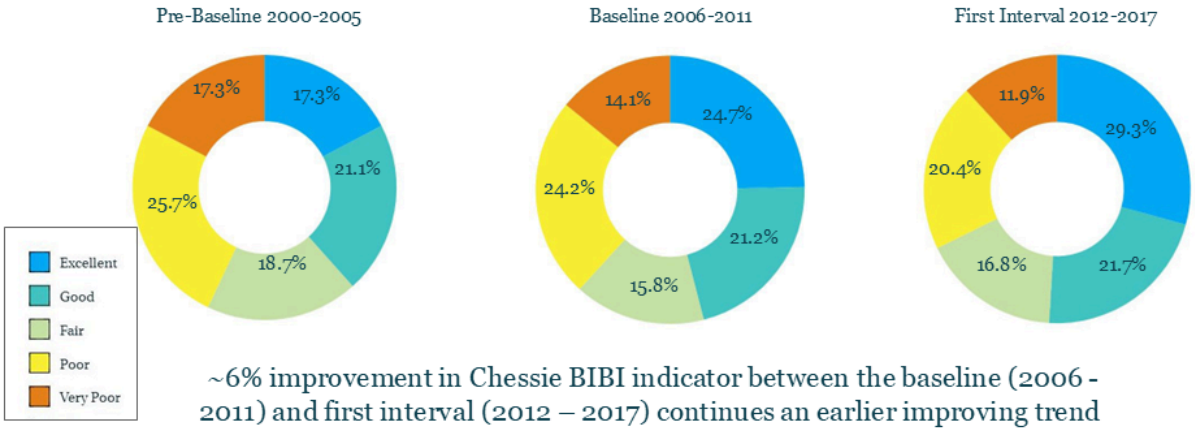
Possible Goal Structure

Goals & Outcomes? *For Consideration & Discussion*

Clean Water	Lands and Watersheds	Habitats and Wildlife	Engaged Communities
Water Quality Standards Attainment and Monitoring	Forest Buffers	Blue Crab Abundance	Public Access Site Development
2025 WIP	Tree Canopy	Oysters (Habitat & Abundance)	Environmental Literacy Planning
Toxic Contaminants	Land Use Decision Support	SAV	Students
	Protected Lands	Brook Trout	Stewardship
	Adaptation	Fish Habitat (Tidal & Nontidal)	Workforce
		Wetlands (Tidal & Nontidal)	Local Leadership
		Stream Health	
		Fish Passage	

Chessie BIBI

OUTLOOK
ON COURSE



~6% improvement in Chessie BIBI indicator between the baseline (2006 - 2011) and first interval (2012 – 2017) continues an earlier improving trend

Stream Health Workgroup Outcome Assessment

EC Charge: That changes reflect

- A renewed and **greater emphasis on engaging all communities** of the watershed as active stewards of a healthy and resilient Chesapeake Bay and its watershed
- Our mandate to address water quality **and living resources** throughout the Bay and watershed
- **Elevating conservation** as a key pillar of the Chesapeake Bay Program, alongside science, restoration, and partnership
- A grounding in the most recent scientific understandings and issues that have emerged since the current Chesapeake Bay Watershed Agreement was signed in 2014
- Goals and outcomes that are **measurable and time bound.** Time frames should be sufficient to accomplish the outcomes as quickly as possible. In particular, our regulated nutrient and sediment load reductions, especially those within non-point sources
- Acknowledgement that our scientific understanding is continuously evolving and that our efforts need to constantly adapt accordingly
- The fact that while each partner shares a common goal, we are all approaching this goal from different perspectives, challenges, and opportunities.

STREAM HEALTH OUTCOME

OUTCOME DISPOSITION ADVICE TO MANAGEMENT BOARD:
UPDATE

GOAL: Vital Habitats. LEAD: Habitat Goal Team (GIT2)

OUTCOME: Continually improve stream health and function throughout the watershed. Improve health and function of ten percent of stream miles above the 2008 baseline for the watershed.

- Update the outcome to reflect a more holistic approach to improving ecological integrity of stream systems and stream corridors, based on sound science, coupled with land management, planning, and protection to improve and sustain stream health.
  - Need additional indicators of stream health to measure changes in certain stream functions and identify specific ecological stressors. A project is underway to determine the appropriate indicators or metrics of stream health by identifying existing datasets and the feasibility of using them to measure stream health.
- Value
  - key outcome to achieving fishable, swimmable, drinkable water
  - incentivizes Bay jurisdictions to coordinate policies across the watershed
- Opportunities:
  - incorporate the findings from the 2023 CESR report and our 2023 STAC workshop
  - leverage work being done by related goal teams and consolidate data management and analysis

Presented by: Alison Santoro

Stream Health Workgroup Outcome Assessment

Is the Outcome SMART (Specific, Measurable, Achievable, Realistic, Time-bound)?

Outcome	ERG Comments	S	M	A	R	T	Overall
Stream Health Outcome - Continually improve stream health and function throughout the watershed. Improve health and function of ten percent of stream miles above the 2008 baseline for the Chesapeake Bay watershed.	The outcome statement meets the SMT criteria ERG assessed. Methods to assess stream health are available on CP.	✓	✓			✓	✓
Brook Trout - Restore and sustain naturally reproducing brook trout	The outcome statement meets the SMT criteria						

Outcome Format

OUTCOME

High level outcome language. (The change in state we aim to influence or the future state we aspire to reach as a consequence of our actions and their outputs.) This language does not need metrics.

- Bullets of **measurable targets** or objectives. These are shorter-term steps and results: this is the place to be as specific, measurable, achievable, relevant, and time bound (SMART) as possible to ensure we are tracking our work, learning from the results, and being publicly accountable.
- These could be more direct measures of our efforts and whether we are following through on plans and commitments.
- Interim steps and tiered targets acknowledge what is realistic in a set period while leaving space for what we ultimately know is needed for the healthy watershed we envision.
- Targets that are not thoroughly flushed out can be listed as "under construction."

New Outcome - Rough Draft

Continually improve and protect stream health and ecological integrity throughout the watershed based on sound science, coupled with land management, planning, and protection. (High Level Language)

- Annually improve health and function of at least <X>% of stream miles each year. (Measurable Target)

High Level Language

Continually improve and protect stream health and ecological integrity throughout the watershed based on sound science, coupled with land management, planning, and protection. (High Level Language)

Summary of Comments:

- Like "continually improve
- Like "protect"
  - Could be added as a separate target?
    - Ex: Annually increase the stream miles protected by 1 percent per year or 10 percent over ten years.
    - Discuss targets in later slides

High Level Language

Continually improve and protect **stream health and ecological integrity** throughout the watershed based on sound science, coupled with land management, planning, and protection. (High Level Language)

Summary of Comments:

- "Stream Health" and "Ecological Integrity" are similar, redundant
  - Define "ecological integrity" OR
    - Just of streams or the ecological integrity of streams and lands
  - Remove "ecological integrity" and let "Stream Health" stand alone

- "Stream Function" was removed from 2014 high level language
  - Leave it in updated outcome OR
  - Sufficient to call out in Targets

High Level Language

Continually improve and protect stream health and ecological integrity **throughout the watershed** based on sound science, coupled with land management, planning, and protection. (High Level Language)

Summary of Comments:

- Does it include Non-tidal AND Tidal streams?
  - Specify only non-tidal OR
  - Keep "Thoughout the watershed" OR
  - Clarify as "non-tidal and tidal stream health"
- Do we need a new indicator for tidal streams?
  - Chessie BIBI (benthic macros) only applied to small non-tidal streams

High Level Language

Continually improve and protect stream health and ecological integrity throughout the watershed **based on sound science**, coupled with land management, planning, and protection. (High Level Language)

Summary of Comments:

- "sound science" can be subjective
  - Remove "sound" or replace with better word?
- Science element be rolled into the list of tools
  - "Continually improve…throughout the watershed using sound science and land management, planning, and protection"

High Level Language

Continually improve and protect stream health and ecological integrity throughout the watershed based on sound science, **coupled with land management, planning, and protection.** (High Level Language)

Summary of Comments:

- Most liked the inclusion of these points
- "coupled with" intent is unclear
- If intent is to ensure watershed is considered (NOT just stream), replace the second part "with integrated consideration of the stream in its drainage basin context." or similar
- Simplify to "Continually improve…throughout the watershed by managing, restoring and protecting waterways and lands."
- Change to "sound science, technology and data."

High Level Language

Continually improve and protect stream health and ecological integrity throughout the watershed based on sound science, coupled with land management, planning, and protection. (High Level Language)

Additional comments:

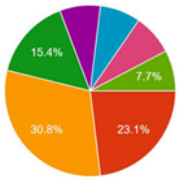
- Consider updating outcome high level text to include something identifying the importance to people of 'stream health and ecological integrity'
- Current language sounds like the SHWG is actually doing the work of improving stream health
  - Are the jurisdictions doing the management and restoration work?
  - SHWG becomes a supporting arm on the jurisdictional efforts
  - The outcome should focus more on monitoring, data analysis/assessment, and tool generating to inform what work is done and where.

Measurable Targets

- Annually improve health and function of at least <X>% of stream miles each year. (Measurable Target)

Preference for the annual rate of improvement in stream health Bay-wide for the updated outcome.

The 2014 agreement outcome language had an unspecified annual improvement of ~0.58%. (10 percent over 17 years, 2008-2025). The overall Ba...n stream health Bay-wide for the updated outcome.
13 responses



Please see comment below under further thoughts.
Bi-annually measure the health and function of stream miles watershed-wide, utilizing the extensive data provided by each jurisdiction through the required U.S. EPA 305b Integrated Water Quality Reports submitted by each Chesapeake Bay jurisdiction.

0. We should not have a collective target in a voluntary partnership with voluntary action, it is not a recipe for success from a scientific or and expectations setting (communications) perspective

Make it equal to or slightly greater than the rate derived after the Chessie BIBI analysis of 2018-2023.

Improvements due to restoration? or to ecosystem responses?

Measurable Targets

Annually improve health and function of at least <X>% of stream miles each year. (Measurable Target)

Summary of Comments - Numerical Target:

- Annually is a bad time frame
  - Stakeholders expect annual updates
  - annually is too fine given the time it takes to sample, process and release all data
  - Restate the rate tied to Chessie BIBI - every 6 years
    - Improve health and function of at least 3% (OR 3.5%) of stream miles every six years.
- keep it conservative with existing climate change and flooding. We may have seen the improvements from the wastewater sector and the remaining nonpoint source sector will be delayed from lag times and other factors.

Measurable Targets

- Annually improve health and function of at least <X>% of stream miles each year. (Measurable Target)

Summary of Comments - Overall Language

- How are stream health and function differentiated?
  - If too similar, only one should be used. Are you using "function" to capture abiotic metrics? If so, this needs to be articulated to understand the outcome.

- Disagree with including "and function"
  - multiple stream functions that can be improved which would produce no improvement in stream health, nor water quality, nor utility by people, etc.
  - reword to state "improvement in functions likely to increase stream ecological integrity and or improve water quality."

Measurable Targets

- Annually improve health and function of at least <X>% of stream miles each year. (Measurable Target)

Additional Comments:

- Are you talking about site-specific actions to improve stream miles (e.g. restoration, riparian buffer planting) or overall ecosystem responses in streams watershed-wide (e.g. Chessie BIBI)?
- What collective actions are the jurisdictions willing to commit to? Base the outcome language on that
- I do not like the assumption that all streams in a HUC12 are healthy based on just three sample points
  - The scale of accounting should be reconsidered- perhaps transitioning to NHD catchments or relying on larger and less clustered samples within each HUC12.

Measurable Targets - New?

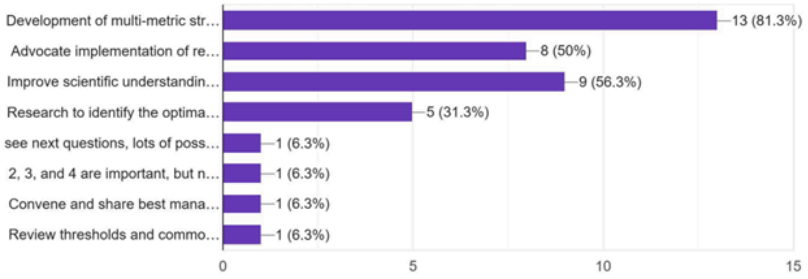
Continually improve and **protect** stream health and ecological integrity….

- Annually increase the stream miles protected by 1 percent per year or 10 percent over ten years.
  - Are streams already protected under federal and state regulations?
  - could "protect" mean it would be under protective covenant or easement?

Measurable Targets and Activities

We have brainstormed a few other potential targets. Please choose which (if any) activities you think are appropriate to recommend to the Manage... consider when new metrics/targets may be ready.

16 responses



Measurable Targets and Activities

- Development of multi-metric stream health indicators to complement the Chessie BIBI. (81.3%)
- Advocate implementation of restoration practices directly tied to improving instream biological conditions. (50%)
- Improve scientific understanding and predictions of stressors to the stream ecosystem at the spatial scale of individual stream reaches to assist in the choice of restoration approaches. (56.3%)

Measurable Targets and Activities

- Additional Suggestions
  - Research to identify the optimal amount of dynamic geomorphic change for various stream ecosystem attributes could help restoration designs.
  - Research to identify the optimal amount of dynamic geomorphic change for various stream ecosystem attributes could help restoration designs.
  - Review thresholds and common elements of state BSID procedures
  - Convene and share best management practices, best science and policy, communications best practices

Measurable Targets and Activities

- Stream health indicators should include watershed conditions and biological stressor assessments relating stream corridor and watershed conditions to impairments.
- If thresholds for stressors exists that is another option for a target - Identify biological thresholds for each key stressor, but this is a difficult task.
  - identify priority stressors for remediation
- I think it is worth the workgroup's time to investigate how we could achieve the suggested targets related to stream restoration, it might be premature to make a recommendation to the management board at this point.

Measurable Targets and Activities

- Stream Health Workgroup could synthesize the progress in other groups that help to improve stream health, e.g., Brook Trout, wetlands, (fish) passage, healthy watersheds.
- Health has a biological endpoint with indicators based on these (bug, fish, mussels, people); indicators of stress (pH, geomorph); indicators of drivers (LULC, climate). Cross-walk these with related Outcome teams.