Setting Ecological Targets in Different Systems

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Restoration Principles

1. Target root causes of habitat and ecosystem change
2. Tailor restoration actions to local potential
3. Match the scale of restoration to the scale of the problem
4. Be explicit about expected outcomes

Adapted from Beechie et al. (2010).

Process Based Restoration seeks to reinitiate the processes that initially created the habitat and community structure

Get to Know your system

- Identify the overall type of ecosystem and habitat
  - Depositional, transport reach, forest, grassland, wetland, meadow, agricultural land, urban stream
- Get a species list for the area
  - What lives there now, what potentially lived there historically
- Know your site history:
  - Was it mined? Grazed? Farmed? Logged? Straightened? Drained? Burned? Can we find information on historical conditions
- Know your community structure:
  - Animal and plant interactions, life history requirements, limiting factors, historical and contemporary impacts, habitat requirements, spatial and temporal behavior/life history
- Identify Constraints and Opportunities

How do we do the greatest good for the largest area, with the least harm and risk to existing resources?

How do we identify restoration goals under a changing climate?

How do we know what a site “should” look like?

How do we reconcile what is feasible under current conditions and constraints with historic conditions?

Diverse Landscapes, Diverse Ecological Constraints and Opportunities

- Headwaters:
  - Constraints: Low Stream power, small contributing watershed, small sediment supply, ephemeral systems
  - Opportunities: Very little human infrastructure, potential to restore to historical conditions
- Meadows:
  - Constraints: Very little wood, often grazed (at least historically), tend towards eroding when not functioning well
  - Opportunities: Depositional habitat, mobile sediment, vegetation communities that promote aggradation and floodplain connectivity, often less human infrastructure than other areas
- Foothill Forests:
  - Constraints: Lots of human infrastructure, long history of alteration
  - Opportunities: Lots of wood and debris, larger watersheds, easier access
- Central Valley:
  - Constraints: Hugely altered, dominated by human infrastructure, lots of regulatory and administrative hurdles
  - Opportunities: Pairing agricultural folks with conservation folks to improve working land for wildlife, anadromous fish
- Coastal Streams:
  - Constraints: Short watersheds, often flashy, history of intensive logging practices, very altered
  - Opportunities: Lots of wood, diverse habitats within a short distance, anadromous fish, lots of other protected species
- Deserts:
  - Constraints: Very little water, often very limited wood supply, ephemeral systems
  - Opportunities: Flashy precipitation events, drought adapted plants, lots of mobile sediment

Goals and Objectives

- Set SMART Goals and Objectives

(Specific, Measurable, Achievable, Relevant, Time-Bound)

  - Increase and Reclaim Fluvial Space
  - Increase active valley bottom
  - Assess infrastructure: How does it impact ecosystem function or species utilization of habitat? Can it be improved? Removed?
  - Think longitudinally: What’s upstream? What’s downstream? How will my project affect these things?
  - Monitor system before and after, set efficacy metrics

What are we designing for?

- Understand historical conditions but know we cannot necessarily achieve them
  - Altered system, contemporary infrastructure constraints
  - Altered climatic conditions, contemporary weather patterns, flows don't match historical floodplain
  - Altered species distribution
  - Passage barriers
  - Thermal or flow barriers

  - The strength of PBR is that it works with the system we have now and the processes drive habitat formation, structure, and function

LOW-TECH PROCESS-BASED RESTORATION PRINCIPLES FOR STRUCTURALLY-STARVED RIVERSCAPES

Riverscapes Principles

1. Streams need space
2. Structure forces complexity and builds resilience
3. The importance of structure varies
4. Inefficient conveyance of water is healthy

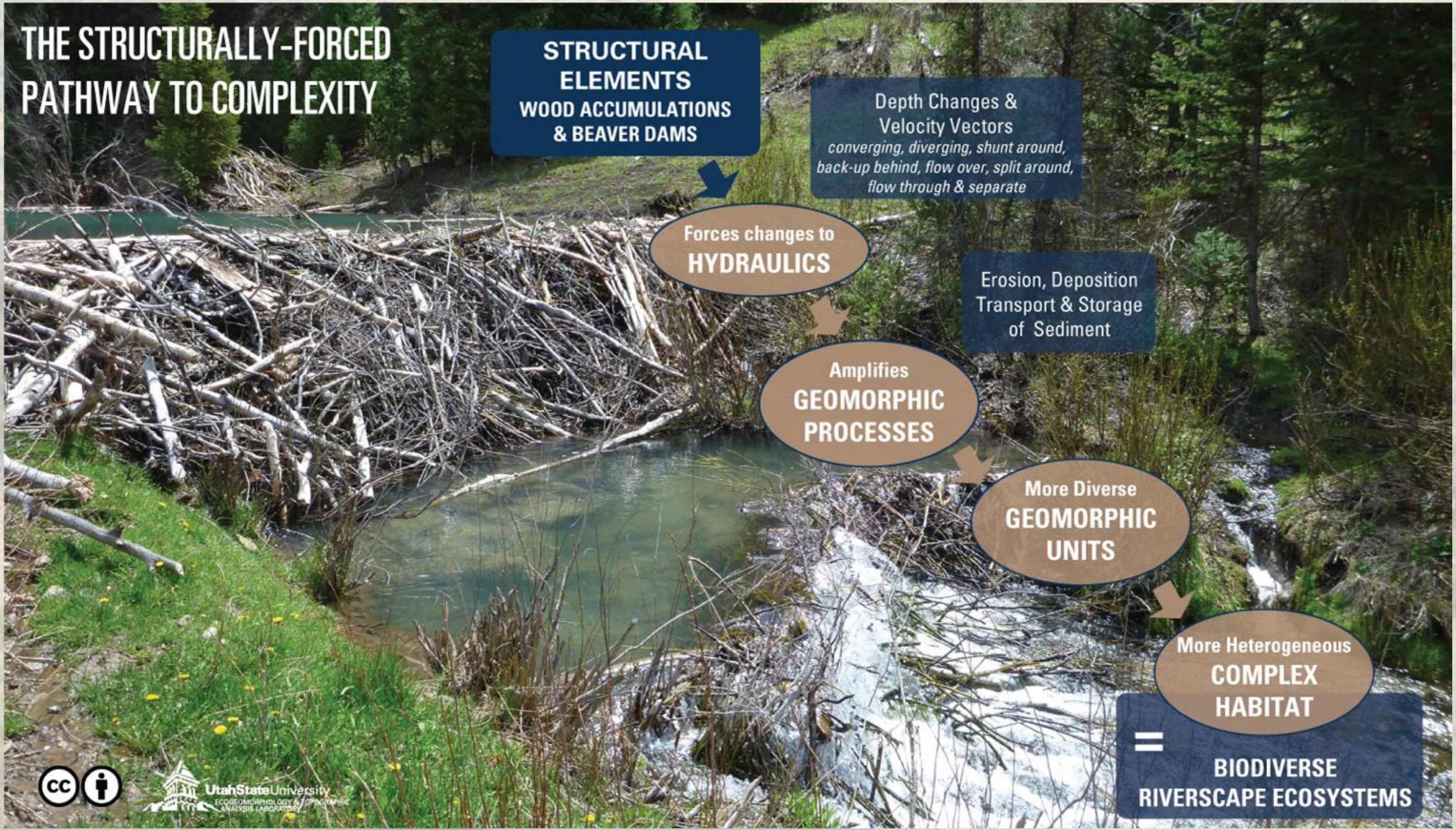
By which we mean complex, dynamic, longer residence time, slow, variable

Restoration Principles

1. It's okay to be messy
2. There is strength in numbers
3. Use natural building materials
4. Let the system do the work
5. Defer decision making to the system
6. Self-sustaining systems are the solution

https://lowtechpbr.restoration.usu.edu/

From Wheaton et al. 2019 LTPBR Design Manual


THE STRUCTURALLY-FORCED PATHWAY TO COMPLEXITY
STRUCTURAL ELEMENTS
WOOD ACCUMULATIONS & BEAVER DAMS
Depth Changes & Velocity Vectors
converging, diverging, shunt around, back-up behind, flow over, split around, flow through & separate
Forces changes to HYDRAULICS
Erosion, Deposition Transport & Storage of Sediment
Amplifies GEOMORPHIC PROCESSES
More Diverse GEOMORPHIC UNITS
More Heterogeneous COMPLEX HABITAT
= BIODIVERSE RIVERSCAPE ECOSYSTEMS
UtahStateUniversity






Structure

- Wood
- Beaver dams
- Sod/Sedge
- Riparian Vegetation

Complexity

- Water Velocity
- Sediment Sorting
- Channel Heterogeneity

Diversity

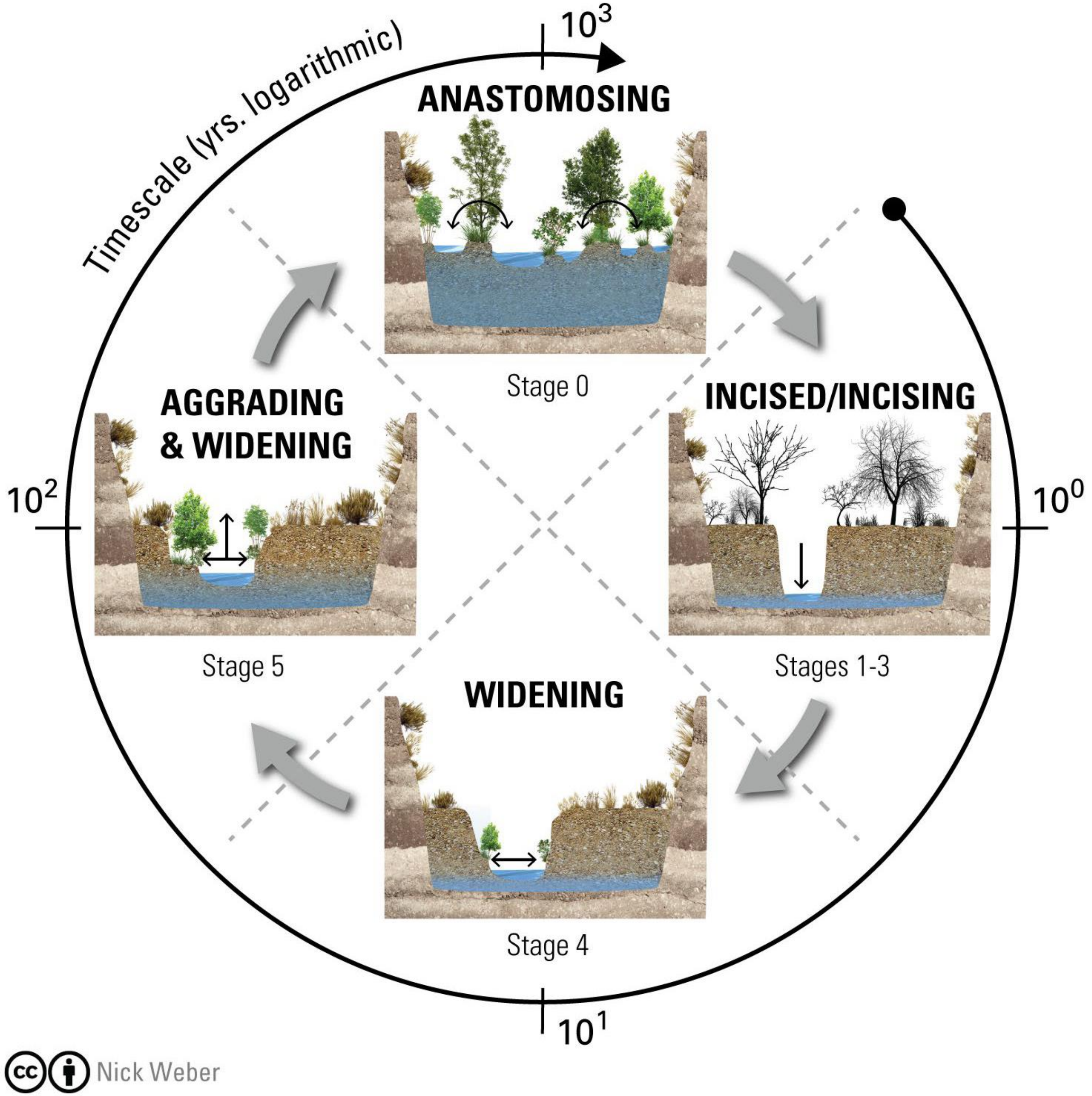
- Flows
- Habitat Types
- Vegetation
- Bugs
- Fish

Structure Comes in many forms

'Slash Ain't Trash, It's Beneficial Biomass!' – Brock Dolman
Occidental Arts and Ecology Center:
https://oaec.org/forest-thinning-and-gully-repair/

Goals and Objectives for Depositional Habitats

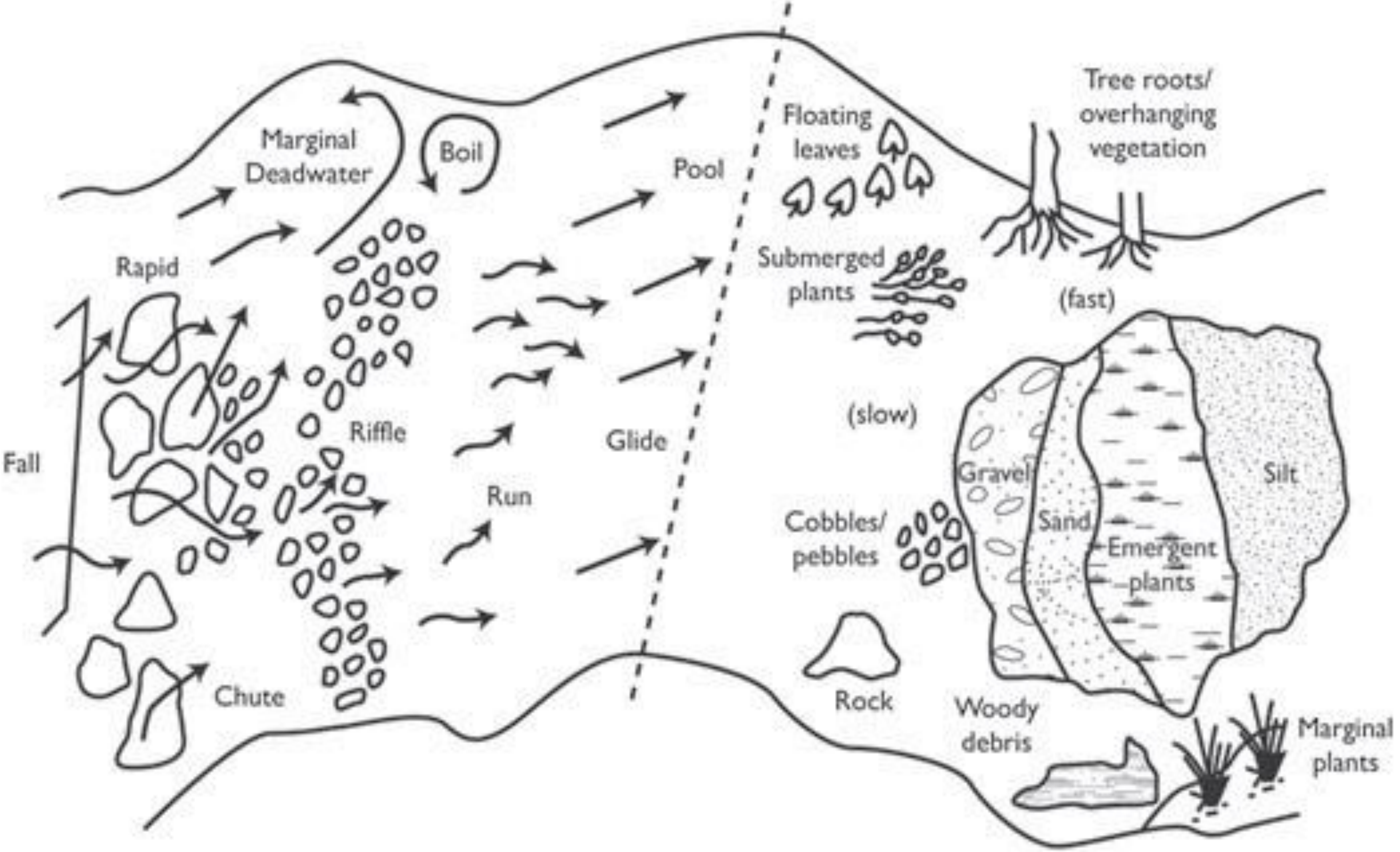
- Multi-thread, Anastomosing channel
- Fully connected Floodplain
- Use structure to force complexity
- Reduce and capture unchecked bank erosion and sediment loss from the system
- Encourage Sediment Deposition and Aggradation
- Increase Hydraulic Complexity, Sediment sorting
- Increase area of Active Valley Bottom



Adapted from Cluer and Thorne 2014

Designing Habitat for Specific Species

- Know all life history requirements, assess what you can and cannot affect
  - Example: Salmonid fish
    - Stream Passage: When do they need to move? How long? What are barriers to movement? Seasonal Volitional Passage
    - Spawning habitat (substrate size, depth, velocity, temperature)
    - Rearing habitat (food supply, flow, backwaters, floodplains, protection from predators)
    - Other issues: Disease, Non-native species, ESA listing
    - Make sure you don’t accidentally improve the habitat for undesirables
    - Make habitat diverse, the critter will decide what it likes, don’t get too hung up on form-based, deterministic design



Marginal Deadwater
Boil
Pool
Floating leaves
Tree roots/ overhanging vegetation
Rapid
Submerged plants
(fast)
Riffle
Glide
(slow)
Fall
Gravel
Silt
Run
Sand
Cobbles/ pebbles
Emergent plants
Chute
Rock
Woody debris
Marginal plants

Table IV. Scores for the physical and vegetative attributes for each stage in the Stream Evolution Model. Scores are based on an ordinal scale where 3 = abundant and fully functional, 2 = present and functional, 1 = scarce and partly functional and 0 = absent or dysfunctional

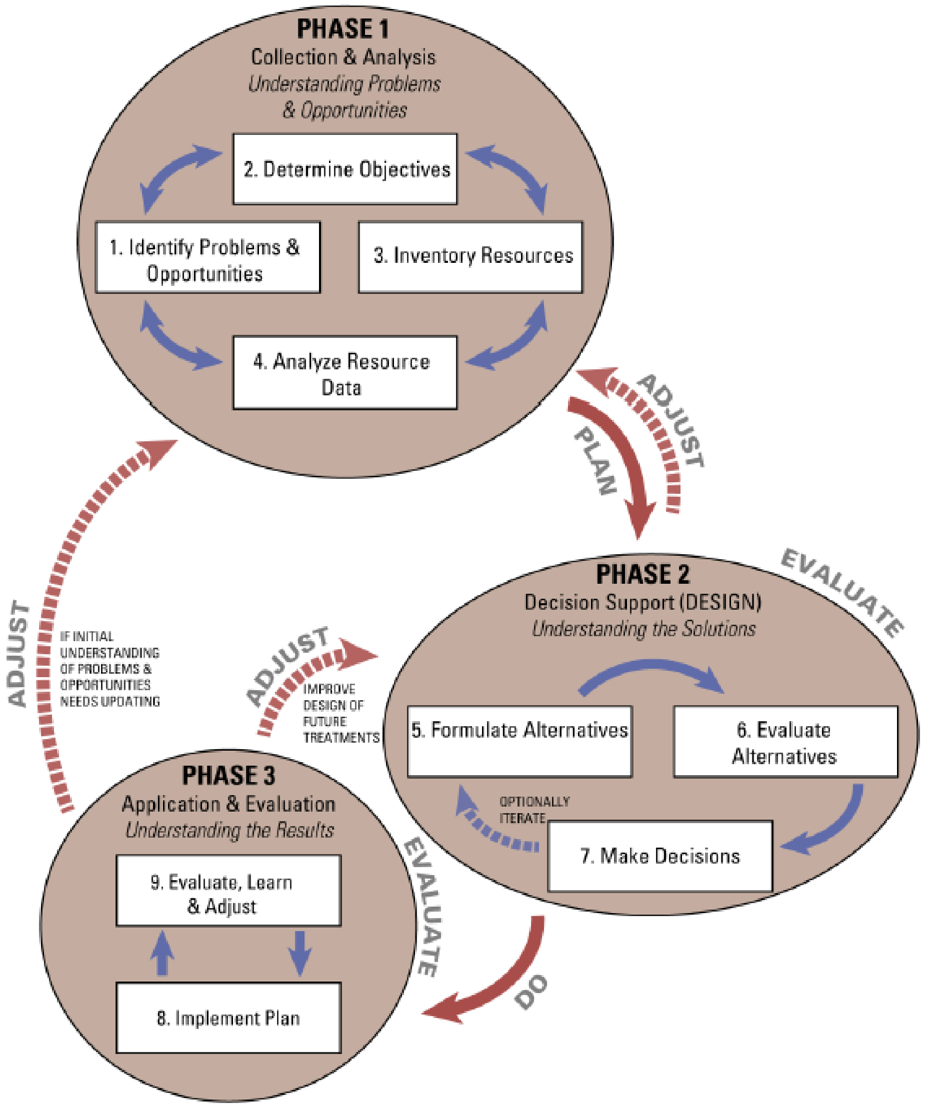
Hydrogeomorphic Attributes Table

Stage	0	1	2	3	3s	4	4-3	5	6	7	8
Physical Channel Dimensions											
Wetted Area Relative to Flow	3	2	1	1	1	0	0	1	1	2	2
Shoreline Length and Complexity	3	2	1	1	1	0	0	1	1	2	2
Channel and Floodplain Features											
Bedforms and bars	2	3	1	0	0	1	0	2	3	3	2
Islands	3	1	0	0	0	0	0	0	0	1	3
Local Confluence/Diffluences	3	1	0	0	0	0	0	0	0	1	3
Stable banks	3	2	2	2	2	0	0	1	2	2	3
River cliffs	2	2	0	1	2	2	2	2	1	2	2
Riparian Margins	3	2	1	1	1	0	0	1	2	2	3
Floodplain Extent and Connectivity	3	3	1	0	0	0	0	1	2	2	2
Side channels	3	2	0	0	0	0	0	0	1	2	2
sediment storage	3	2	1	0	0	0	0	0	1	2	3
Connected Wetlands	3	2	1	0	0	0	0	0	0	1	2
Substrate											
Substrate Sorting	2	3	0	0	1	0	0	1	1	2	2
Substrate Patchiness	3	3	0	0	1	0	0	1	2	3	3
Hydraulics											
Hydraulic Diversity	3	2	0	0	1	0	0	1	1	2	3
Marginal Deadwater	3	2	0	0	0	0	0	0	1	2	3
Vegetation											
Aquatic plants	3	2	1	0	0	0	0	1	2	2	3
Emergent Plants	3	1	1	1	1	1	0	2	2	1	3
Riparian plants	3	2	0	0	1	0	0	1	1	2	3
Floodplain plants	3	3	2	0	0	0	0	0	1	2	3
Woody debris	3	1	0	1	1	2	1	2	2	1	3
Leaf litter	3	2	0	1	2	0	0	1	2	2	3
Hydrological Regime											
Flood pulse	1	1	2	3	3	3	3	2	2	1	1
Flood attenuation	3	2	1	0	0	0	0	0	1	2	3
Base flow	2	3	1	0	0	0	0	0	1	3	2
Hyporheic connectivity	3	3	2	0	0	0	0	1	2	3	3
Results											
possible	78	78	78	78	78	78	78	78	78	78	78
sum	72	54	19	12	18	9	6	22	35	50	67
ratio	92%	69%	24%	15%	23%	12%	8%	28%	45%	64%	86%

Table V. Scores for the habitat and ecosystem benefits for each stage of the Stream Evolution Model. Scores are based on an ordinal scale where 3 = abundant and fully functional, 2 = present and functional, 1 = scarce and partly functional and 0 = absent or dysfunctional

Habitat and Ecosystem Benefits Table

Stage	0	1	2	3	3s	4	4-3	5	6	7	8
Habitat											
Flood Refugia	3	2	0	0	0	0	1	1	1	2	2
Drought Refugia	2	3	0	0	0	0	0	0	1	3	2
Exposed tree roots	3	1	0	1	1	1	0	0	1	1	3
Water Quality											
Clarity	3	2	1	0	0	0	0	1	2	2	3
Temperature amelioration (shade and hyporheic flow)	3	3	1	1	2	0	0	1	2	3	3
nutrient cycling	3	2	1	0	0	0	0	1	1	2	3
Biota											
Biodiversity (species richness and trophic diversity)	3	2	0	1	1	1	1	1	1	2	3
Proportion of Native Biota	3	2	1	1	1	1	1	1	1	2	3
1st and 2nd Order Productivity	3	2	1	1	2	1	0	1	2	2	3
Resilience											
Disturbance	3	3	1	0	1	0	0	1	1	2	2
Flood and Drought	3	2	0	0	1	0	0	1	2	1	2
Results											
possible	33	33	33	33	33	33	33	33	33	33	33
sum	32	24	6	5	9	4	3	9	15	22	29
ratio	97%	73%	18%	15%	27%	12%	9%	27%	45%	67%	88%


PHASE 1
Collection & Analysis
Understanding Problems & Opportunities
2. Determine Objectives
1. Identify Problems & Opportunities
3. Inventory Resources
4. Analyze Resource Data
ADJUST
PLAN
PHASE 2
Decision Support (DESIGN)
Understanding the Solutions
EVALUATE
5. Formulate Alternatives
6. Evaluate Alternatives
OPTIONALLY ITERATE
7. Make Decisions
DO
ADJUST
IF INITIAL UNDERSTANDING OF PROBLEMS & OPPORTUNITIES NEEDS UPDATING
ADJUST
IMPROVE DESIGN OF FUTURE TREATMENTS
PHASE 3
Application & Evaluation
Understanding the Results
EVALUATE
9. Evaluate, Learn & Adjust
8. Implement Plan

PBR Principles

- Do No Harm
- Use Natural Materials
- Use Natural Energy Sources as much as possible
- Connect Upland to Riparian Processes (Slash ain’t Trash!)
- Build Redundancy and Resiliency
- Let the system decide
- Process is iterative and adaptive
- Structure Drives Complexity and Complexity Drives Diversity