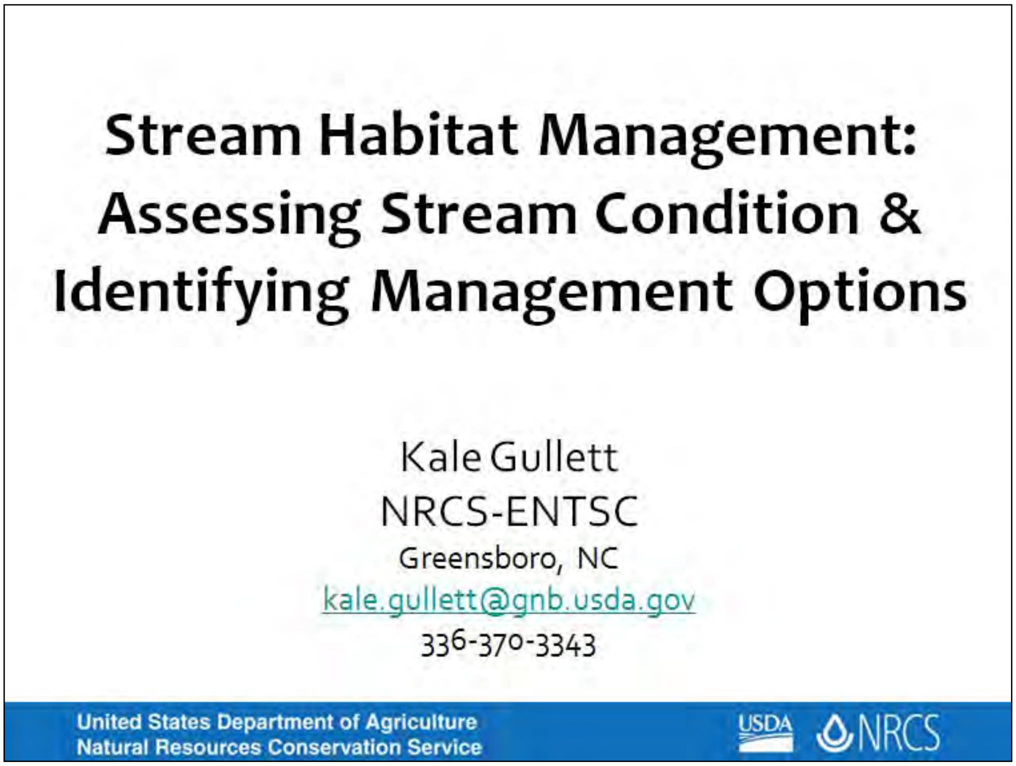


Hello, and thanks for the introduction, Holli.

So, today I hope to provide insight into the world of stream habitat management. As with other webinars, I'll go over a whole lot of material without the luxury of much detail. So, please feel free to contact me at any time to further discuss or get additional information on anything I talk about today.

If you think of a question during the show, type it into the box and we'll get to any and all at the end.

An apology…

- The following information assumes some familiarity with concepts of hydrology, fluvial geomorphology, and river ecology.
- "River Science (Hydrology and Fluvial Geomorphology) for Non-engineers: Basic principles, terms, and tools to aid conservation planning"—July 25, 2012.

I need to start with an apology of sorts. Much of what I'm about to go over assumes some familiarity with concepts of hydrology, fluvial geomorphology, and river ecology.

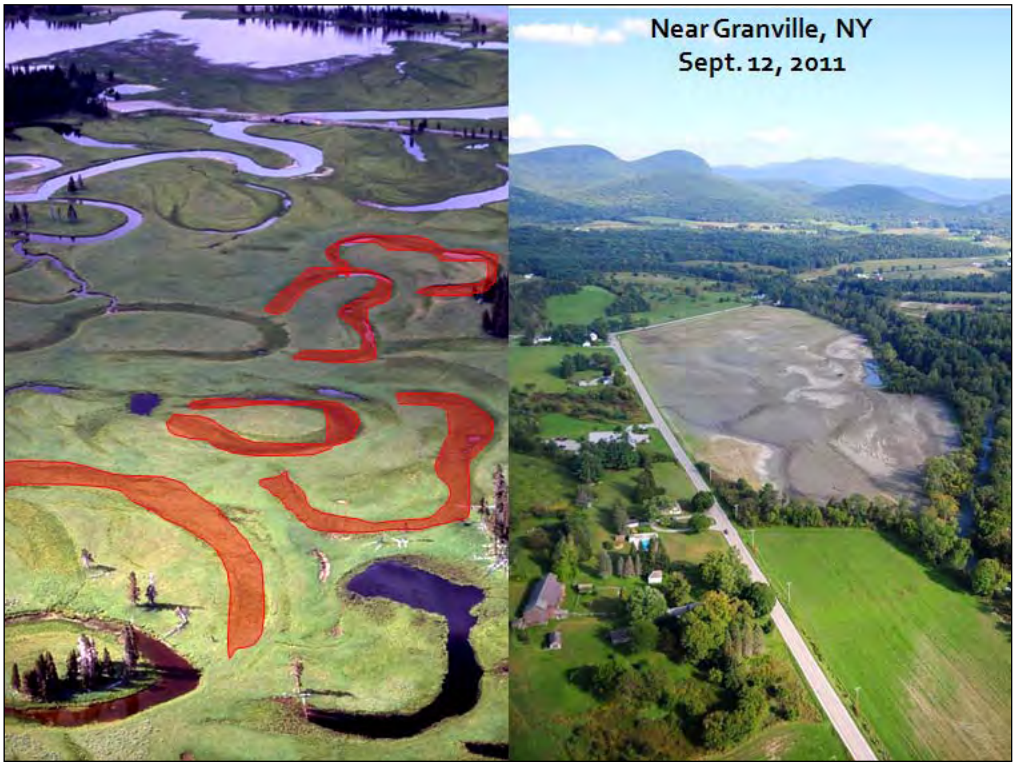
I'm planning to do another webinar this July that covers some basic principles and terms of hydrology and fluvial geomorphology for non-engineers. Sort of the cart before the horse, but its an artifact of the choreography of these seminars and the order in which I proposed some topics. I'll try to minimize the use of jargon as much as I can, but some will be necessary.

Regardless of your level of expertise or educational background related to rivers, I think most people have a gut reaction to the how a stream looks when they first visit a site. That little voice in your head says “this seems pretty nice” or [CLICK] “wow, what happened here” or [CLICK] just plain “wow”.

Sometimes this qualitative reaction can be spot on as far as judging stream condition. Sometimes streams are messy and what we think may be fairly degraded may be relatively predictable or expected. Sometimes what looks like good habitat is actually an ecological desert.

I'd like to start today by outlining the physical basis of stream habitat and river ecology.

By just about any definition, rivers and streams are systems, and many systems are simple machines that manage power to accomplish a task. In this context, the primary task rivers are responsible for is landscape change. Gravity is the basic energy source, water does most of the work, and rocks, soil, streamside vegetation and large woody debris provides some resistance to erosional processes.



Before we go any further, I want to touch on something that I think gets overlooked or underemphasized when it comes to work associated in and around rivers--floodplains. Most rivers have floodplains of varying magnitudes, and [CLICK] evidence of prior channel positions over time can often be seen in aerial photography.

In landscapes with a long and extensive history of development [CLICK] society tends to forget about floodplains, and reminders can often be sudden and painful as recently seen in the northeast last summer when Hurricane Irene swept up the coast. Here, the road fill defined the lateral extent of the floodplain, and the main channel of the river could easily have ended up in the middle of this farmed field. The river put that material there, and it can basically return for it at any time.

In any discussion of river function, channel stability, and habitat quality, floodplains cannot be uncoupled or considered separately from their river channel.

So, river channels and floodplains are coupled together but it takes time to make that connection. When you consider any drainage basin [CLICK], with a river running down through it [CLICK], a number of variables regulate how that river will look, what animals will live in and around it, and what vegetation will grow alongside it at any point downstream.

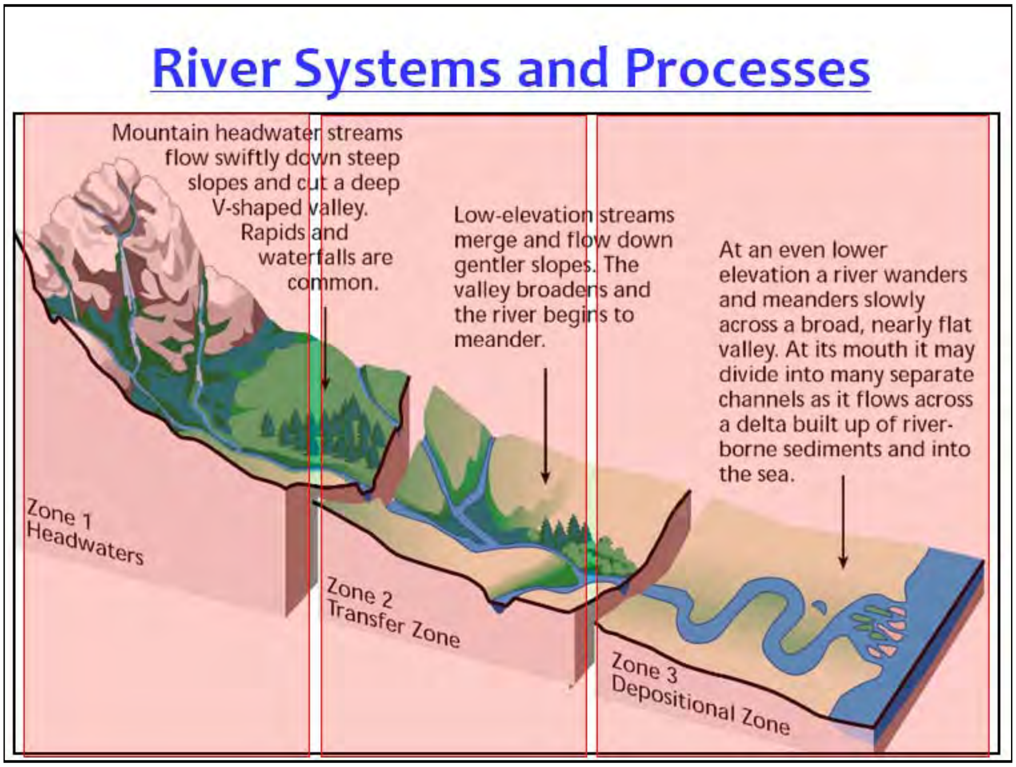
Governing Variables

- Climate, geology, topography, vegetation, and land use govern streamflow, large wood, and sediment balance.
- River channel and floodplain morphology (width, slope, depth, pattern, etc.) adjusts to prevailing regime. Vegetation moderates adjustments.

A few large-scale physical sideboards dictate the way river basins look and function.

Climate, geology and the physical geography of a watershed govern the amount of water and sediment a river will process on any given day of the year.

River channel and floodplain geometry adjust themselves to the prevailing precipitation and sediment regime, and vegetation helps to moderate the magnitude of these adjustments.

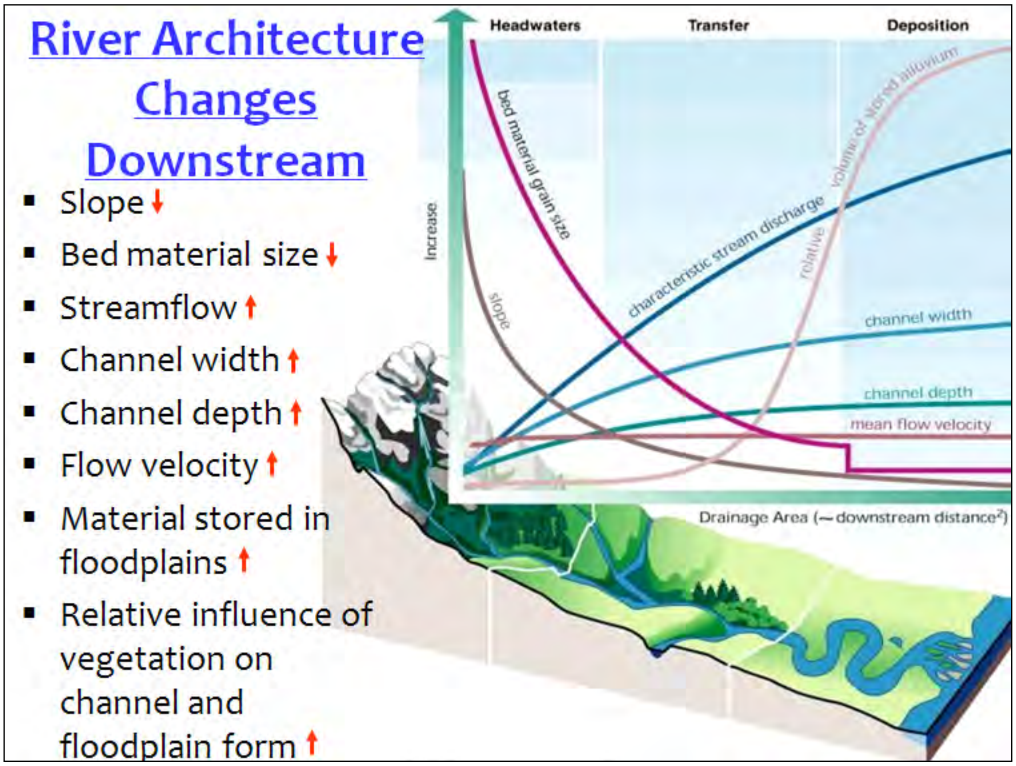


In simplest terms, river systems can be broken into 3 component parts within a given watershed, each interacting with and driven mostly by gravity, water, and the materials it carries. However, in each zone at all scales, river systems must find a way to expend excess energy to maintain equilibrium.

[CLICK] Zone 1, the headwaters or uppermost reaches of a stream, serves as the supply zone. Erosional processes are most pronounced here as surface landforms are often younger, climate, precipitation, and topography are at the extreme end of the spectrum, and gravity is steeper across smaller spatial scales.

[CLICK] Zone 2 – also known as the Transfer Zone – is where rivers respond to materials delivered from upstream reaches. Floodplains become more extensive, channel morphology can be diverse, and streamside vegetation plays a bigger role in floodplain and channel structure and function.

[CLICK] Zone 3 – the Deposition Zone – is where we see the largest rivers in a given landscape, extensive floodplains, high species diversity in plant and animal communities, and a receiving water body which serves as the ultimate base level for the system.

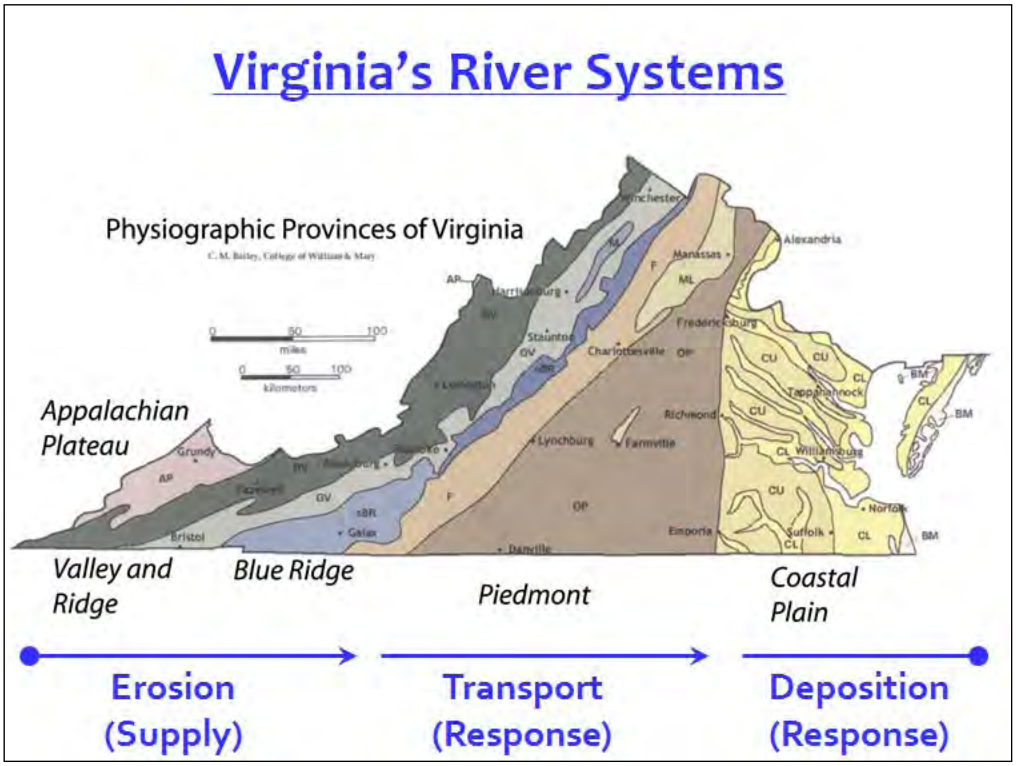


Assuming that river systems are organized from headwaters downstream, we can make some generalizations about the general architecture of any river along its course.

As you move downstream, slope and the average size of bed material decreases.

Streamflow, channel width, depth, and average velocities increase.

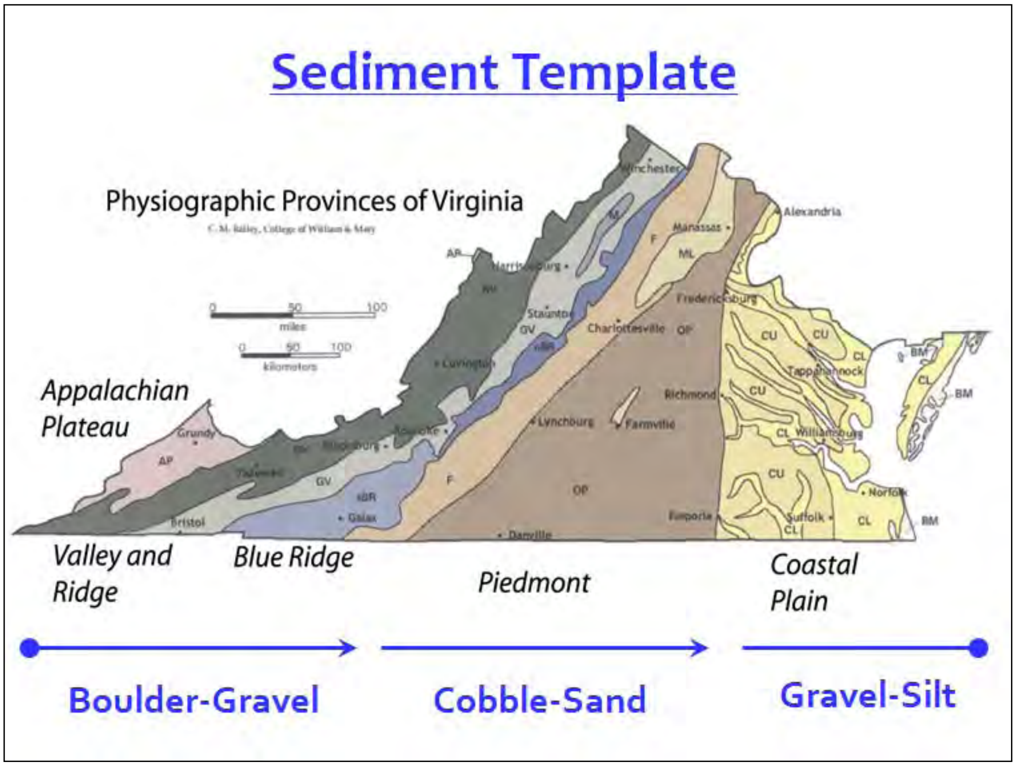
In addition, the average amount of sediment stored in the channel and floodplain increases, as does the relative influence of vegetation on channel and floodplain form.



When applied to any larger geographic region, you can make broad scale assumptions about river zonation and general architecture.

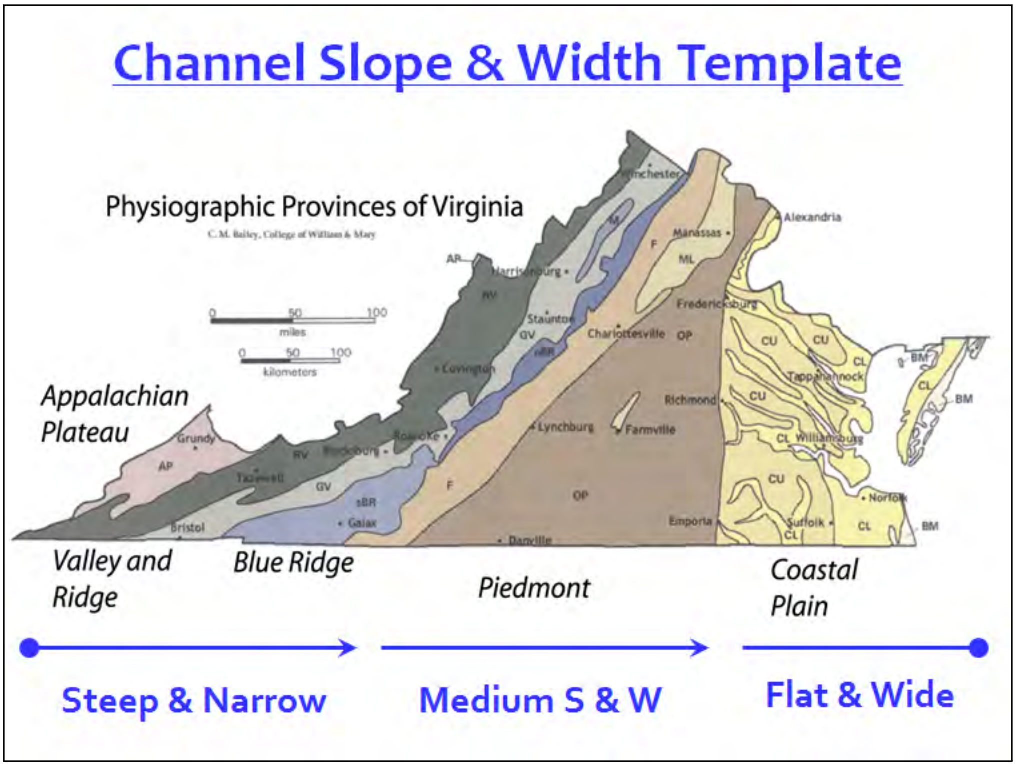
Consider Virginia, with mountains in the west, a broad piedmont along the middle, and a coastal plain down the eastern margin.

[CLICK] Comprised of 5 physiographic provinces, the state can also be broken into broad categories of erosion, transport, and deposition moving from west to east.

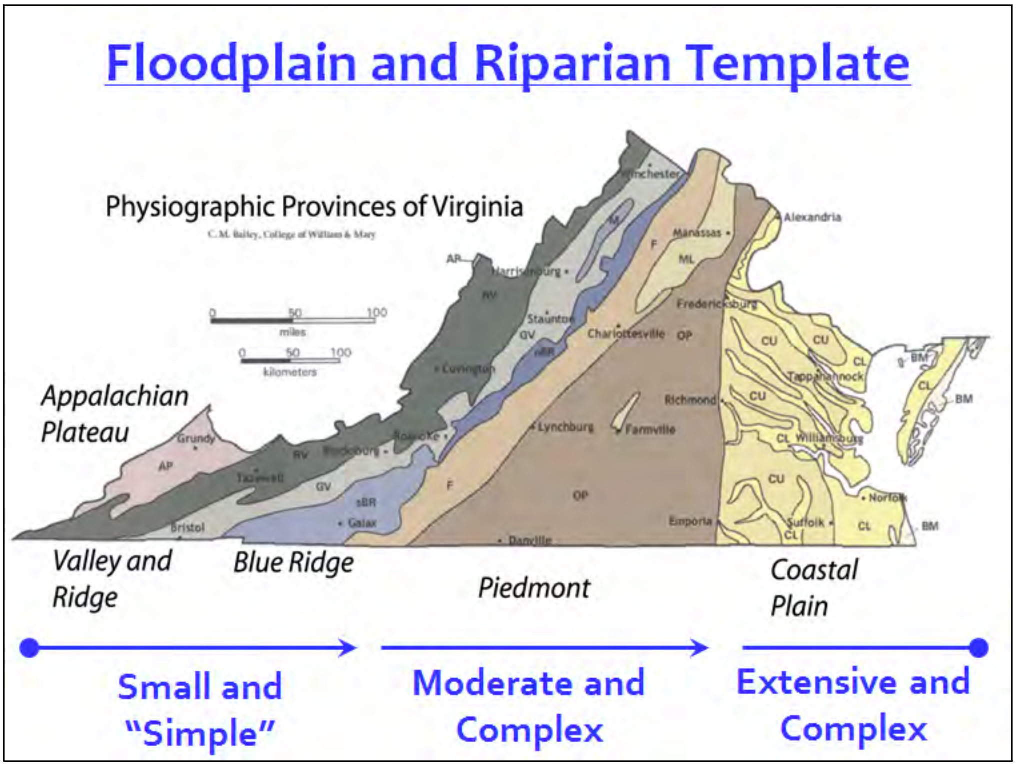


Drilling down, you can assume a template for average sediment size according to physiography and changes in river architecture.

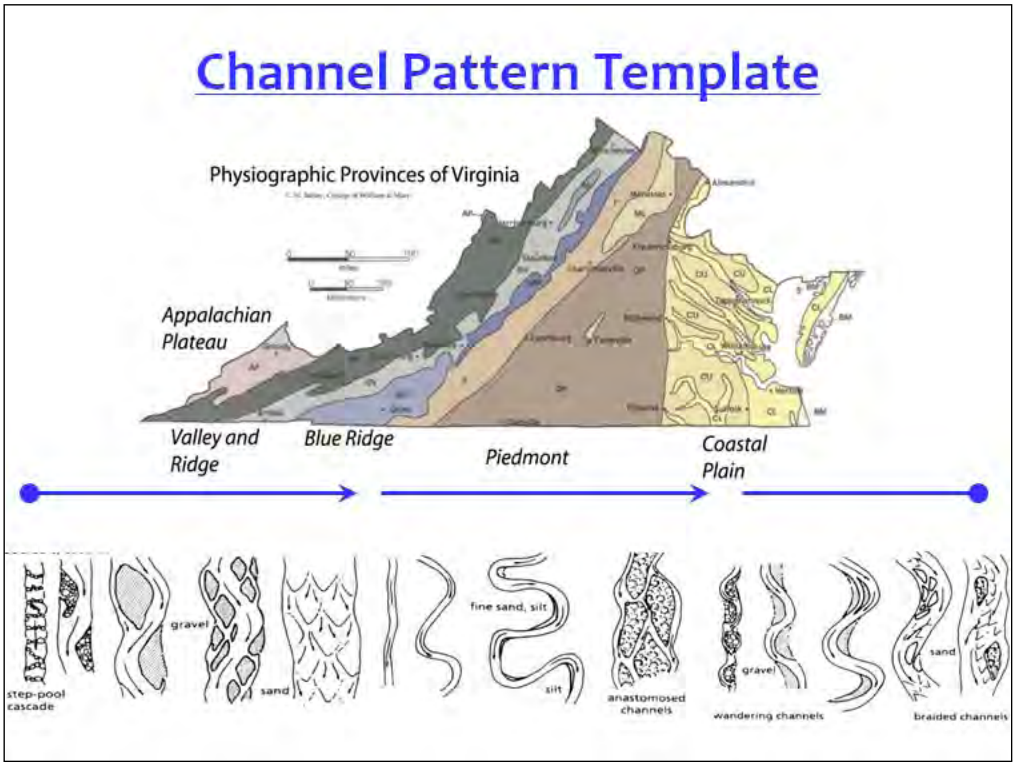
Larger material in the steeper parts of the state transitions to smaller sediments along coastal depositional environments.



Channel slope and width can be generalized as well. Steep narrow channels widen and become flatter as you move toward the ocean.



Floodplains and riparian complexes also change from west to east, ranging from relatively narrow bands composed of a few species to extensive swaths covered by a broad range of vegetation at the coast.



Combining sediment, slope, and vegetative influence gives insight into the range of possible channel patterns.

In broad terms, channels in mountainous regions are dominated by coarse sediment and woody debris-forced morphology which transitions to meandering streams bracketed by sometimes extensive floodplains floored with finer depositional materials held together by a complex mosaic of floodplain riparian vegetation.

So, when you think about a drainage basin in your area and get a mental picture of how a river changes from its headwaters on down[CLICK], hopefully you'll agree that there are some general similarities amongst streams across landforms in a watershed.

Up high [CLICK], they're a steeper with larger bed materials, less developed floodplains, and vegetation adapted to higher elevations and climatic differences.

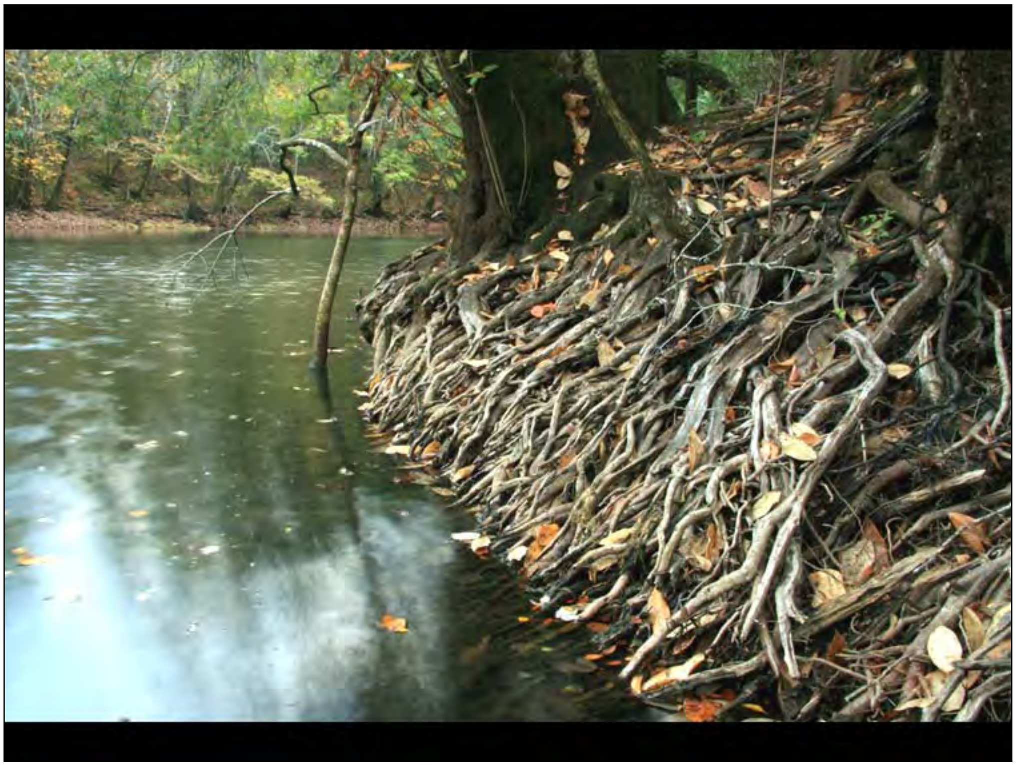
[CLICK] Moving down the watershed, slopes even out, rivers get bigger, substrate sizes decrease, floodplains are more pronounced, and vegetation changes to the prevailing conditions.

Floodplains shouldn’t be uncoupled from stream channels in any discussion about rivers. Twenty years ago, the influence of riparian vegetation on channel morphology wasn’t really given the attention it deserved. But, streamside trees recruited into a channel as it interacts with its floodplain strongly influence how a river channel looks and processes water and sediment.

Floodplain vegetation also plays a big role in creating and maintaining floodplain surfaces. This photo illustrates fine sediment deposition on a floodplain after an overbank flow event.

When channel changes occur, floodplain vegetation influences bedload deposition.

This photo illustrates coarse sediment deposited as a plug behind a log jam at the head of a former channel following a high flow event. Over time, this depositional wedge may be colonized by vegetation, but it definitely serves as a sediment storage site that influences system stability.



And in many river settings, stands of native trees like these water tupelo have roots that do a heck of a job maintaining bank stability and channel morphology.

River Classification Schemes

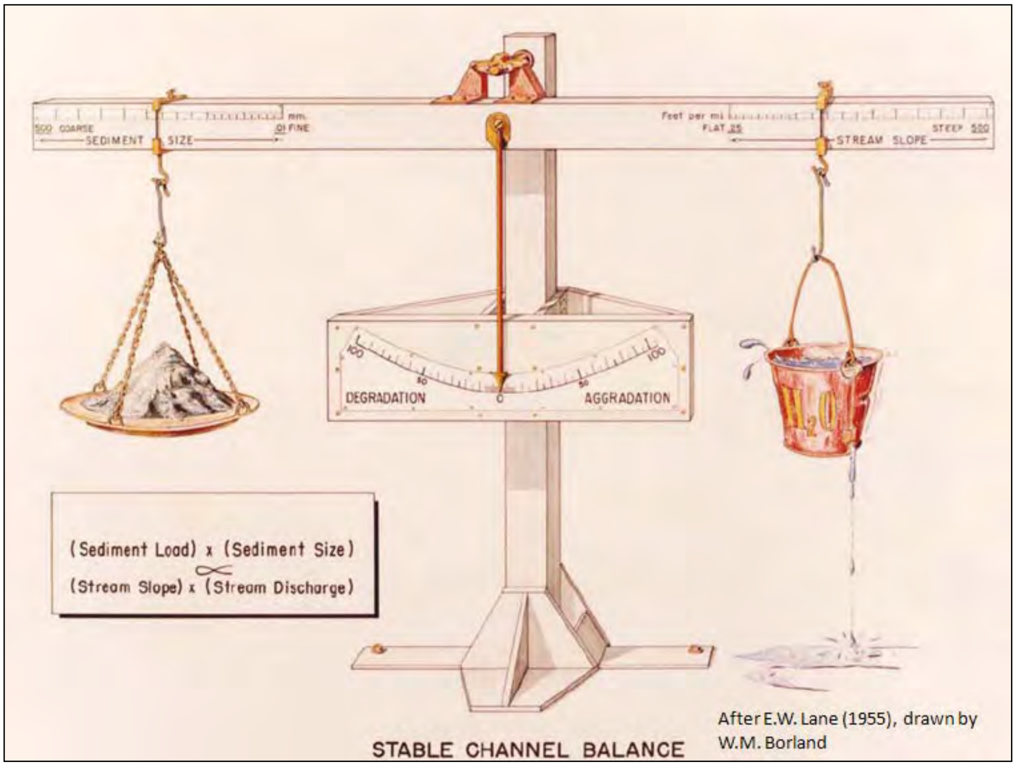
- **Schumm, Harvey and Watson (1984)**—“Incised channels: morphology, dynamics, and control”
- **Rosgen (1994)**—“A classification of natural rivers”
- **Montgomery and Buffington (1997)**—“Channel-reach morphology in mountain drainage basins”
- **Brierley and Fryirs (2000)**—“River Styles… ”

So, all of the stuff I’ve just covered—relationships between geology, physiography, sediment, slope, woody material, and vegetation—provides the basis for many of the river classification schemes out there that attempt to categorize and describe channel configuration.

These are some of the most common approaches you will encounter, each has its strengths and weaknesses, and their foundations range from process-based models to snapshots of channel morphology at the time you visit a site.

Expected or reasonably predictable channel and floodplain features take long periods of time to develop. Given slope and precipitation, you can generate a channel relatively quickly, as shown here after a forest fire. Although this channel has well defined banks and is floored with sediment, you'd be hard pressed to find repeated diagnostic elements that fit the channel according to many of the classification schemes shown in the preceding slide.

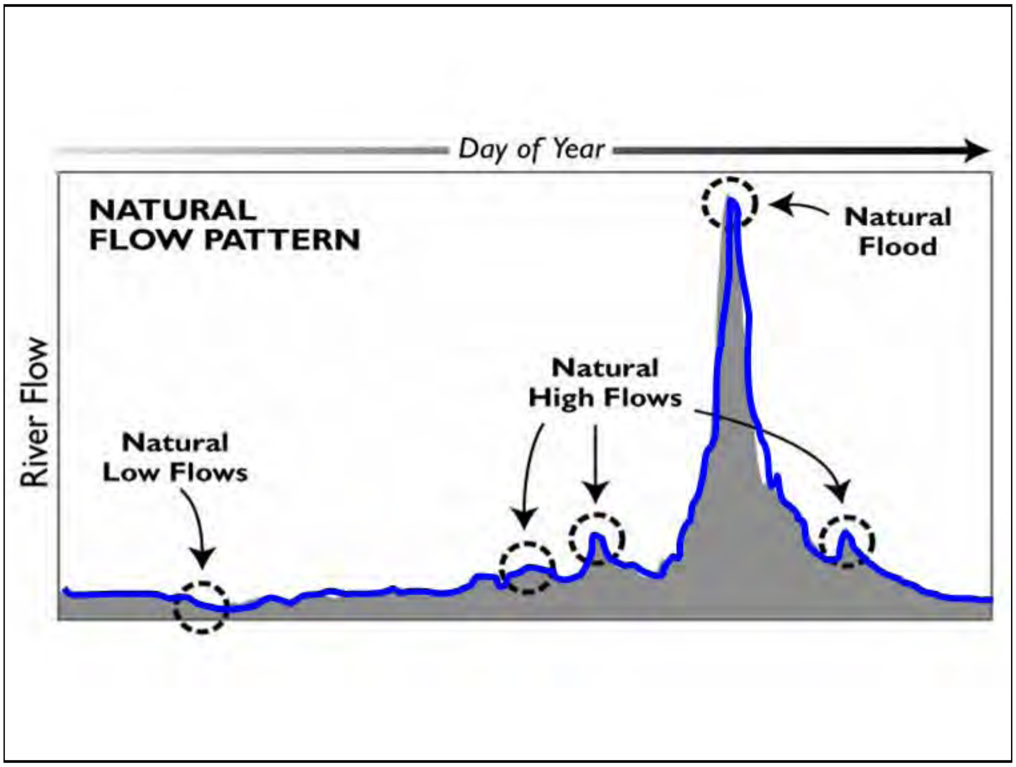
[CLICK] It takes time for river channels and floodplains to organize themselves and reach equilibrium. Conversely, it often doesn't take much time to upset that equilibrium.



Over time, river systems tend to reach a balance between streamflow and the materials it carries—mostly sediment and wood.

Many of you may have seen this little ditty, known as Lane's Balance, originally used by the Bureau of Reclamation in the design of stable channels.

This simple tool illustrates how altering any one of four components forces channel adjustment because predictability and stability are dependent on a proportionality between the load and size of sediment and the slope and streamflow of a system.



Now for a bit about streamflow. Stream systems are created and maintained by precipitation that results in runoff and streamflow.

None of the classification methods on the previous slide blatantly include metrics that describe or incorporate the flow regime of a given river, even though the variables they all consider are dependent on a range of streamflow over time.

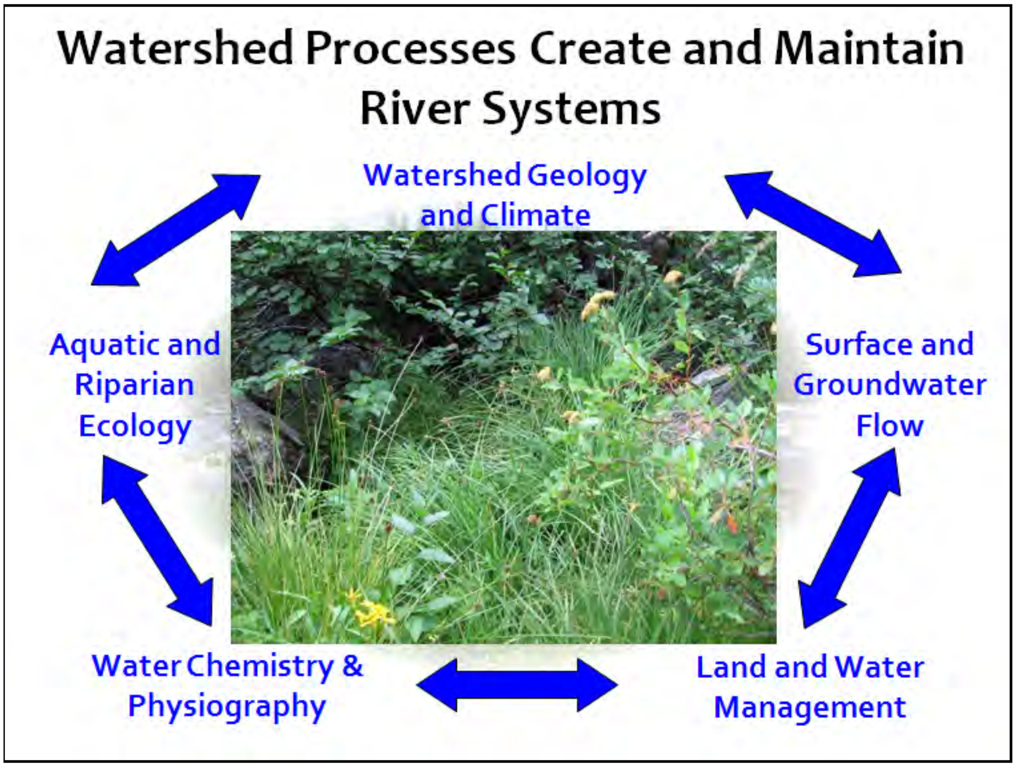
Streamflow Regime

- Streamflow powers the engine that creates and maintains riverine habitat.
- Sediment, riparian vegetation, and watershed metrics govern the amount of work a river can accomplish.
- Groundwater recharge keeps streams and riparia alive during periods of low or no precipitation.

Streamflow is the master variable with respect to its influence on river systems and habitat. There are virtually no elements of the physical, biological, or chemical structure and function of a river system that cannot be linked to it.

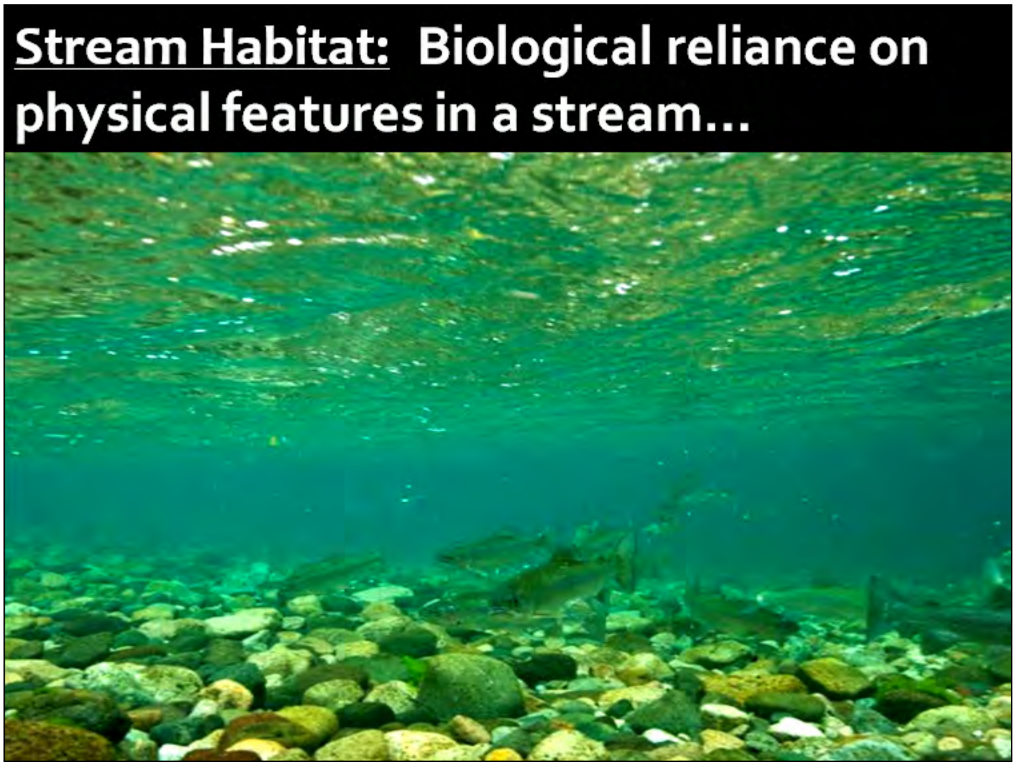
Sediment, riparian vegetation—both live and dead, and watershed conditions such as slope and geology, govern or throttle the amount of work a river can accomplish.

Precipitation that gets into the ground at all locations in a watershed returns to stream channels throughout the year, keeping streams and riparian areas going during times of low or no precipitation.



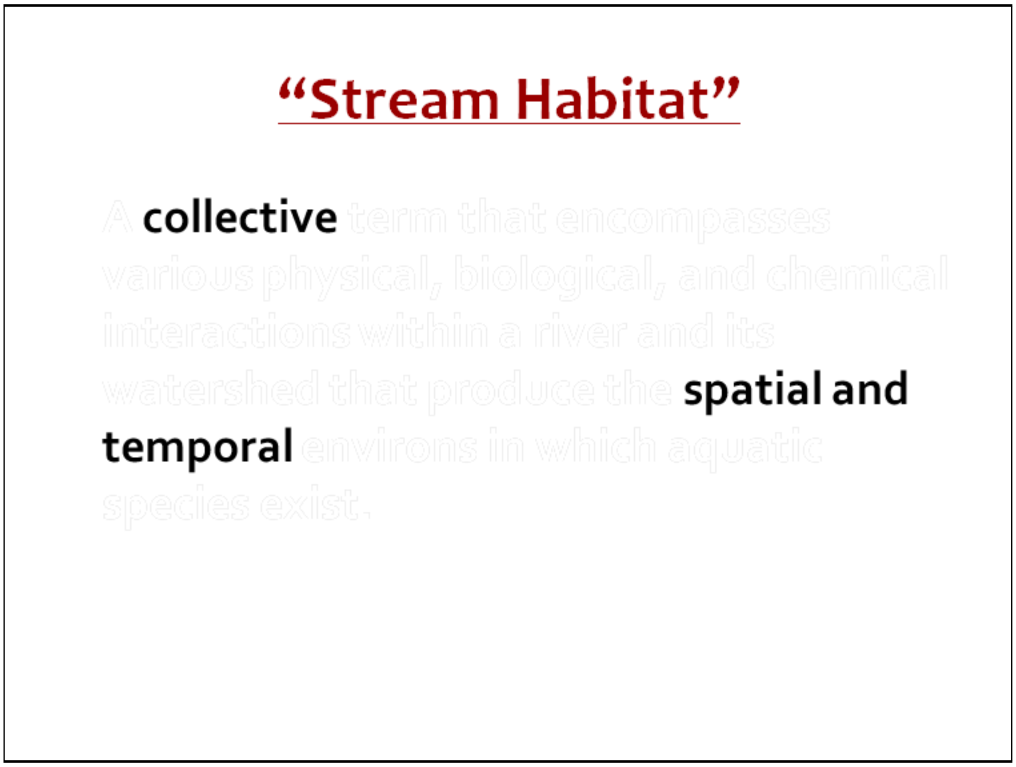
So, streams integrate all that happens upslope, and watershed processes create and maintain river systems.

[CLICK] Interactions between numerous physical, biological, chemical, and human factors affect the way a river looks and functions, and [CLICK] influences what we refer to as habitat for aquatic and [CLICK] streamside vegetation.



So, I've talked about and around the word habitat, and now I think we have the basis to provide a working definition. For today's purposes, lets use this: Stream habitat is biological reliance on physical features in a stream.

[CLICK] As a physical feature, substrate acts as the channel boundary, holds its position, and helps expend stream energy as roughness. [CLICK] In a habitat sense, it serves as substrate for the base of the food web that sustains populations of larger vertebrates. [CLICK] In a population sense, substrate supports the reproduction of a number of different aquatic animals—without a proper arrangement and availability of certain sizes of substrates, some populations cannot make it.



Stream habitat is a general term, and I bet if you were to ask 5 aquatic biologists the same question "what is aquatic habitat", you'd get at least 4 different answers. I've used this definition in the past, and it has its place, but is sorta clunky.

However, some key elements [CLICK] of this definition are collective, spatial, and temporal. Collective because the habitat in any river is used by more than one species with numerous life histories, spatial because habitat varies at all scales in a river, and temporal because habitat changes naturally over time, and species need time to develop and maintain a population.

River Ecology

- Relationship between riverine animals, physical habitat, and streamflow.
- Confined to water—can't walk or fly away if conditions deteriorate.
- Streamflow changes

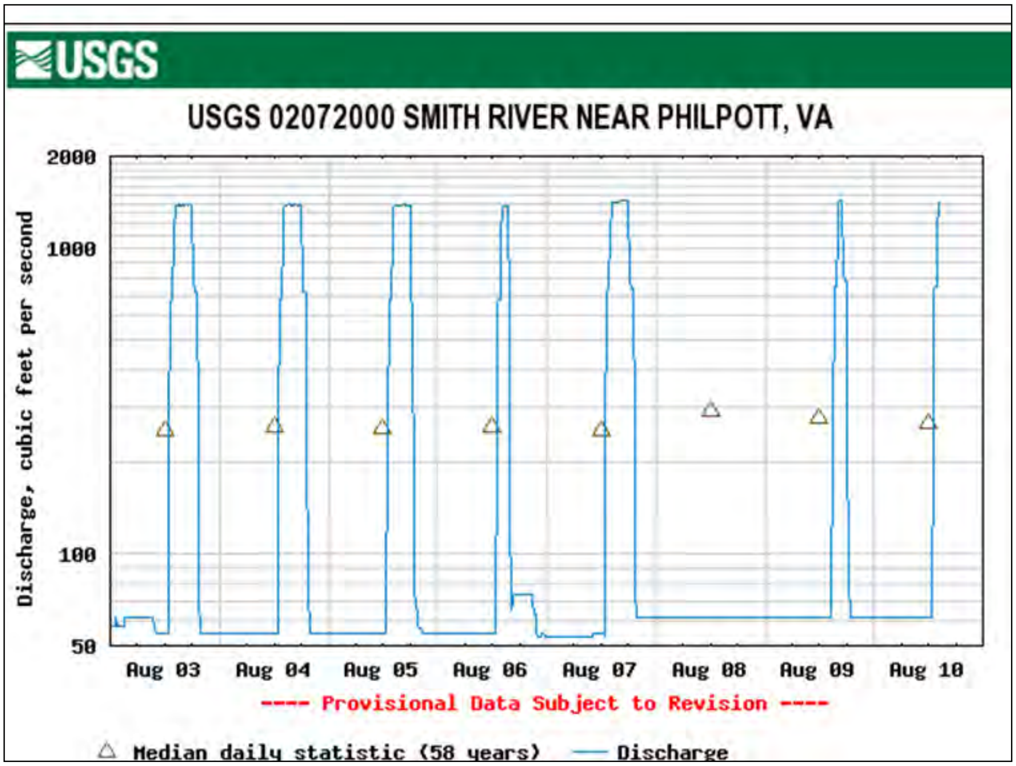
Streamflow Regime and Habitat

- Habitat requirement and usage by aquatic organisms changes by:
  - Life stage (juvenile vs. adult)
  - Time of day (nightime foraging)
  - Season (winter vs. summer)
- Because streamflow changes—naturally or artificially—across a given year.

Aquatic animals use river systems according to developmental stage, time of day, and season.

One major reason for this is that streamflow at any point in a river changes at various time steps—annually, daily, and even hourly in some cases.

Precipitation drives natural flow fluctuations across a given year, but the flow regime of many river systems has been modified to meet society's needs.



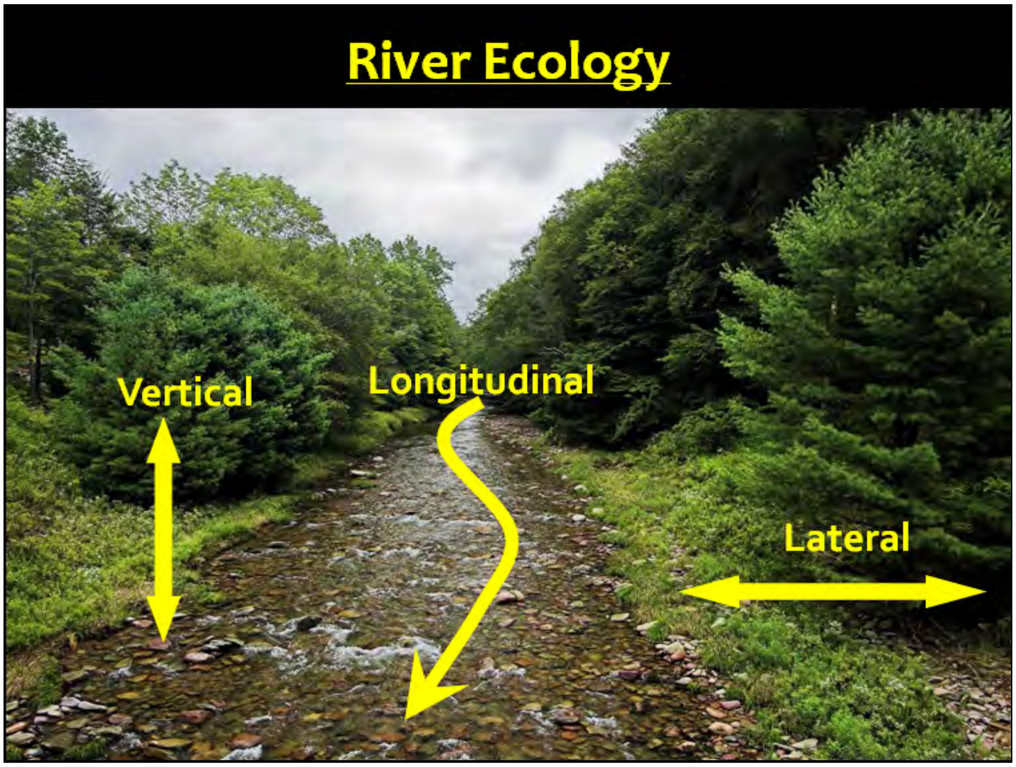
Here's an example hydrograph of flow regulation for hydropower production.

As you can see, daily streamflow in the Smith River below Philpott Dam in Virginia ranges from about 55 cfs up to 1500 cfs for a few hours when power is being made, and then drops off at night.

These data were collected during August of 2009, and the spikes correspond to demand during the hottest part of the day, especially when people get home from work.

How does that sort of manipulation affect a river? Here's an example, although not specifically in the Smith River. When the turbines are off, the river looks like this—[CLICK] I've roughed in the margins of the wetted channel with this red line. So do me a favor—pick a rock anywhere in the center of the channel and keep looking at it. [CLICK] When power is being made, streamflow jumps up and the river now looks like this. Chances are you can't see the rock you were looking at. [CLICK] After demand drops, power generation is curtailed and streamflow drops.

These rapid changes in flow have a pretty big effect on stream habitat and often, over time, influence river structure and function.



There are a lot of moving parts to River Ecology, and it helps to consider them in a few different dimensions.

(CLICK) Vertical – such as the contribution of large and small organic debris from riparian vegetation as well as the input of sediment from adjacent hillslopes

(CLICK) Longitudinal – which includes the transport and cycling of sediment, nutrients, and organic materials from headwaters to oceans. Or simply, water flows downhill…

(CLICK) and Lateral – the exchange of water and sediment between river and floodplain during overbank flows which helps replenish landforms and can recharge aquifers that bracket and underlie the stream. In fact, many aquatic animals count on access to floodplain habitats during some part of their life history.

River Continuum

- Rivers are dominated by geomorphic and hydrologic factors that create and maintain the drainage network
- Ecological communities are selected in response to these factors in a more-or-less predictable manner

As I mentioned earlier, we group aspects of watershed elements into classification systems that help us describe and predict channel morphology. In addition, we can look at flow histories in a given river system to gain insight into how precipitation is delivered and processed in a watershed.

Similarly, we can use these very same watershed and river attributes to describe and predict riverine communities. River ecologists call this the river continuum concept because the relative physical and hydrological changes along a river from headwaters on down also dictate ecological community distribution. These ecological communities include all organisms and vegetation, from algae to higher vertebrates like fish and amphibians.

So, using Virginia as an example, streams in the mountains look a lot like this, and [CLICK] brook trout and sculpin are common inhabitants.

Moving downslope into the foothills and piedmont, we see streams that look like this, inhabited by a more diverse community including sunfish and rock bass.

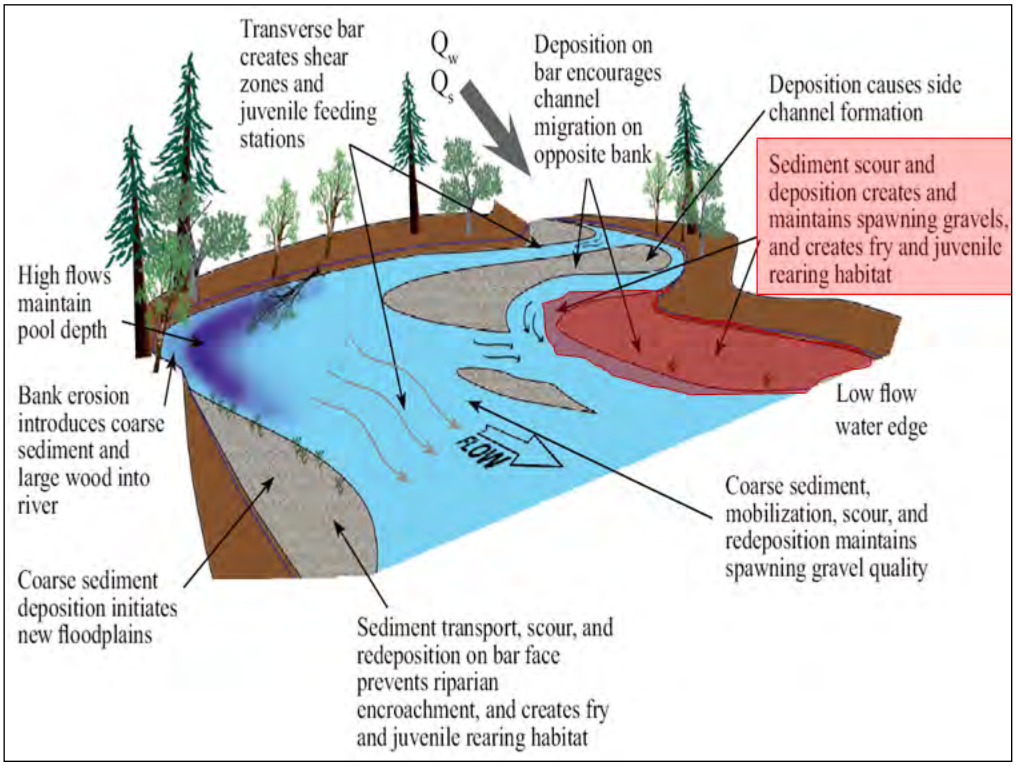
Further on into the eastern piedmont and coastal plain, rivers look like this and aquatic communities much more diverse. Common fishes include numerous species of catfish and large diadromous animals like striped bass.

River Continuum

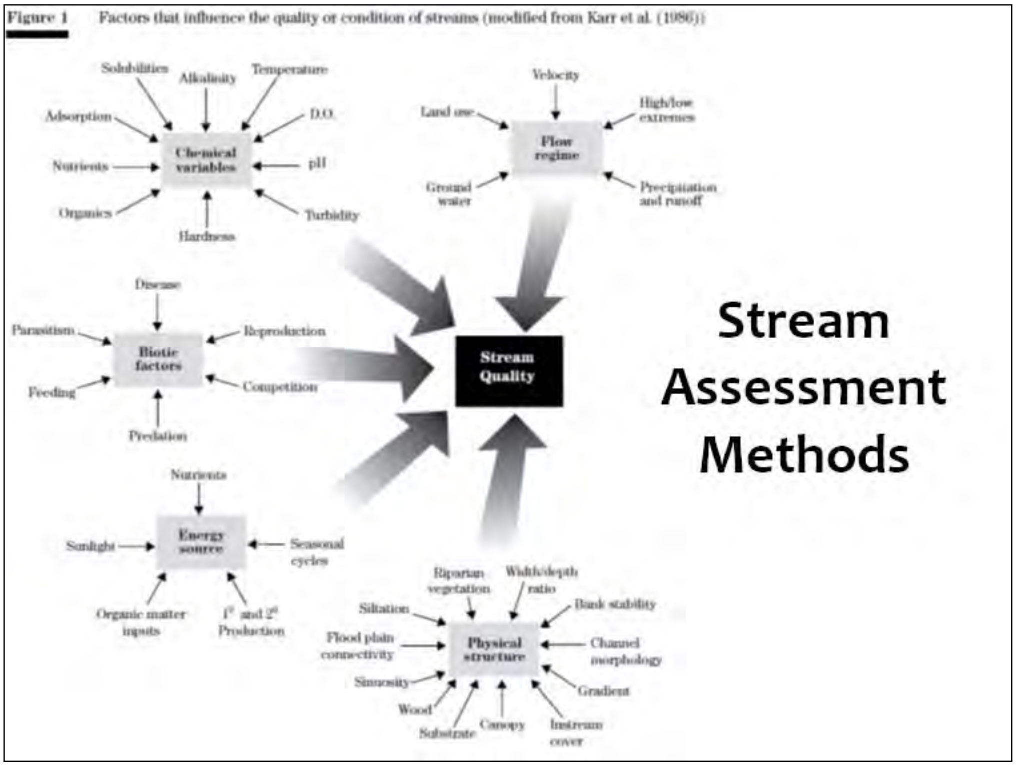
- River function is a gradient (continuum) that changes according to spatial scales
- Stream communities are in dynamic equilibrium with the stream—as the physical characteristics change, so will the biota

So, as rivers change, so do the animals that inhabit them.

Just as rivers try to maintain equilibrium with their watersheds, aquatic communities exist in a dynamic equilibrium with their habitat conditions. As the conditions change, so will the animals—communities can expand, contract, or blink out within a given river as habitat conditions respond to watershed changes.

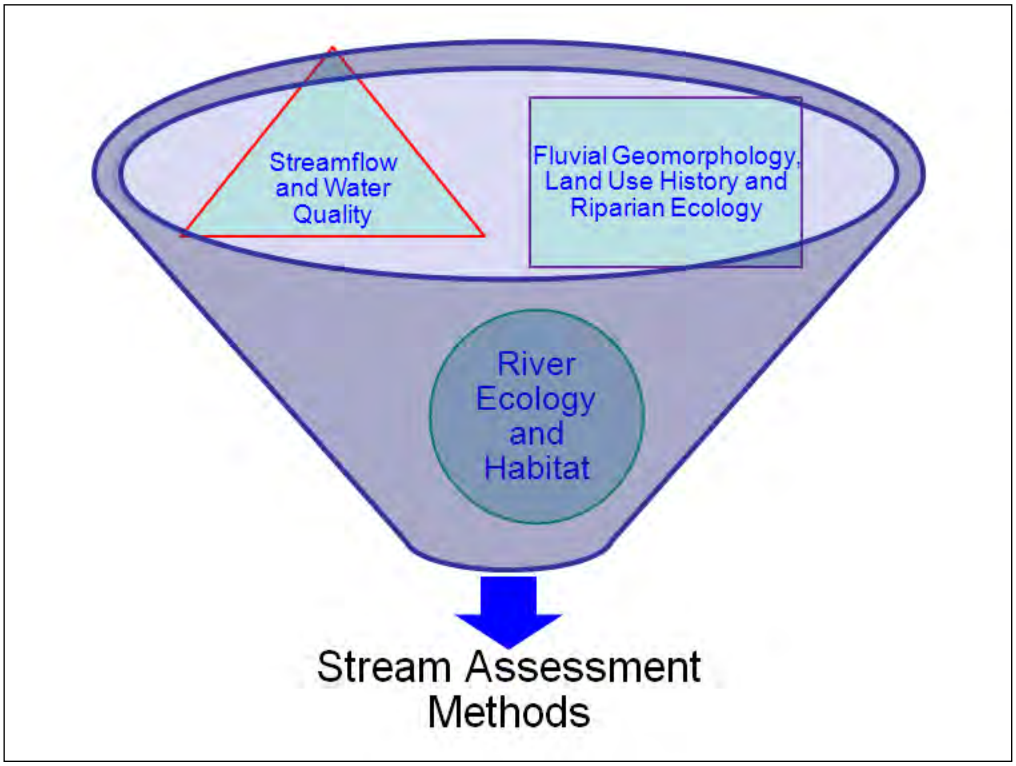


Combining all of this information into a reach of river allows us to use [CLICK] physical habitat processes and conditions to describe where species and age classes of aquatic animals will reside, and where certain types and ages of vegetation will be found. For example, [CLICK] areas where scour and deposition occur creates and maintains spawning gravels, fry and juvenile rearing habitat, and provides colonization sites for riparian vegetation.

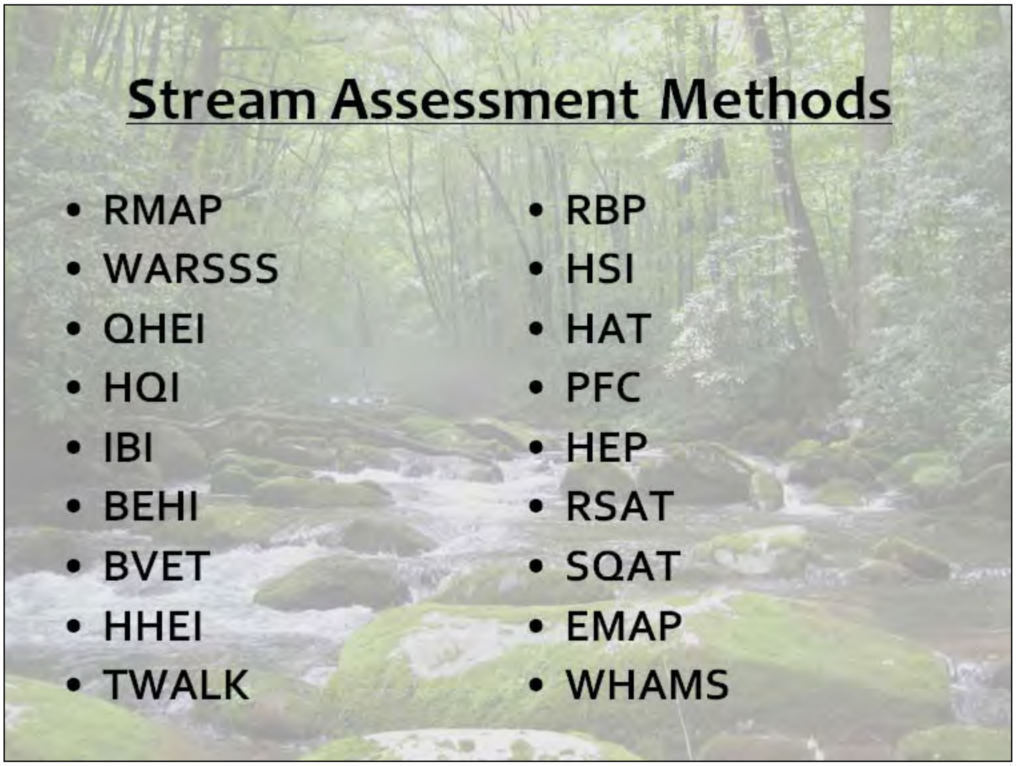


Alright, so I've talked about geomorphic and ecological classification schemes or models, but what about tools that characterize stream condition?

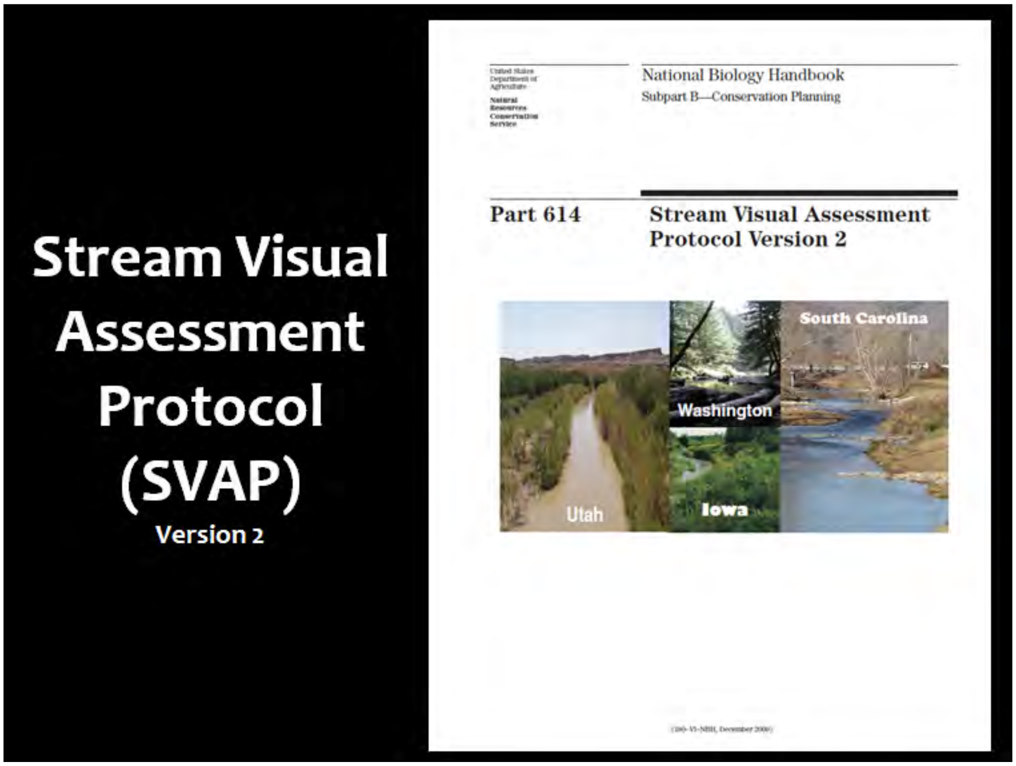
Stream assessment methods are intended to help make a little more sense out of complicated and somewhat hard to understand graphics like this. I don't like much about this figure or those like it, except to say that they try and illustrate the myriad factors and interconnected processes that create and maintain the functional health of a stream.



Stream assessment methods cram a range of different metrics into a process that funnels a cumulative consideration of many different elements of river science into a single method that describes stream habitat or health or condition.



When you start looking into stream assessment methods, you'll come up with an alphabet soup of acronyms related to various indices, systems, protocols, and procedures. Here are a few, gathered from my shelves and past experiences. Like the channel classification methods presented earlier, they each have a range of data requirements, necessary field equipment, and utility.



As many of you know, NRCS has its very own stream assessment method, known as the stream visual assessment protocol, or SVAP.

Version 2 was completed a few years ago, and I think it does a good job at what it was intended for—a qualitative analysis of a number of river elements that have strong linkages to overall river function and condition.

In addition, it allows us to benchmark the condition of a reach of river to either discuss possible management options with a landowner and, when done after completion of a project on the same reach, it allows us to illustrate the effects of conservation actions.

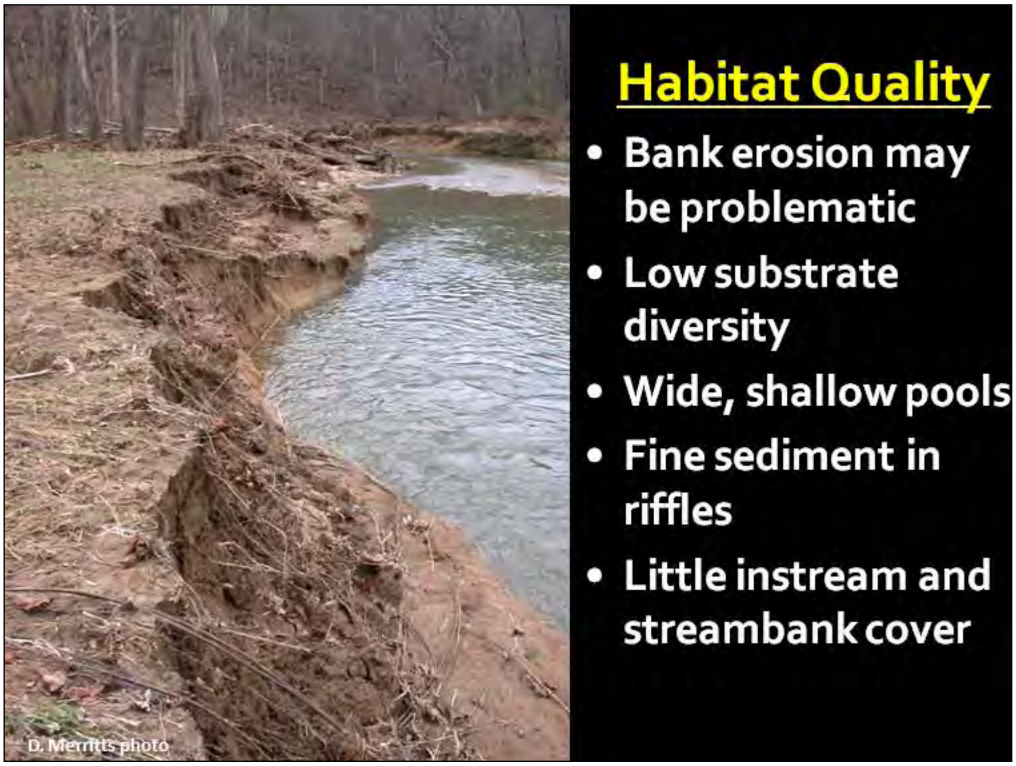
Stream Habitat Assessment

- Channel classification and stream assessment methods like SVAP2 supply a description of condition or relative function
- Don't really tell you the cause of degraded habitat
- Problems arise at the site scale when degraded habitat is noted and solutions are sought

Channel classification methods and stream assessment protocols help describe site conditions and provide insight into the relative functional condition of a reach of stream. However, one shortcoming of these tools is that they don't necessarily help you figure out what factors conspired to create the conditions you're seeing in the field.

This can be a problem when you're working on a project where a stream reach appears degraded and landowners are looking for help to address a resource concern or improve stream habitat.

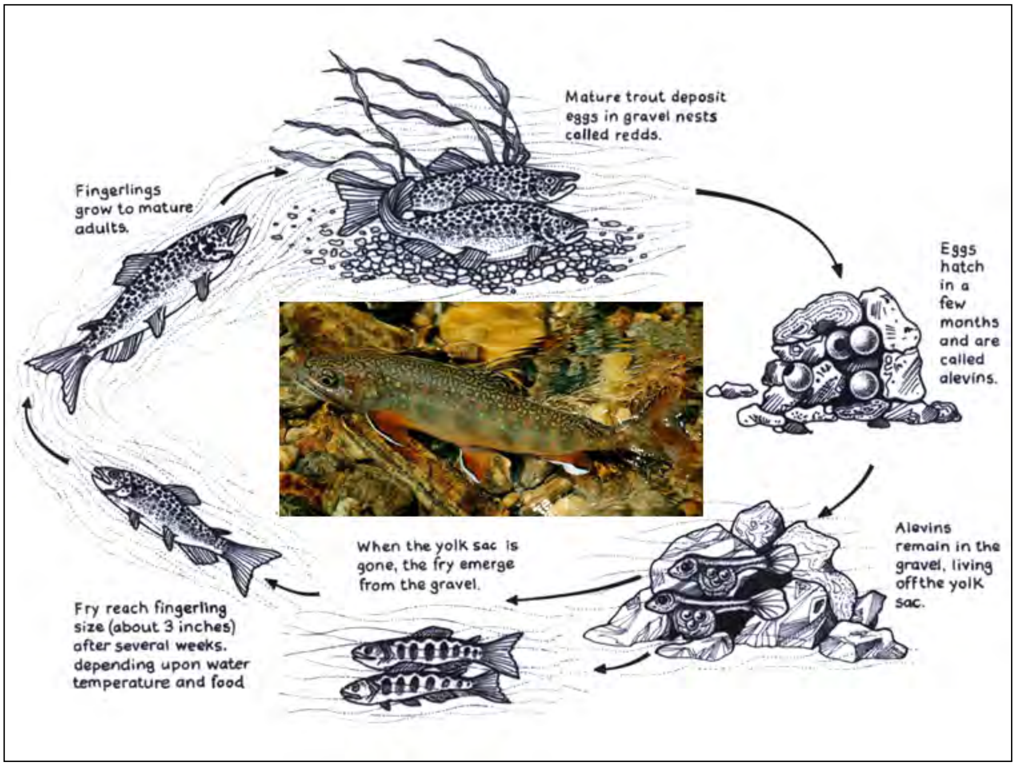
Sometimes the range of factors that have historically contributed to stream degradation are indicated by your first visit to a site.



In other cases, the range of factors that influence stream condition may not be as apparent. Consider this eroding bank along a stream in a mid-Atlantic state.

[CLICK] In addition to what may be a bank erosion problem, the streambed exhibits a lack of substrate diversity, pools are wide and shallow, riffles are embedded with fine sediment, and little instream and overhead cover provides food and habitat.

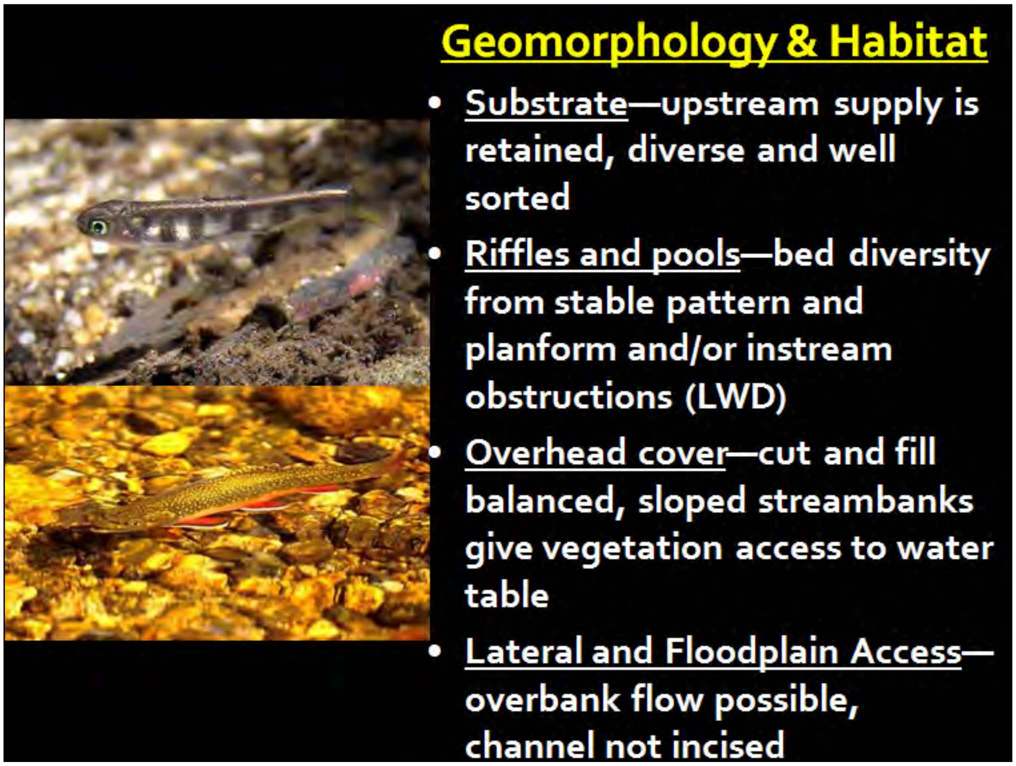
Let's say the landowner's goal is to improve stream habitat, especially to support a population of Eastern brook trout that are present on the property, but don't seem to do too well.



To maintain a brook trout population, each major life history stanza needs proper habitat. Brook trout have a gravel to gravel life history, meaning that they're born in gravel and thus need gravel as adults to reproduce.

Smaller fish—fry and juveniles—need shallow, low velocity areas underlain by sands and gravels with overhead cover because it offers shelter from bigger predators and supports the types of food items they use to grow and evolve.

To reach adulthood, brook trout require riffles composed of coarser material for food production, deep pools as cover from avian predators and refuge during low flow periods, bankside overhead cover that also produces food, and access to side channel and floodplain habitats as refuge during high flows.



Continuously growing brook trout from eggs to adults in a stream requires functional geomorphic processes in the stream channel. Relating the habitat descriptions I covered in the previous in terms of necessary geomorphic functions might look something like this. [CLICK]

Coarse sediment, especially cobbles and gravels, needs to be retained and well sorted by streambed and bank diversity.

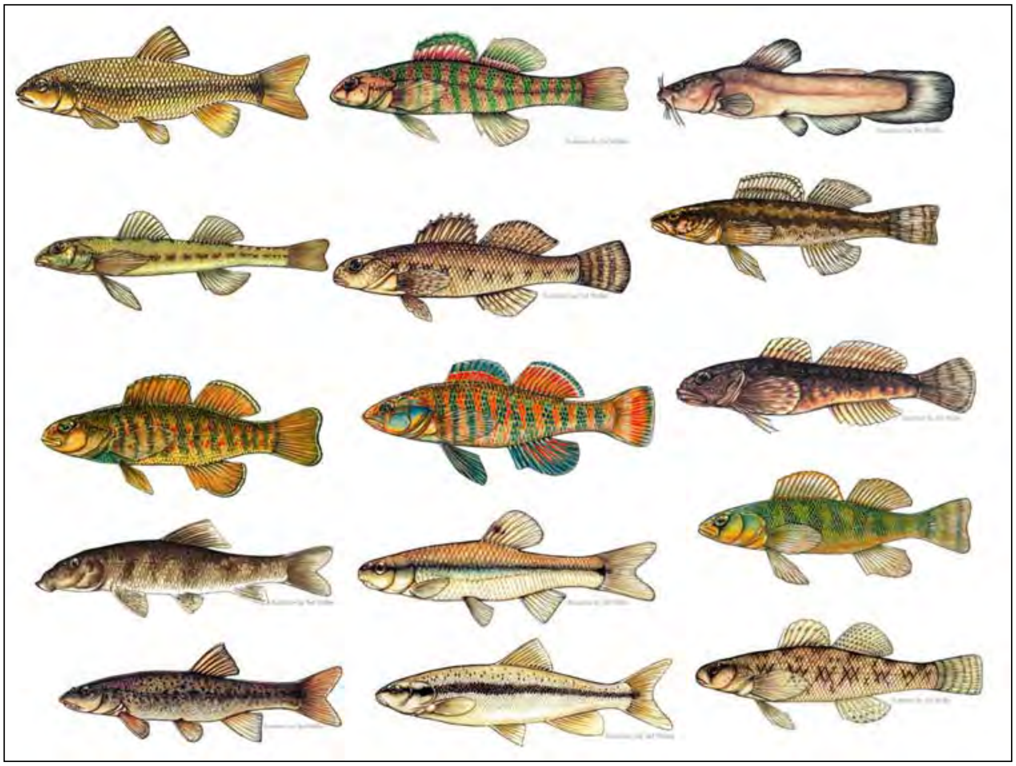
Alluvial topography should be composed of highs—riffles—and lows—pools—created and maintained by channel dynamics, assisted by large woody debris.

Overhead cover is a function of balanced cut and fill process that leave behind sloped streambanks where vegetation has year-round access to the water table.

And, access to lateral and floodplain habitats requires connection between the channel and its adjacent floodplain so that overbank flow occurs with some regularity.

So matching up the habitat needs of the species with some of the geomorphic functions necessary to meet those needs leaves you with a list of treatment options that might look something like this. Each of these six bullets, whether singularly or in combination, carries a full range of construction impacts, cost, design requirements, cooperation and input from the landowner, material needs, and regulatory implications.

But, you've worked your way through most of that stuff and have identified a couple of the best options that seem to fit the landowner's needs, economic situation, species requirements, and logistical sideboards of the site.



Things move right along until—perhaps as part of the scoping or regulatory process—additional species at the site are brought into the picture, and their habitat requirements or regulatory standing as a threatened or endangered species make the options you've selected less attractive or even hard to pull off because of construction logistics, work windows, cost, or any other number of issues.[CLICK] All of a sudden, you're left with a blank page.

This can be a common problem with projects aimed at a single target species. What might benefit one species may produce detrimental effects to one or more other species, even if its only for a short time during instream construction activities.

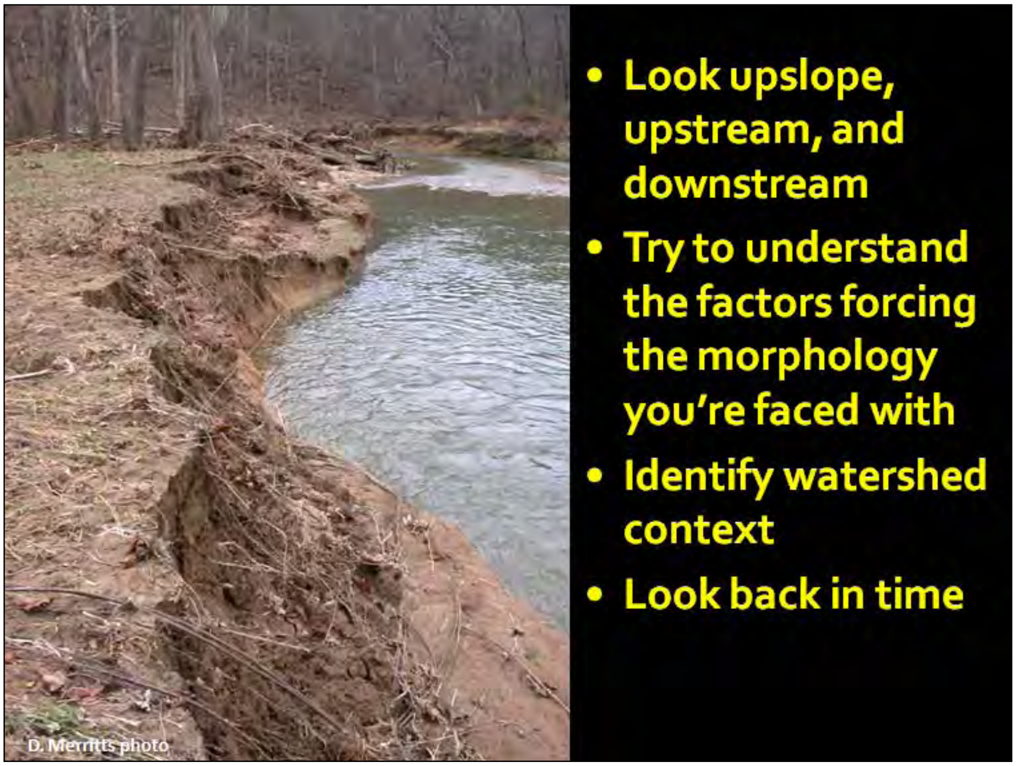
Planning Stream Habitat Management

- Trying to develop a solution that meets the ecological needs of all species will give you a headache.
- Instead, work within the context of the river and its watershed to support all the functions you can.
- Geomorphically functional streams equal quality habitat
- Work with the river (and the landowner) to find the best solution.

Its unlikely that you'll be able to develop a prescription for stream habitat management that specifically meets the habitat and ecology of all species in a river.

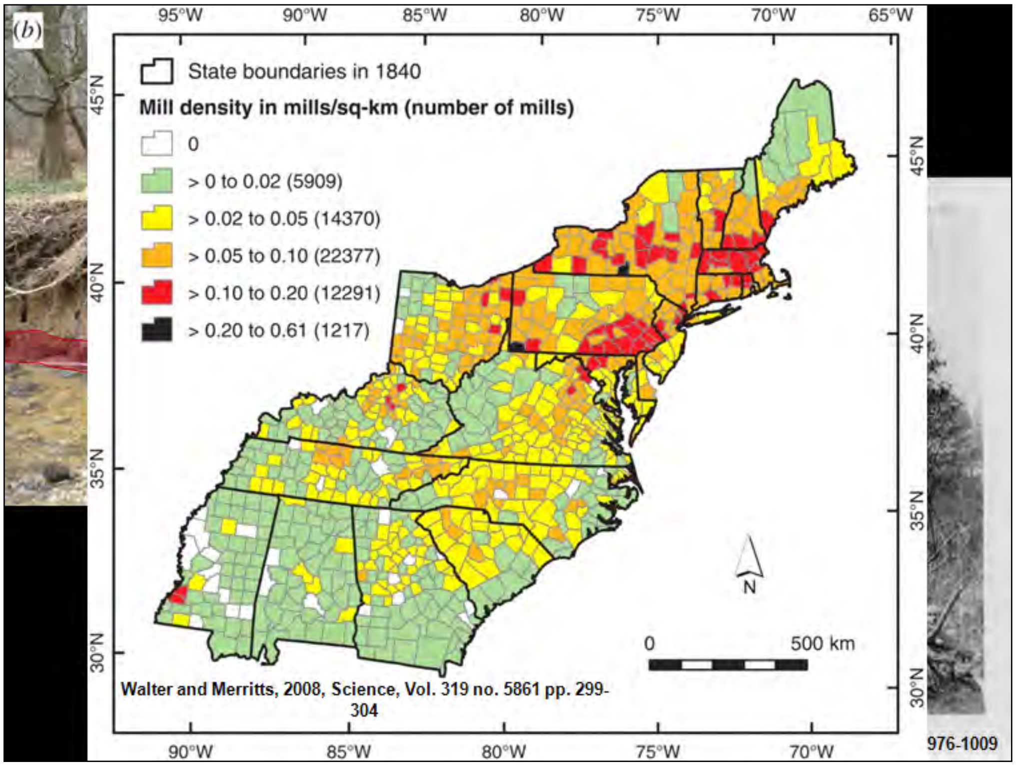
Instead, I'd suggest that working within the context of the watershed—the set of physical and hydrologic conditions that control river structure and function—is the sweet spot for stream habitat management. In fact, NRCS doesn't really manage species, we manage habitat. Otherwise we'd have a whole lot more practice standards.

Working with a river at a site by capitalizing on intact processes will give you the best collection of habitat attributes and will likely improve project stability and success over time.



Part of managing stream habitat, and an inherent component of stream assessment is to try and figure out how a stream should look, especially if it appears to have degraded habitat. Again, it would be very difficult to analyze and describe the habitat condition of every organism in the stream. However, identifying geomorphic problems and the conditions that created them can give you a blueprint towards managing for better stream habitat.

Assessing stream condition and habitat includes looking along the system and around the watershed to try and gain insight into the factors that contribute to the morphology of a given site. Putting the reach into the context of the watershed will help you do this, as does looking backward in time—as much as you possibly can given resources and time—to figure out how past land use history has affected present condition.



Not all vertical streambanks are created equally, especially in the eastern United States. This example, based on some groundbreaking research published by Robert Walter and Dorothy Merritts in January, 2008 really challenges conventional wisdom about how stream channels look and act in the mid-Atlantic region.

Some foundational studies in modern fluvial geomorphology—performed in this same region—provide the basis for the idea that self-formed channels in fine-grained floodplains generally exhibit a meandering pattern with alternating pools, riffles and gravel point bars. However, the presence of this [CLICK] dark layer of hydric soils—usually found in wetland settings—at the base what appears to be a floodplain—set Walter and Merritts on a path that provided insight into the profound effect of [CLICK] thousands of historic mill dams on streams and floodplains in the mid-Atlantic. They suggest that many floodplains along mid-Atlantic streams are actually fill terraces, and that historically incised channels are not natural prototypes for meandering streams.

[CLICK] examination of historic maps and manufacturing census data indicated some 65000 water-powered mills in the eastern US by 1840 and that mill densities in some counties were quite high—mill dams basically lined some streams as consecutive features.

In the context of stream management, common structural treatments that address bank erosion have proven to be problematic at sites assumed to be typical incised, meandering streams but are in reality inset channels bracketed by old millpond sediments.

[CLICK] Prior to water development for milling purposes and other activities like logging and land clearing for agricultural purposes, these streams were probably characterized as laterally extensive, wetland-dominated systems of forested meadows with stable vegetated islands and multiple small channels.

So, if this is how these streams quote unquote should look, a huge outstanding question in systems affected by legacy sediment and mill damming is “can these be restored and what do we restore them to?”

Some believe these systems have undergone irreversible geomorphic changes, and others believe the answer lies in digging up and trucking legacy sediments to allow a natural setting to emerge.

Planning Stream Habitat Management

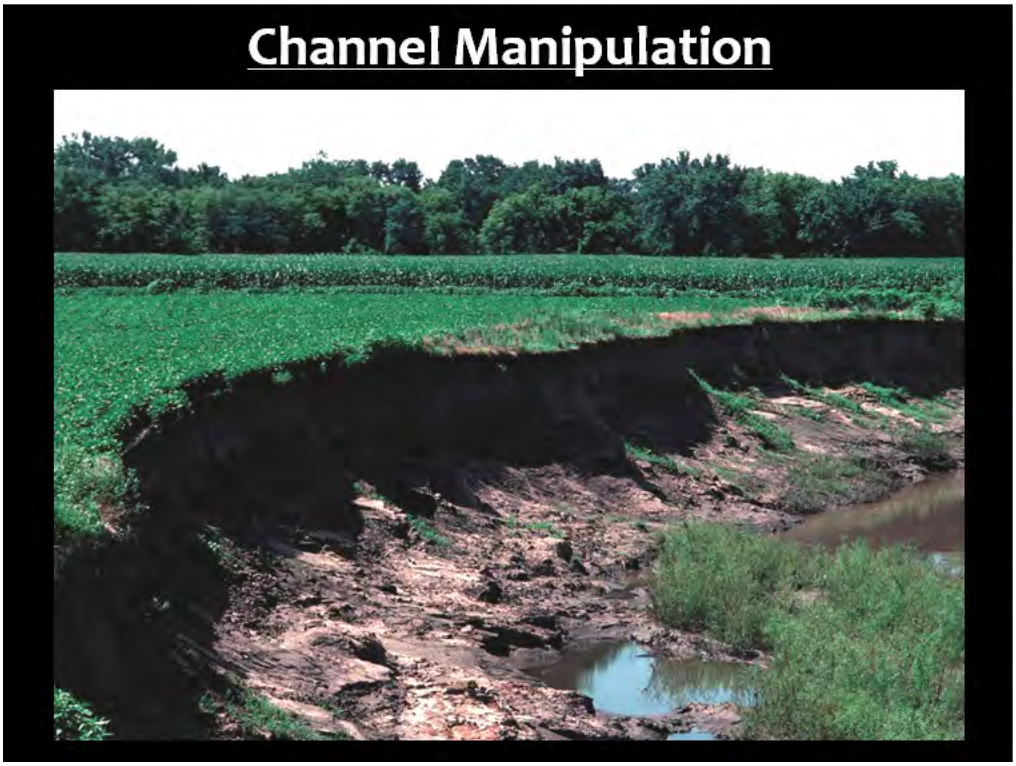
- River Context
- Spatial: what kind of stream is this?
  - braided, meandering? cascade, step-pool, pool riffle?
- Temporal: what was the disturbance history?
  - dam? logging? channel management? when?
- Indentify and capitalize on intact processes (work with the river)

Again, and as I've suggested in this and other ENTSC webinars, I think an essential part of planning for any activity in or along a river includes identifying the context within which the river evolved and presently exists. You may be tired of hearing me say the word context…

Identifying the stream type or style according to some channel classification scheme will help you identify the habitat template of the system.

In addition, we need to factor in the effects of past disturbances over time, accounting for the presence of dams, logging within the watershed, streamside activities like land development and agricultural history, and whether or not the channel has been manipulated.

Taking these things into account and describing the context of the basin and reach of stream you are working on will provide insight into the riverine processes that have been functionally zeroed out, and the processes that are still intact. These intact processes provide the best opportunity to encourage habitat formation and landform stability.

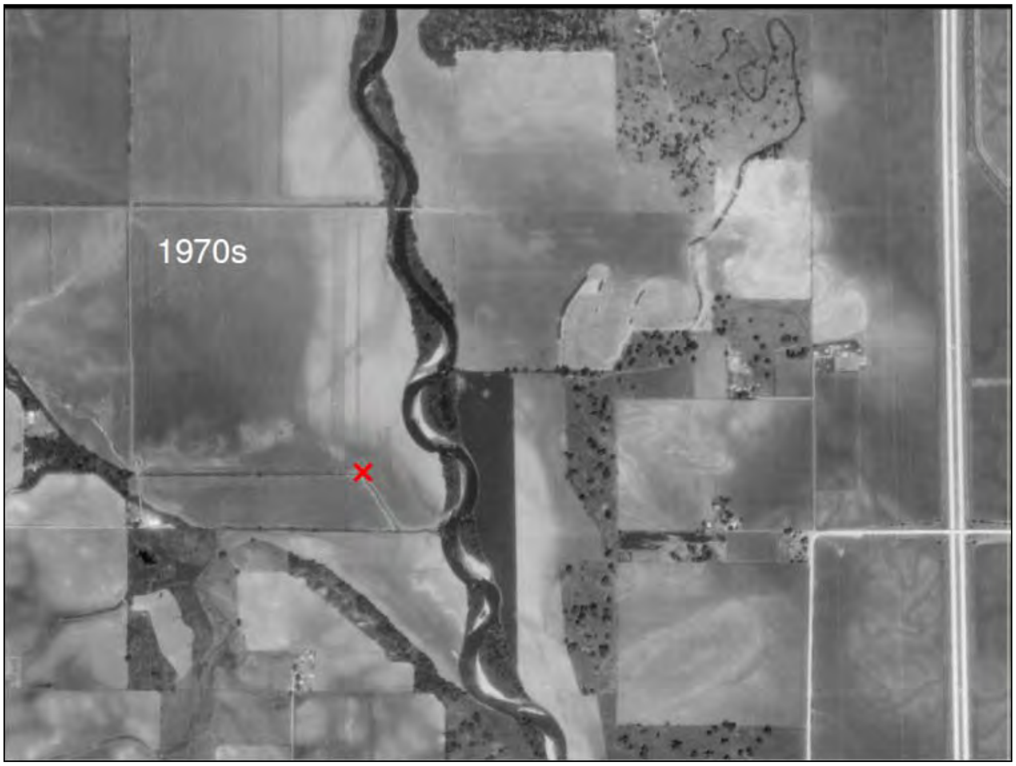


I'll finish today's show with two examples regarding channel manipulation.

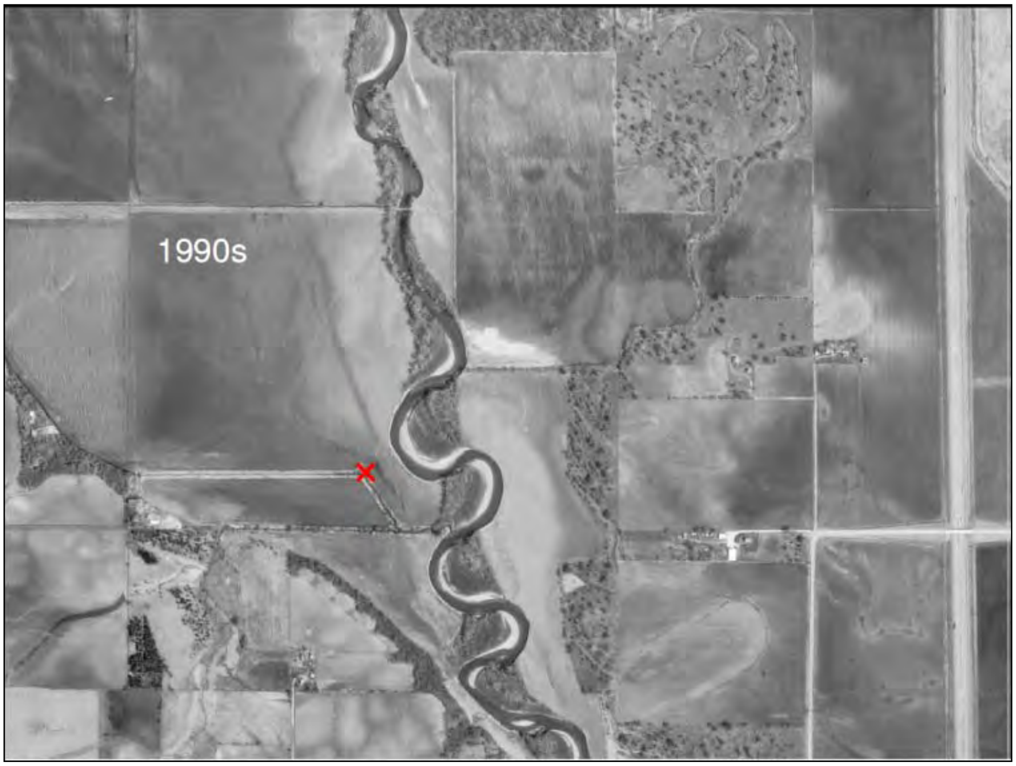
Many Midwestern states have streams along farmed fields with banks that look like this.

A look back in time can often reveal some interesting channel history. Many stream channels in the Midwest were realigned and straightened in an effort to control drainage and maximize farmable acreage. Here's an example of a reach of stream channelized some time during the 1930s. The red X serves as a registration point to anchor your eye through the next few slides.

The stream channel directly adjacent to the X is relatively straight, doesn't have many streamside trees, and I would guess that if you could jump in a "Wayback machine", the streambanks would resemble the previous slide and habitat would be marginal at best.



Some 40 years later the channel has changed quite a bit. Its assumed a meandering profile, the light, unvegetated bands adjacent to the meander bends indicate point bar development, and we're starting to see some streamside vegetation.



Jumping ahead another 20 years, the channel has extended and translated its meander pattern, point bars are more extensive, and streamside vegetation continues to expand.

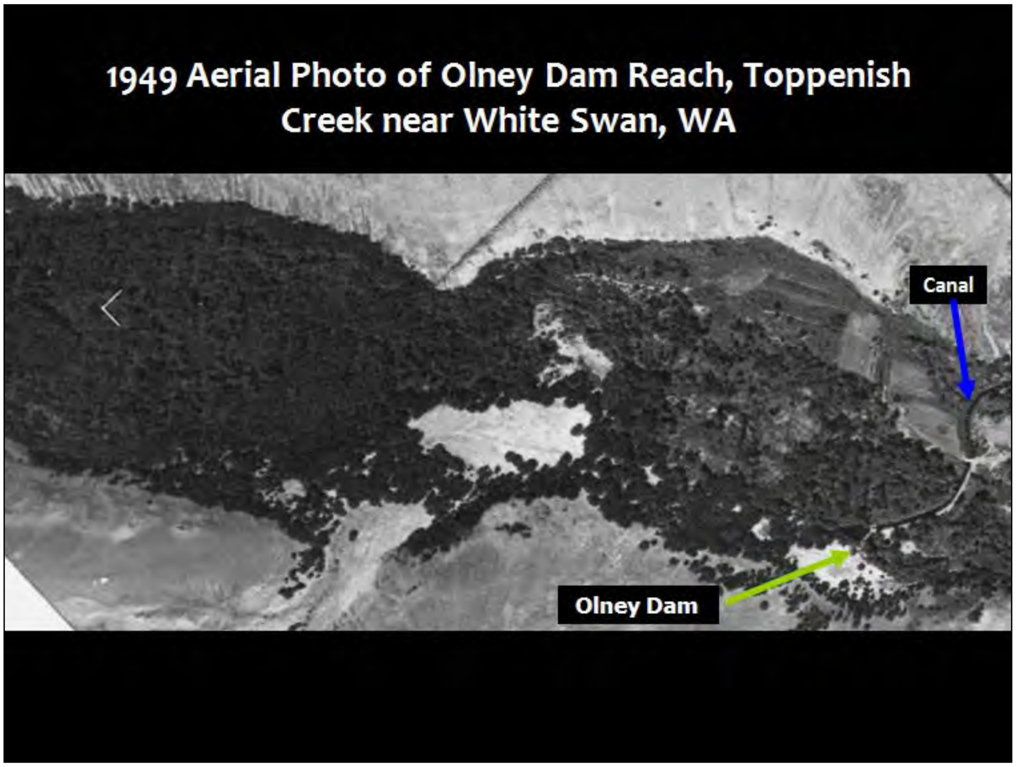
By 2002, we see what appears to be a herbaceous buffer, the meanders are more strongly pronounced, woody vegetation is appears more extensive, there appears to be a cutoff channel across the meander neck just to the right of the red X, and the [CLICK] channel has avulsed and abandoned its former course at the next meander.

And here is a shot from 2007, this time in color. Not a lot of difference between this and the 2002 picture, except that the meander loops have extended and moved downvalley a bit and the riparian corridor appears a more robust and continuous.

So, over the almost 80 years represented by this sequence of aerial photos, the stream has changed dramatically from its channelized condition in the thirties to the meandering system bracketed by a decent riparian corridor in 2007. Although data aren't available for this stream, I would guess that the quality of stream habitat along this reach has increased by a couple orders of magnitude across the period of record represented by these aerials.

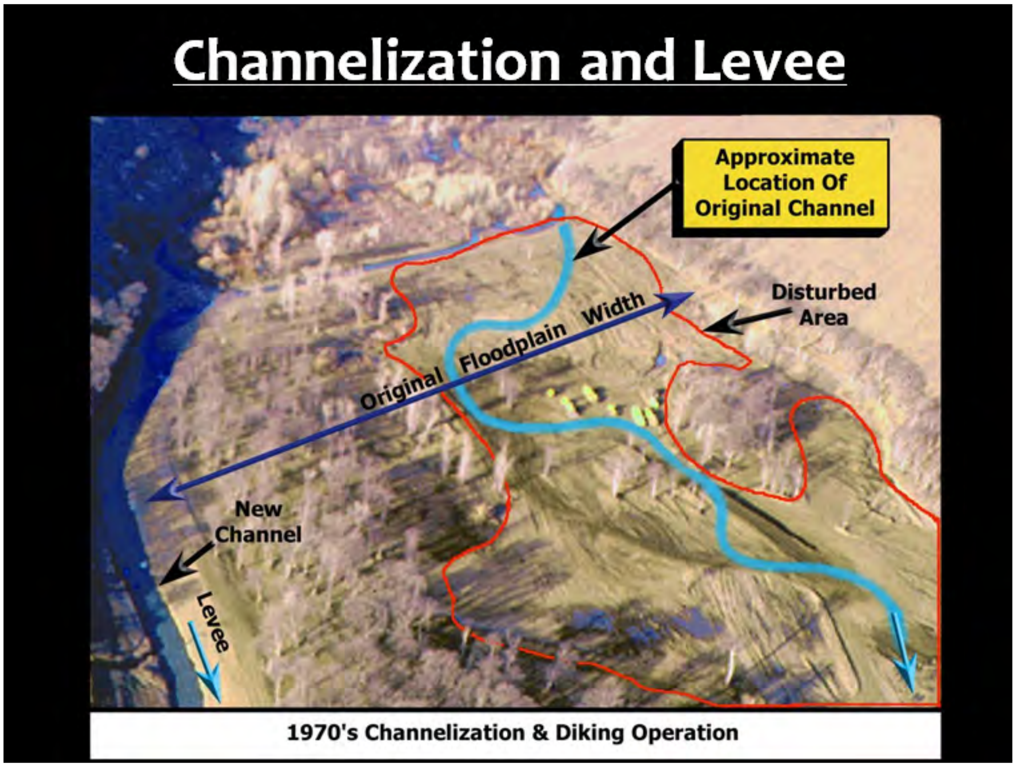
Now, I have a question for all of you out there: "What effect would streambank stabilization treatments in the early stages of meander development have had on the evolution of this channel and its habitat?" I'd be interested to any responses at the end of the presentation, or feel free to contact me.

Alright, the final example today takes us to Washington state, to a stream I spent quite a bit of time thinking about and working on years ago—Toppenish Creek on the Yakama Reservation near White Swan. Toppenish Creek drains about 625 square miles of the east slope of the Cascade Mountains in south central Washington. It comes off of a high plateau covered with spruce-fir forests, travels through ponderosa pine foothills, and then resides in basalt-walled canyons until it flows across the holocene floodplain of the Yakima River.

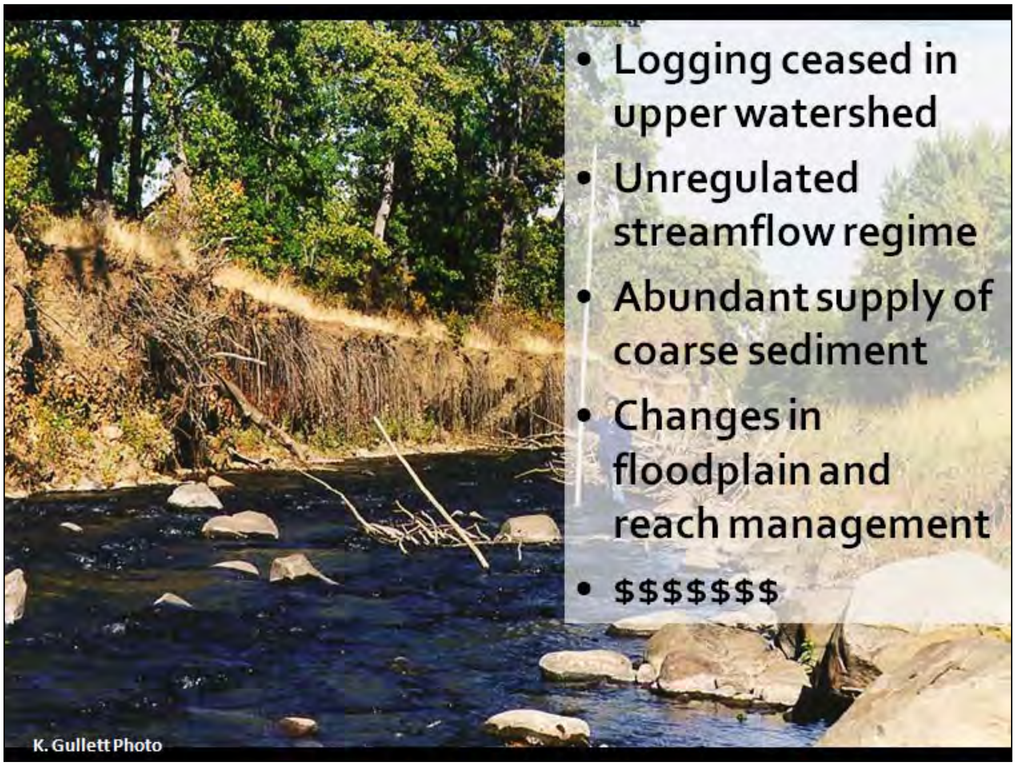


The Toppenish Creek watershed has a long history of logging and irrigated agriculture. I'm going to focus on a reach of the stream in the middle part of the watershed as an example of trying to determine watershed context and capitalizing on intact processes to improve stream habitat.

This aerial photo shows the Olney Dam reach of Toppenish Creek in 1949. As you can see, the valley floor had a thick blanket of trees and the actual stream channel is hard to see. However, it basically flowed down the center of the floodplain to the point labeled as Olney Dam, where water was and is to this day diverted into a canal that feeds alfalfa fields and orchards.

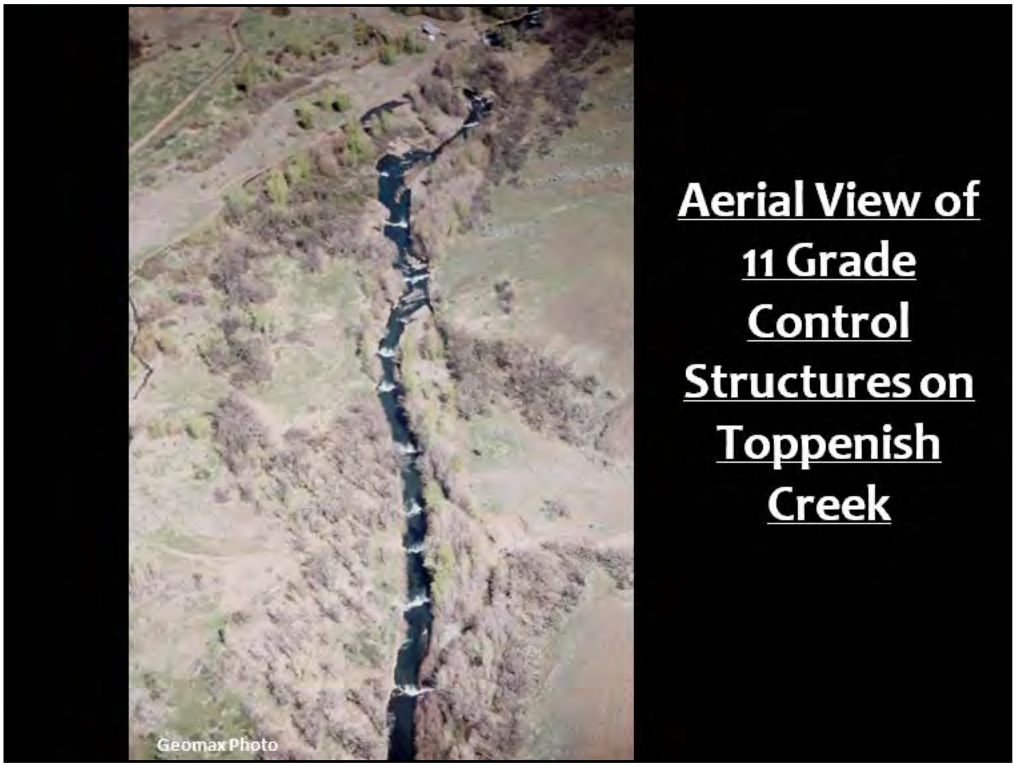


In 1974, the Bureau of Indian Affairs, in conjunction with Job Corps, attempted to address flooding problems that affected irrigation infrastructure and a nearby residence by channelizing Toppenish Creek along the south side of the floodplain and holding it that position with an earthen levee. Much of the floodplain vegetation was cleared during this construction activity. The original alignment of the channel is shown by the light blue line in the center of the photo



The channel responded by incising 10-15 feet into the valley floor beyond and sometimes up to the toe of the levee built in 1974. This picture, taken in 2001, illustrates channel and habitat conditions that persisted for years in the reach. The channel bed was devoid of pools and overhead cover, and composed of a moonscape of large cobbles and small boulders with tiny pockets of gravel throughout. The incised channel pulled the water table down with it, degrading the quality and composition of adjacent floodplain vegetation. Federally threatened steelhead spawned both upstream and downstream of this stretch of creek, but a general lack of suitable spawning gravel made this reach a migration and rearing corridor only.

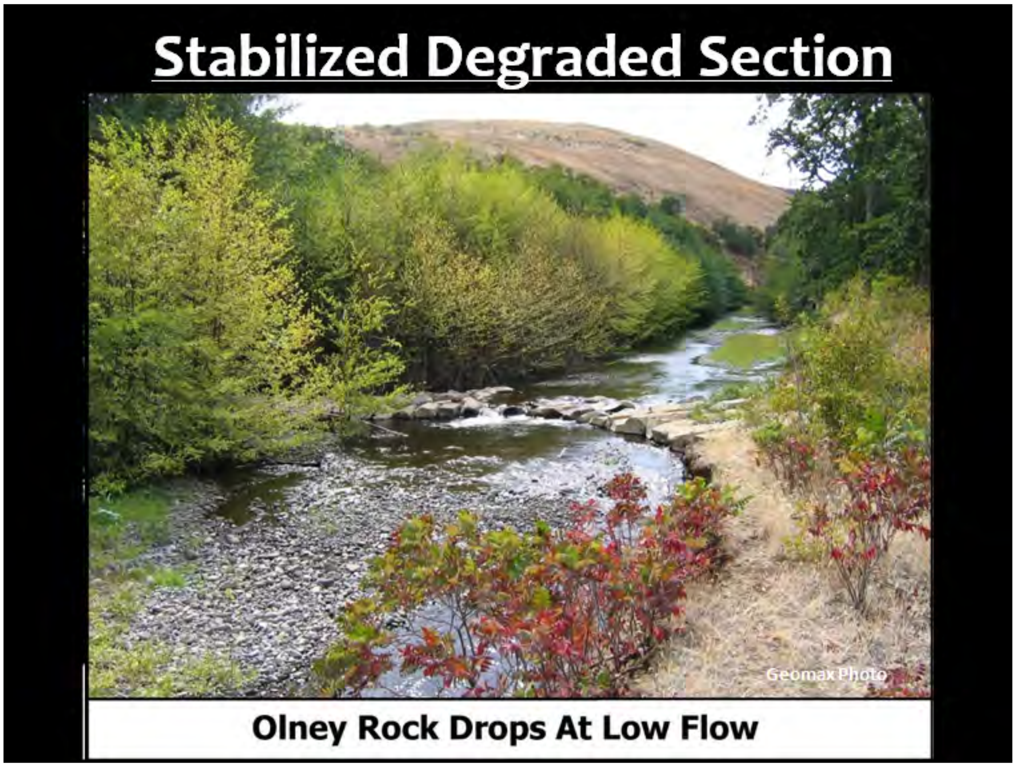
But, some useful processes were still intact. [CLICK] Logging had been curtailed in the upper watershed, the streamflow regime was unregulated at this point in the system, and there was an abundant supply of coarse sediment moving through the reach coincident with snowmelt-generated high flows. In addition, we had authority to make changes in the management and use of the area, as well as a chunk of money to do some work.



As I mentioned, the streamflow regime and an abundant supply of coarse sediment were two intact process that provided a significant opportunity. Problem was, the straightened oversteep reach didn't provide a setting where this bedload would deposit. The idea was that encouraging deposition would allow us the pick up the creek and get it back into contact with the adjacent floodplain, which would one day hopefully create the habitat and floodplain conditions closer to those seen in 1949, before the reach was leveed and channelized.

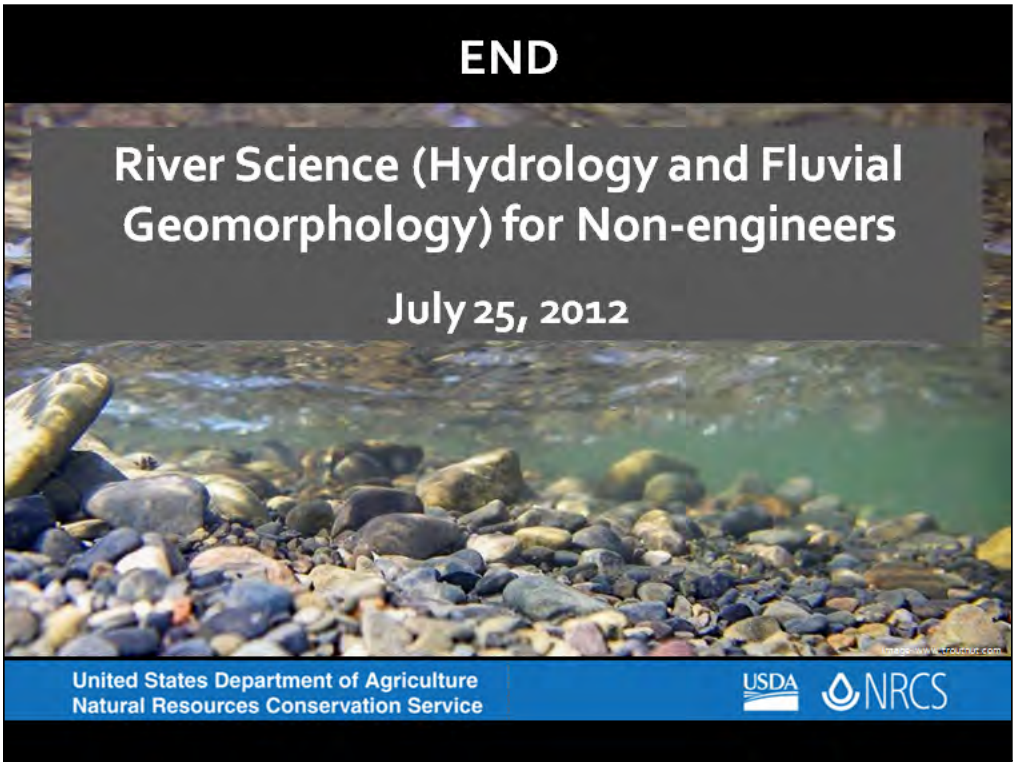
Long story short, a series of eleven channel-spanning rock weirs were constructed along the reach in an effort to create a stair-step profile that would decrease slope through the reach and create depositional areas for bedload moving through the system.

Here is another shot of two of the drop structures, seen this time a bit closer.



Here's a view of the reach from inside the channel. The weirs created a series of pools and riffles, raised the water table as much as four feet, and [CLICK] collected large amounts of cobbles and gravels. All of the material visible below this drop accumulated during the first runoff season following construction.

Stream habitat continues to improve as bedload accumulates and riparian vegetation encroaches the channel. [CLICK] In addition, those threatened steelhead can now spawn and rear in a reach that was once an ecological blank spot along a river corridor.



That is all I have for today, and I really appreciate your time and attention—I went through alot. [CLICK] Before I turn this over to Holli, I'd like to mention another upcoming webinar I'll develop for the end of July, 2012. The working title is "River Science (Hydrology and Fluvial Geomorphology) for Non-engineers".

With that, I'll now turn this back over to Holli, and would be pleased to hear any questions or comments you have regarding today's Webinar...