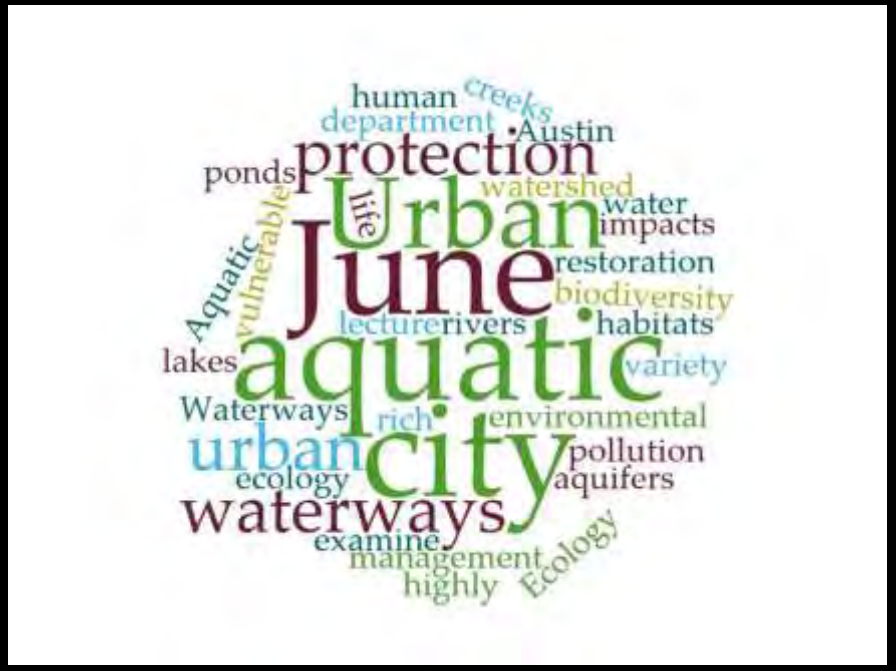
Center for Environmental Research at Hornsby Bend

Austin WATER

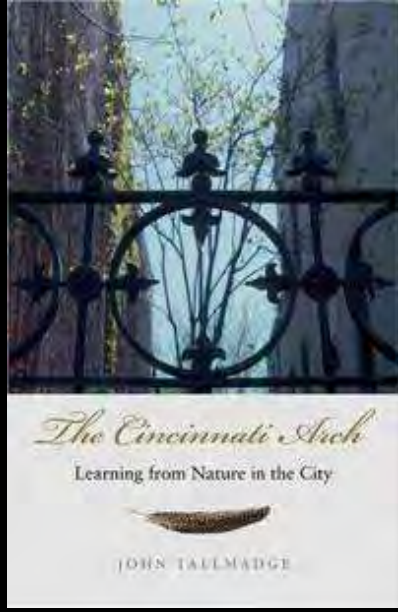
The Aquatic City: The Ecology of Urban Waterways

Kevin M. Anderson, Ph.D.
Austin Water – Center for Environmental Research



Nature in Cities: The Open Question and The Degradation Myth

John Tallmadge *The Cincinnati Arch: Learning from Nature in the City* (2004)



Urban nature is not sublime…There's too much sterility in the form of roofs and pavement, and, oddly enough, there's also too much wildness, too many weeds and wooded borders and tangled banks, not to mention vacant lots going to brush.

Of course, "wilderness" won't do to describe such landscapes either. Despite the degree of wildness, there's too much human impact, too many alien species, too few large animals to meet the legal and cultural criteria.

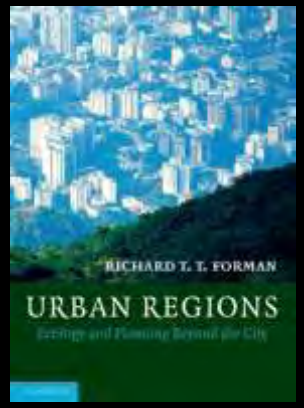
The fact is that urban landscapes are just too mixed up, chaotic, and confused to fit our established notions of beauty and value in nature.

Maybe it's not really nature at all, not a real ecosystem, just a bunch of weeds and exotics mixed up with human junk.

Nature “in” cities - Distinctive attributes, hierarchical scales, and gradients

1. Habitats and species
   - Usually diverse intermixed greenspaces and built patches cover the area.
   - Small sites tend to have few species, whereas large areas are often species rich.
   - Planted ornamentals, as well as spontaneous colonized species, are widespread.
   - Generalist species survive and predominate in urban conditions.

2. Patches and areas
   - Housing developments and house plots emphasize rectilinear repetition.
   - Boundaries are overwhelmingly straight, abrupt, and in high density.
   - Mowed grassy areas range from abundant to essentially absent.
   - Widespread impervious surfaces absorb solar radiation, generate heat, and greatly increase stormwater runoff.
   - Air and water are often heavily polluted.



3. Corridors and flows
   - Rectilinear road networks channel hordes of moving vehicles and people.
   - Underground branching conduits permeate and connect the place.
   - Animal movement is often along stepping stones rather than continuous strips.
   - Watercourses are channelized and flood-prone areas common.

4. Change
   - Many ecological changes are human-caused, rapid, and drastic.
   - Abundant species from afar endlessly arrive, while both native and non-native species disappear.
   - The city expands directionally over suburbs, and suburbs over rural land.

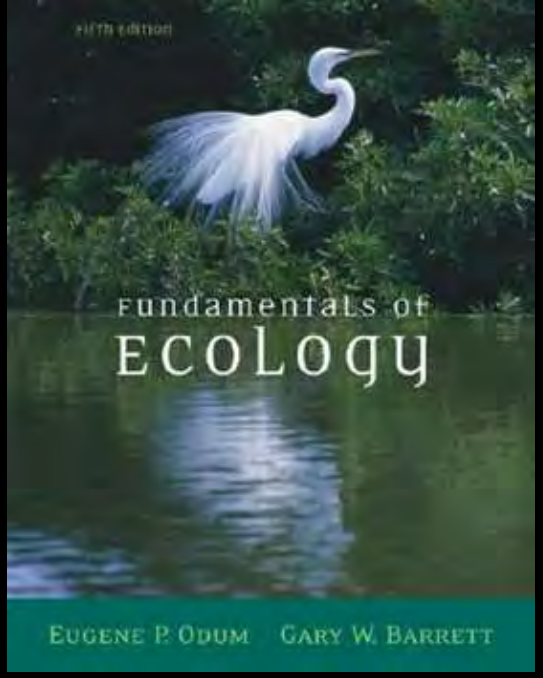
For a natural or agricultural landscape, these patterns would be bizarre.
In urban areas, they predominate.

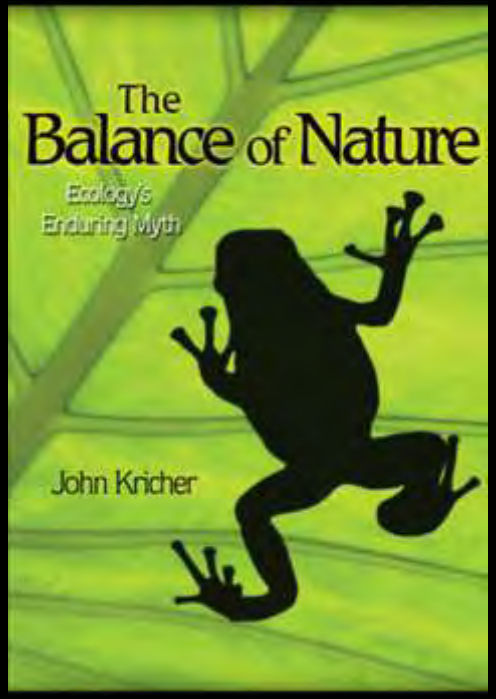
For a natural or agricultural landscape, these patterns would be bizarre. In urban areas, they predominate.

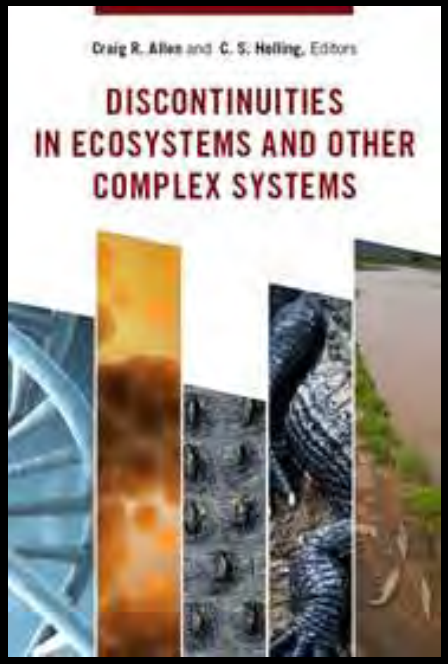
Natural vs. Bizarre - Understanding the Ecology of Urban Waterways

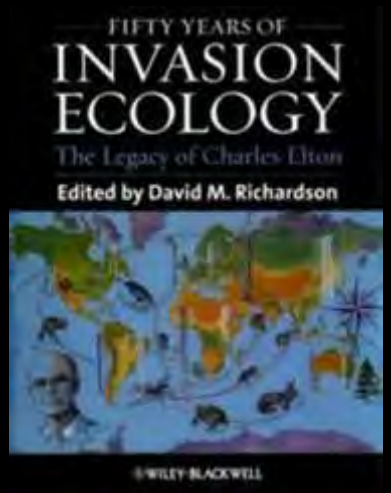
“Old” Ecology 1864-1960s – Humans the Great Disruptors

“New” Ecology 1973 onwards – Disruption is how nature works









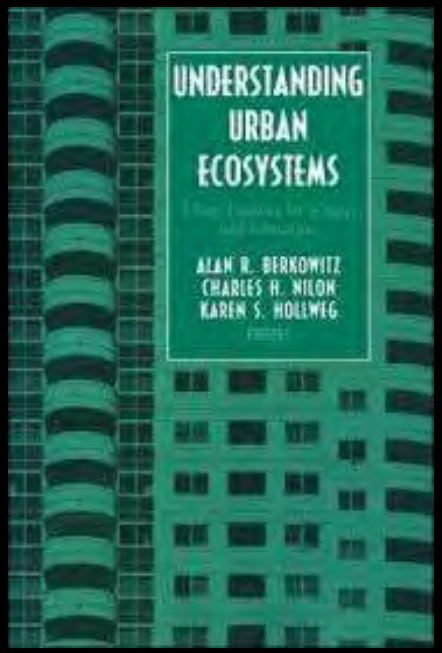
Don’t judge species on their origins

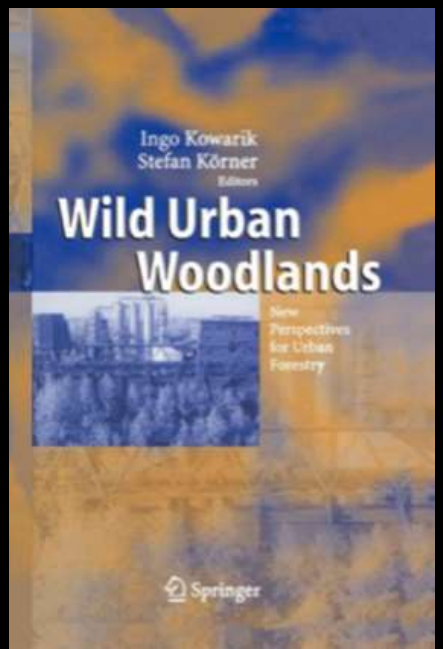
Conservationists should assess organisms on environmental impact rather than on whether they are natives, argue **Mark Davis** and 18 other ecologists.

Ecology “in” cities and European Urban Ecology

… the reference point is not an original condition of a natural landscape, but rather a condition defined based on the current site potential and the greatest possible degree of self-regulation. From this perspective, therefore, the natural capacity for *process* is the central point, not a particular, retrospectively determined and often idealized, *picture* of nature.
- Ingo Kowarik *Urban Wild Woodlands* (2005)

…although wild and rather specialist species may be missing, cities are great havens for biodiversity, in terms of both ecology and species, even in industrial areas.
- Anthony Bradshaw in Berkowitz, *Understanding Urban Ecosystems: A New Frontier for Science and Education.* (2003)





Wind in the Willows and The Ideal Waterway

“I’ll learn’em to steal my house!” Toad cried. “I’ll learn’em, I’ll learn’em!”

“Don’t say ‘learn’em,’ Toad,” said the Rat, greatly shocked. “It’s not good English.”

“What are you always nagging at Toad for?” inquired the Badger, rather peevishly. “What’s the matter with his English? It’s the same what I use myself, and if it’s good enough for me, it ought to be good enough for you!”

“I’m very sorry,” said the Rat humbly. “Only I think it ought to be ‘teach’em,’ not ‘learn’em.’”

“But we don’t want to teach’em,” replied the Badger. “We want to learn’em – learn’em, learn’em! And what’s more, we’re going to do it, too!”

- Kenneth Grahame, The Wind in the Willows (1908)

Water Rats - Decline of UK Population

The water vole is found throughout riparian habitat in mainland Britain. However the water vole suffered a catastrophic decline in the latter part of the 20th century through habitat lost from agricultural intensification and urbanization of the floodplain, along with predation by the introduced American mink.

A survey carried out by the Mammal Society (1989-90) showed that the species had been lost in 94% of the sites where it had occurred earlier in the century.

A survey conducted by the Urban Wildlife Trust (1997) indicated that population decline in urban areas might not be as dramatic as elsewhere. The urban landscape appears to provide a stronghold for the water vole.

Water Vole (Arvicola terrestris)

The Return of Ratty - Urban water voles

Lancashire Wildlife Trust has discovered healthy populations of endangered water voles on some stretches of the Leeds & Liverpool Canal.

This shy creature is actually widespread there because the canal still has brickwork banks in many places and water voles are able to burrow between the bricks.

Ecologists have been surprised to discover that urban water vole populations are doing much better than rural populations probably because there is less intensive management of riparian areas in urban wastelands and abandoned canals and no American minks, since they shy away from urban habitat.

The (Socio)Ecology of Urban Waterways

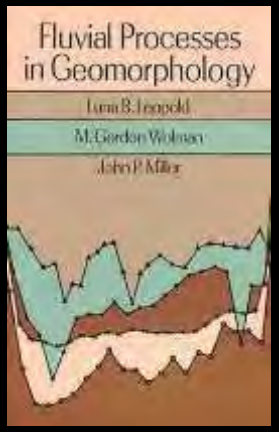
Abiotic, Biotic, and Human Society

The Abiotic Structure of a "Natural" Waterway

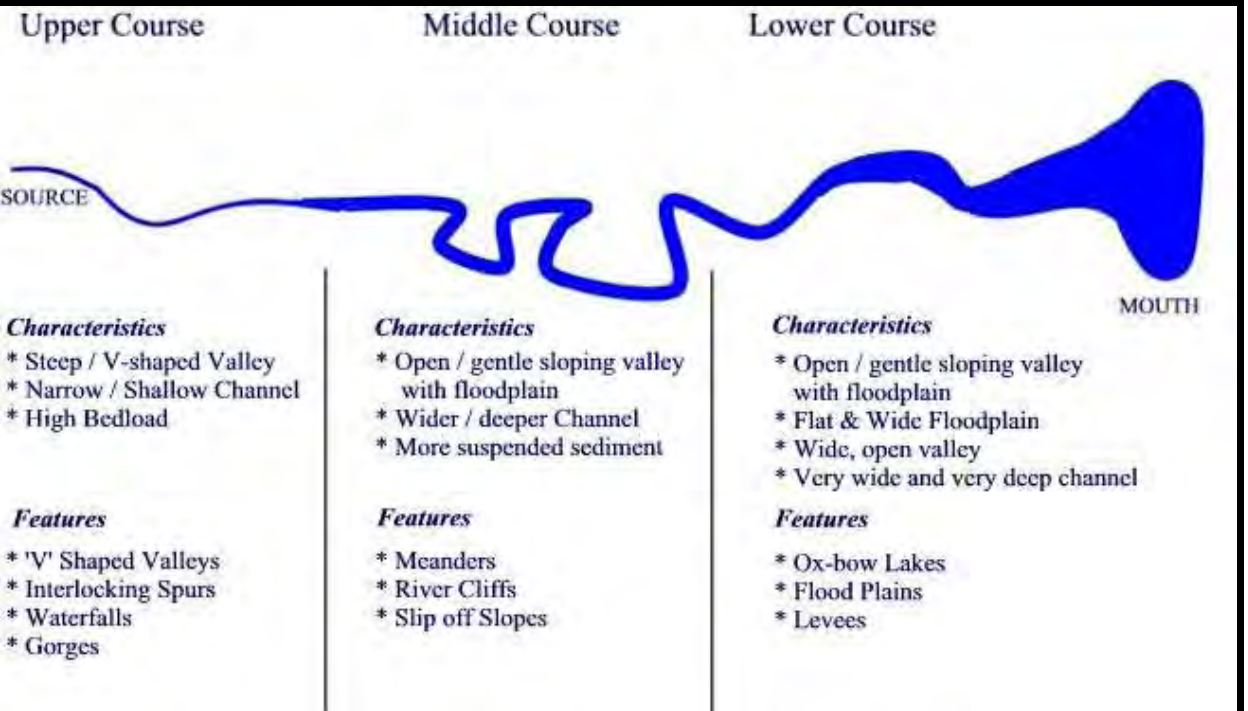
The Upper Course

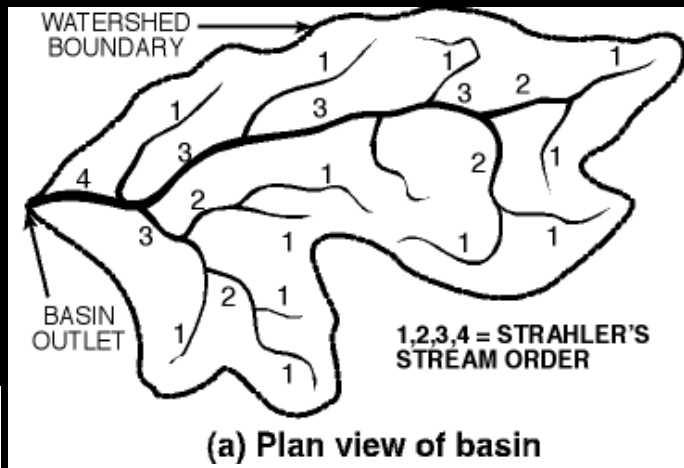
The Middle Course

The Lower Course

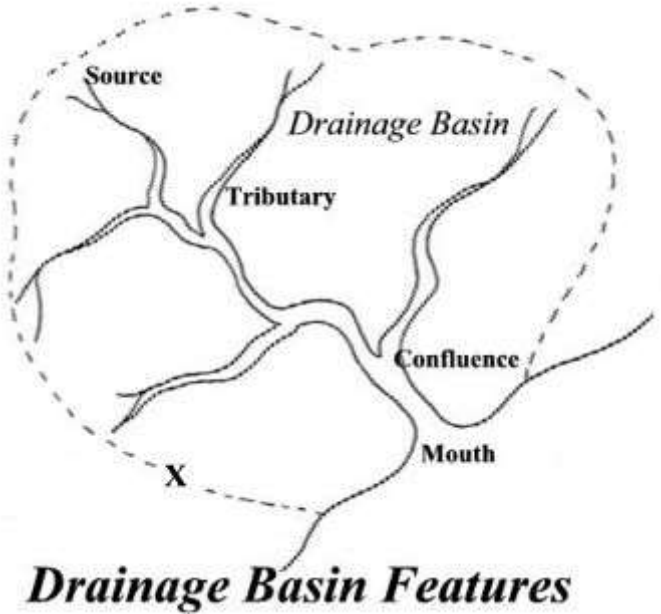


Fluvial Geomorphology





(a) Plan view of basin



Drainage Basin Features

The Life of a River – William Morris Davis

William Morris Davis (1850 - 1934) was an American geographer, geologist, geomorphologist, and meteorologist, often called the "father of American geography". His most influential scientific contribution was the cycle of erosion, first defined around 1884, which was a model of how rivers create landforms.

"The Life of a River"

"Its youthful headwaters are steep and rugged. It rushes toward the sea, eroding bed and bank on its way.

In its central part, it is mature, winding sedately through wide valleys adjusted to its duty of transporting water and sediment.

Near its mouth it has reached, in its old age, a nearly level plain through which it wanders in a somewhat aimless course toward final extinction as it joins the ocean that had provided the sustaining waters through its whole life span."

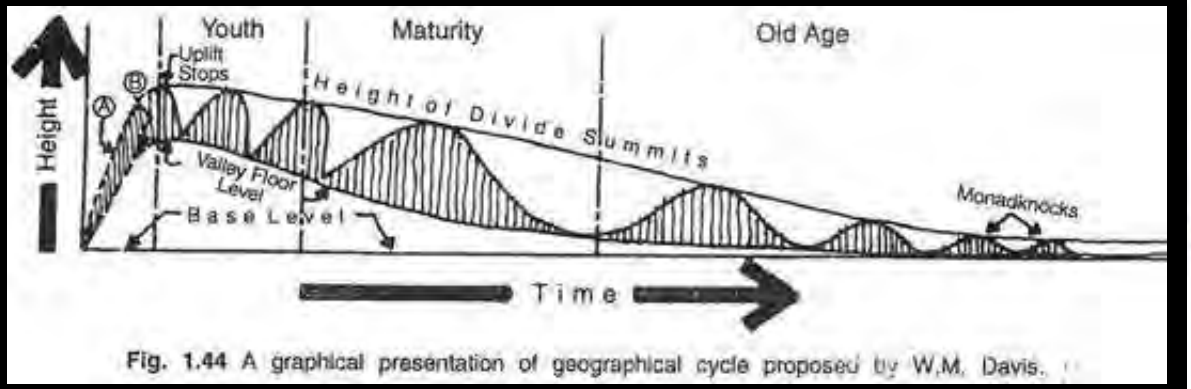
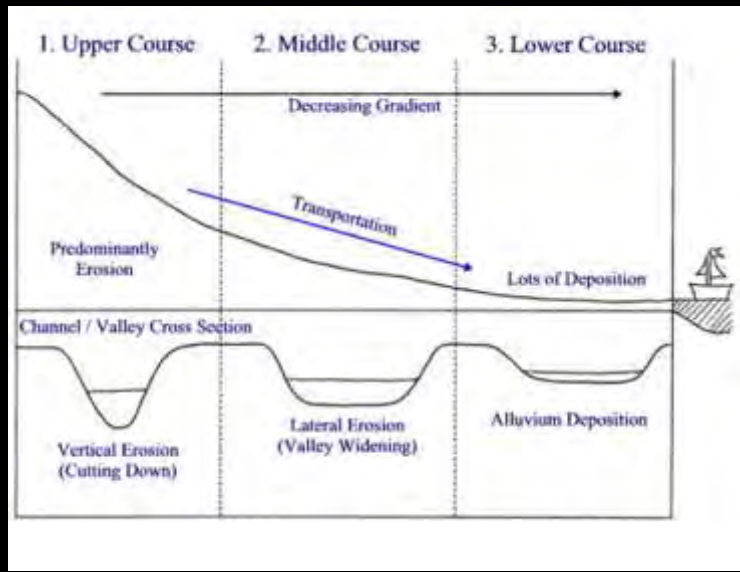


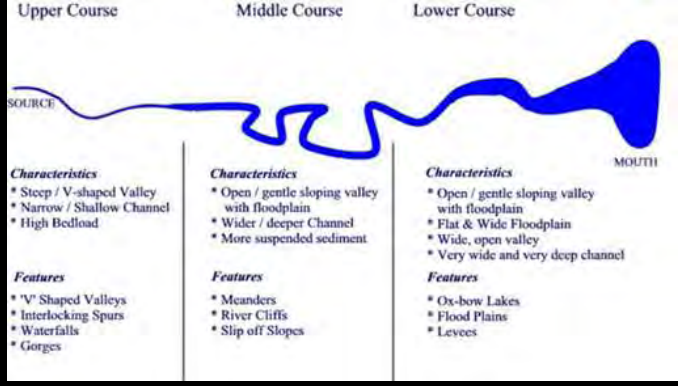
Fig. 1.44 A graphical presentation of geographical cycle proposed by W.M. Davis.



Upper Course – Source or Headwaters

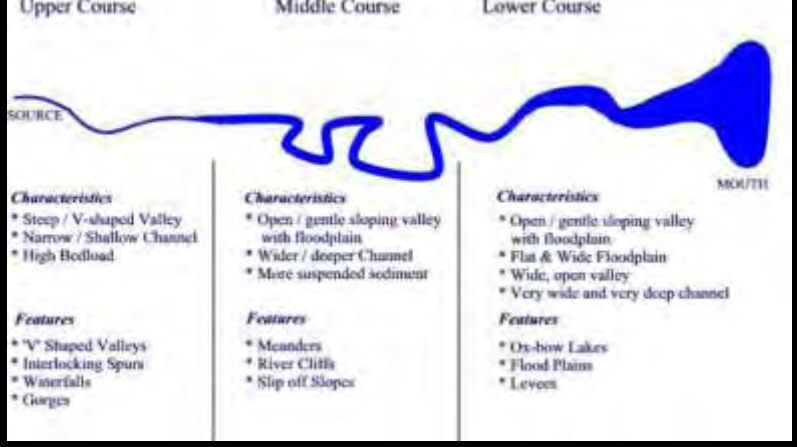
"youthful headwaters are steep and rugged"

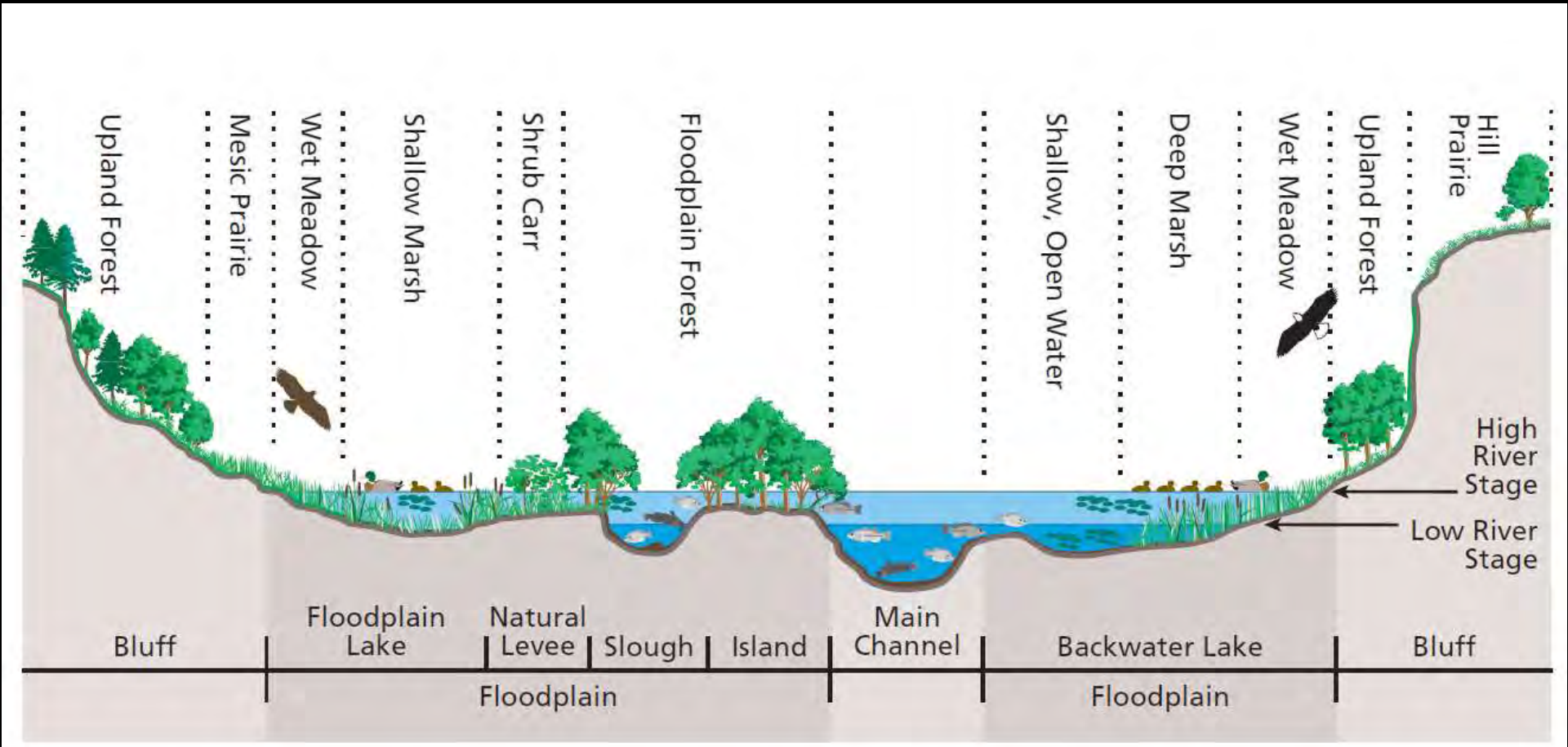
- In temperate environments, small streams tend to be shaded by an interlocking, overhead tree canopy.
- Such conditions result in cool, well-oxygenated streams that are abundantly supplied with a food base of leaves.
- Fine particles of organic matter are released as the leaves are broken down by biological communities in the streams



The Middle Course:
Habitat Diversity in the Meander Belt

"mature, winding sedately through wide valleys"



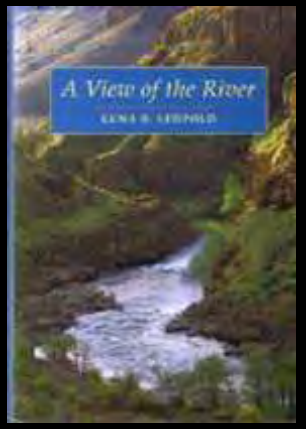


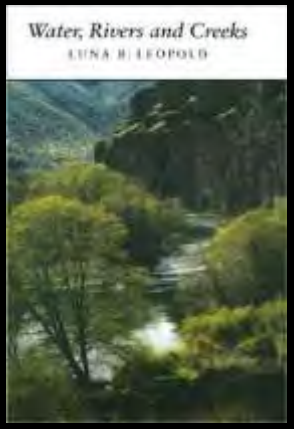
The Lower Course: the Delta

"toward final extinction as it joins the ocean"

- Very large rivers are usually low gradient and very wide, resulting in negligible influence of riparian canopy in terms of shading and leaf-litter input.
- Water currents keep fine solids in suspension, reducing light penetration to the benthos.
- Organic matter in suspension is by far the largest food base in these very large rivers.
- Larger alluvial rivers in their natural state are diverse habitats with side channels, sand and gravel bars, and islands that are formed and reformed on a regular basis.

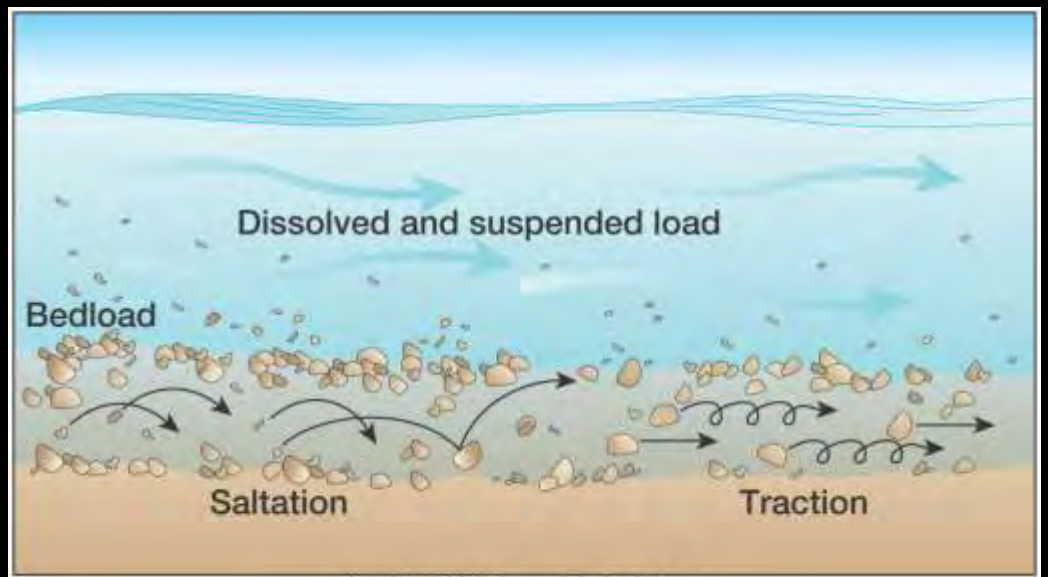
Fluvial Transportation – Abiotic and Biotic
Water, Sediment, and Organic Material





Waterways transport three main materials downstream – water, sediment, and organic material.

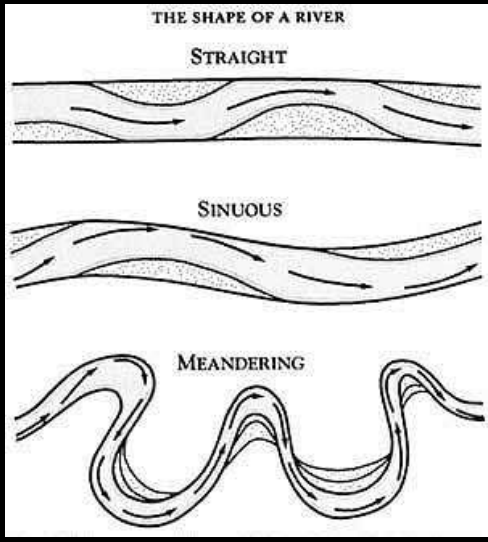
- The abiotic components – water and sediment – most directly affect the shape of the channel.
  [Fluvial Geomorphology]
- A change in either the flow of water or the sediment load can lead to increased deposition or erosion.
- The biotic components of a waterway's transported load range from dissolved organic matter to large woody debris.

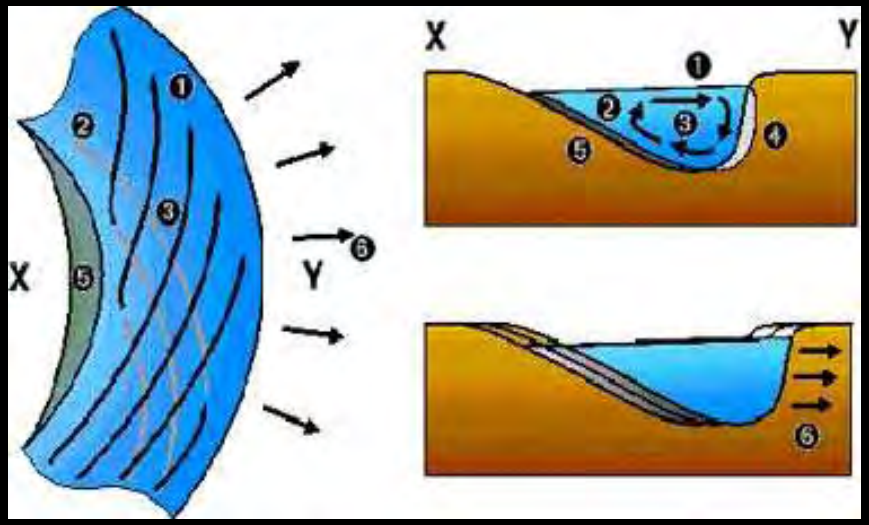


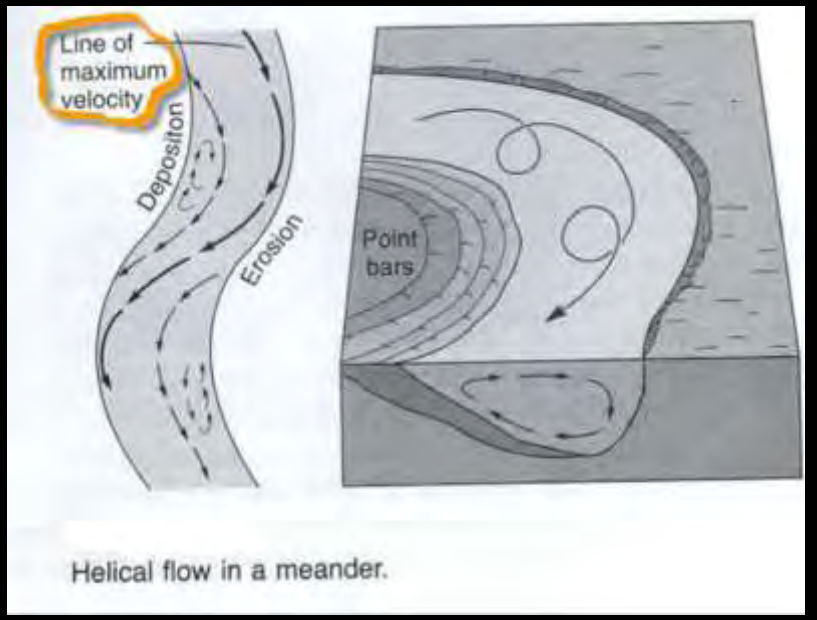
Fluvial Process – Erosion, Deposition, and Meanders

The helical flow of water plays an important role in the formation of meanders

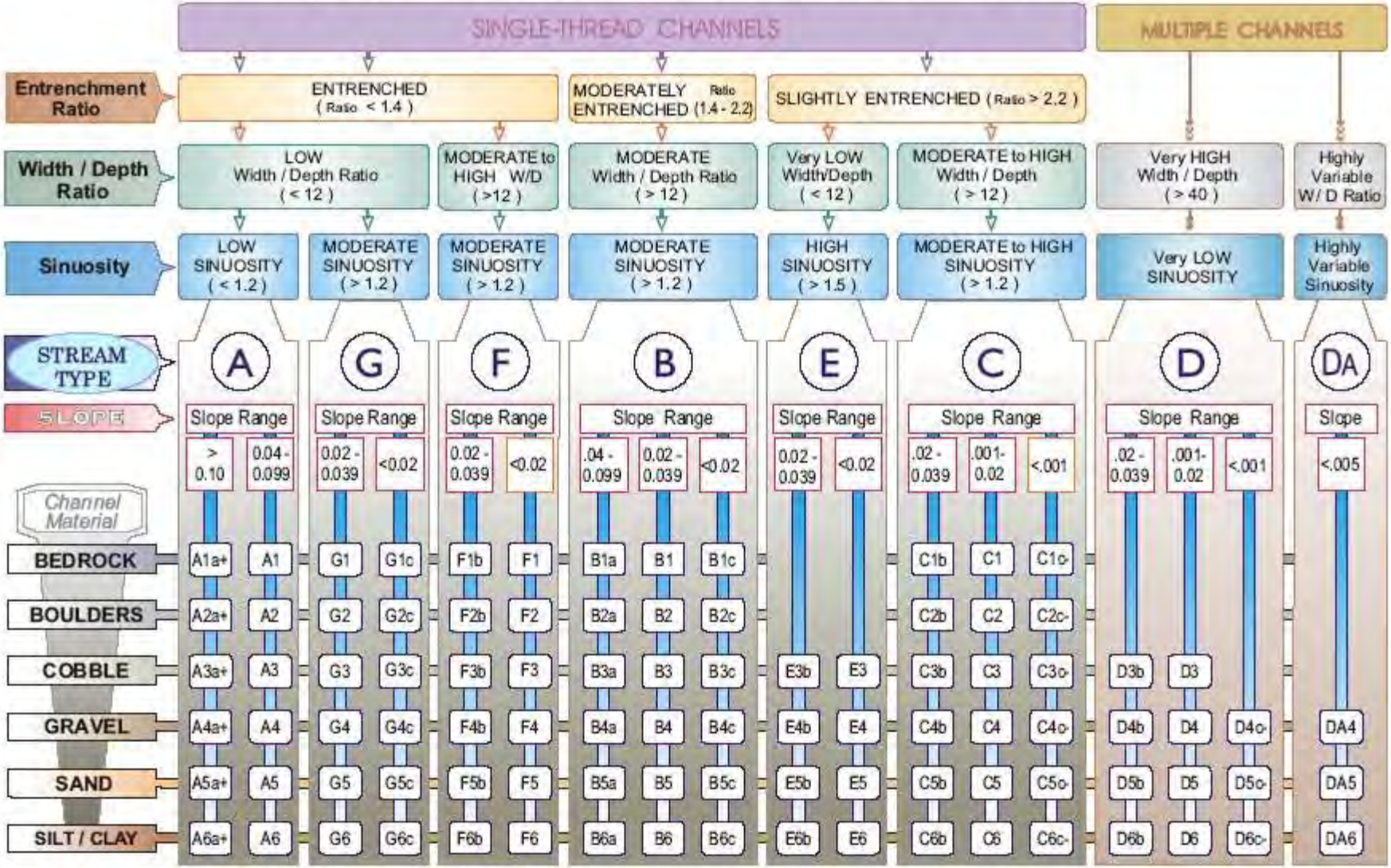
- The helical flow erodes the outside of a bend and deepens the pool.
- Redistributes scoured material and deposits it on the slip-off slope and riffle section.
- This continuous process cause meanders to migrate and contract at their neck until the flow cuts directly through, forming a new channel







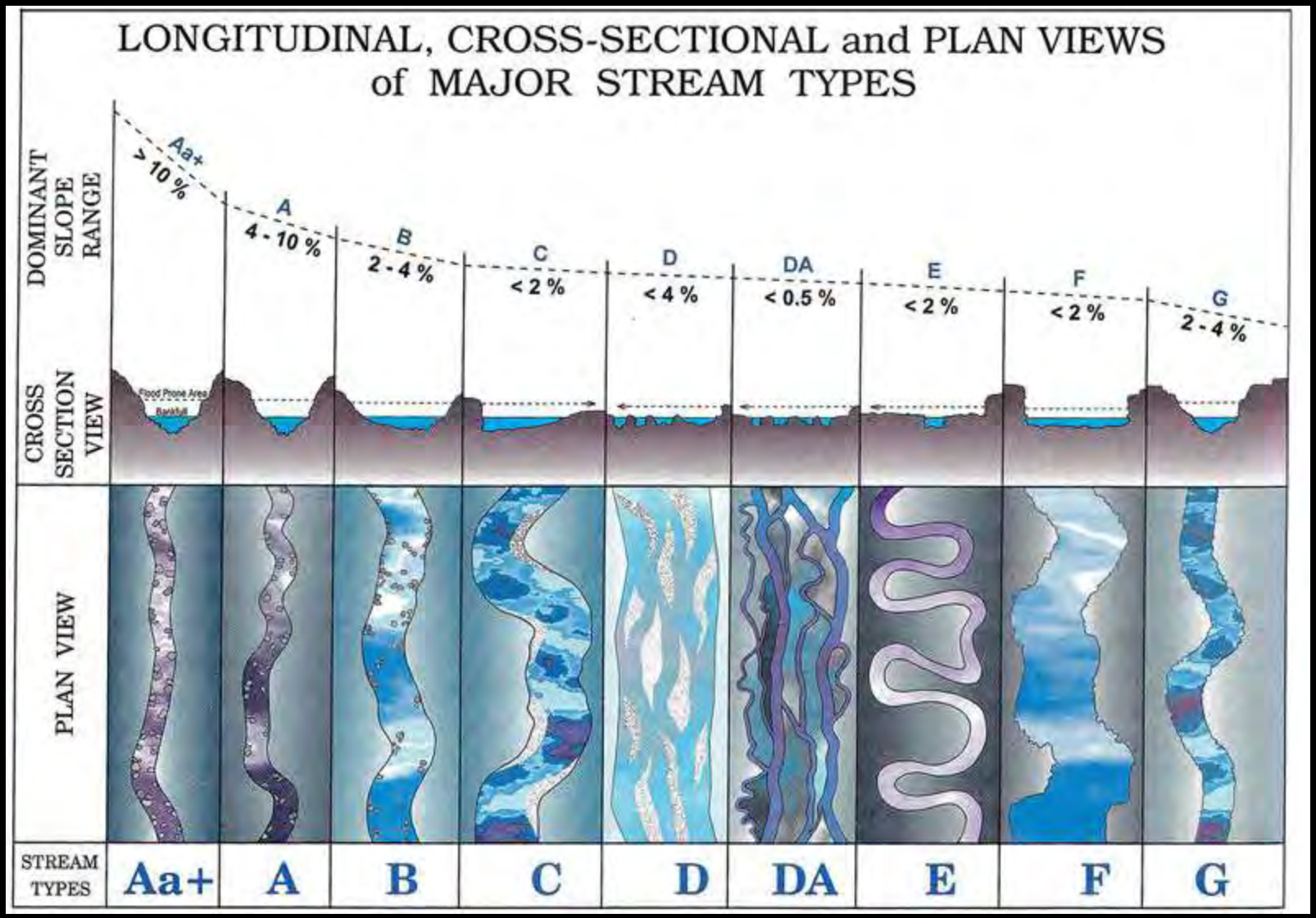
The Key to the Rosgen Classification of Natural Rivers



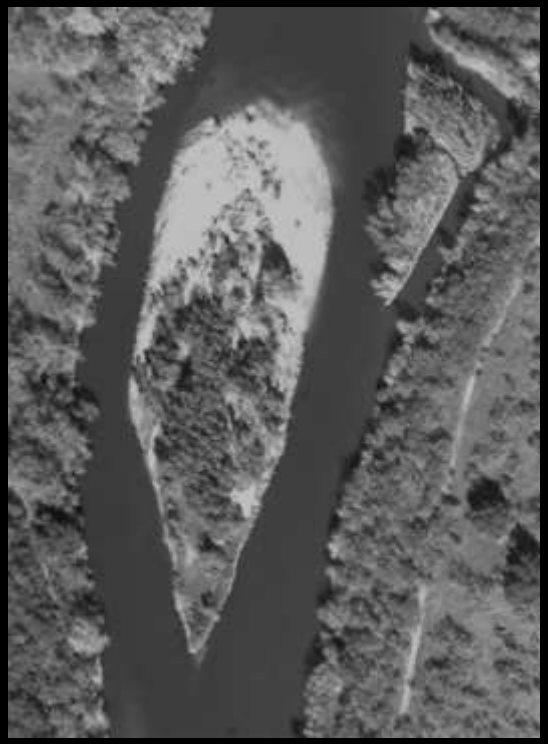
KEY to the ROSGEN CLASSIFICATION of NATURAL RIVERS.

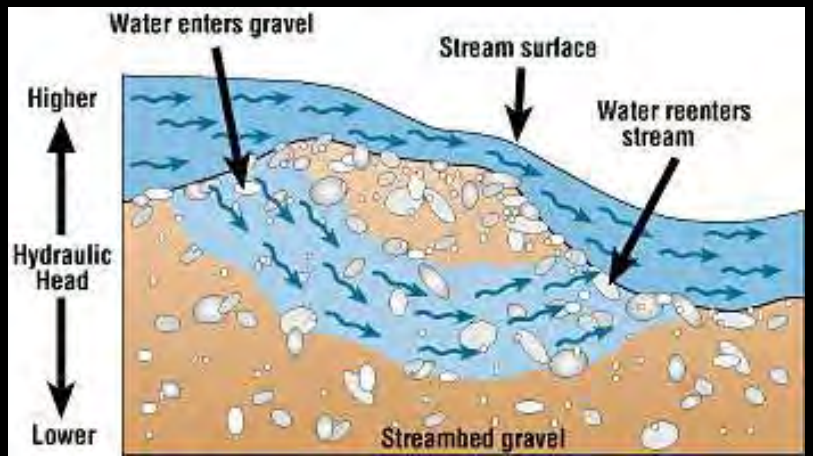
As a function of the *"continuum of physical variables"* within stream reaches, values of ***Entrenchment*** and ***Sinuosity*** ratios can vary by +/- 0.2 units; while values for ***Width / Depth*** ratios can vary by +/- 2.0 units.

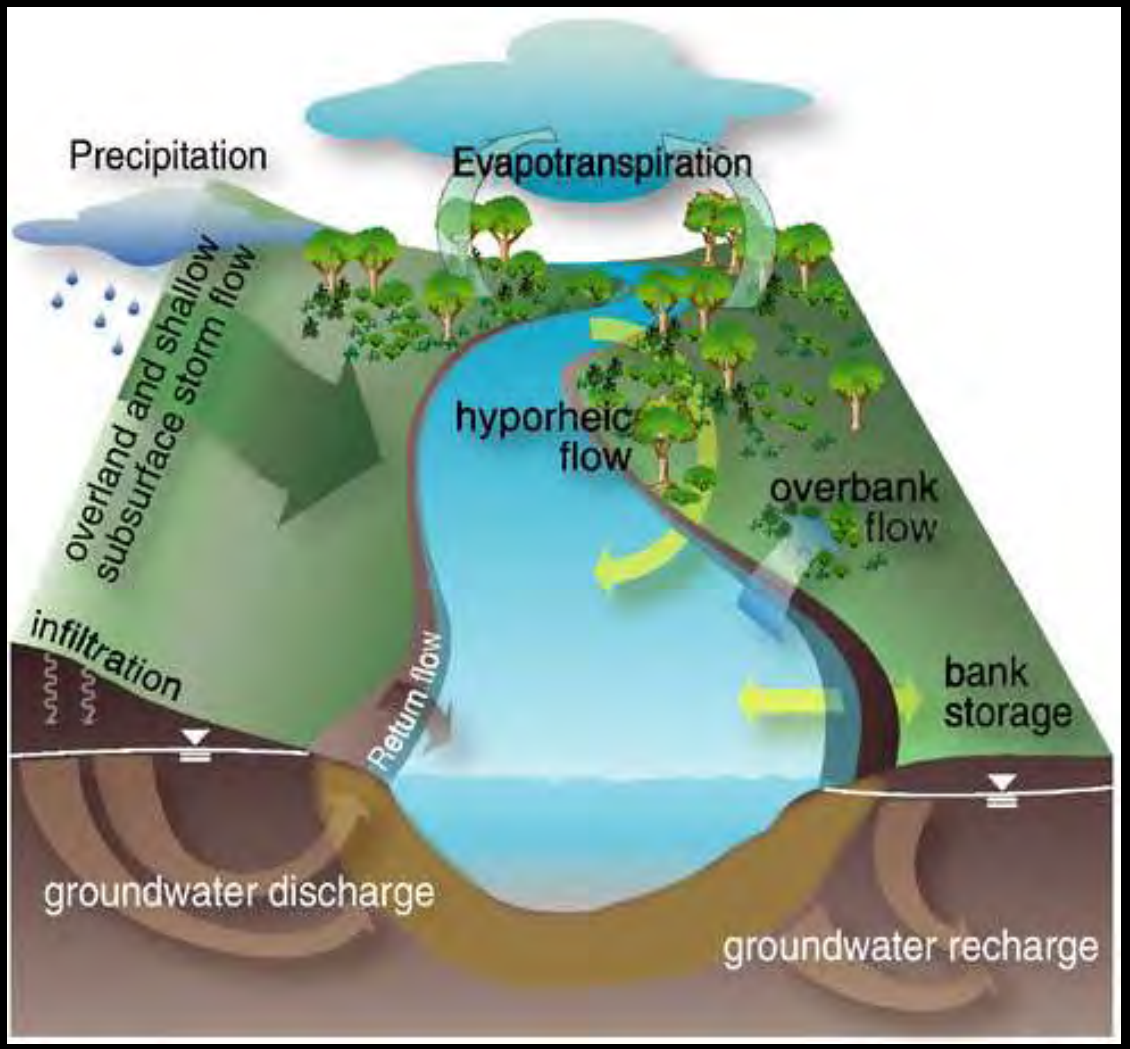
Sinuosity is inversely proportional to slope



The Hyporheic Zone – Abiotic/Biotic Interface





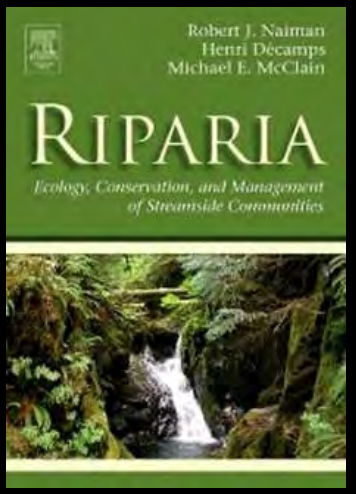


Riparian Zone and Hyporheic Flows – Hydrological Interface

They are areas through which surface and subsurface hydrology connect water bodies with their adjacent uplands.

The Riparian Sponge

- One of the attributes of a properly functioning riparian area is the sponge effect and water storage capacity within the riparian area.
- This large absorbent sponge of riparian soil and roots will soak up, store, and then slowly release water over a prolonged period.
- This riparian sponge can be managed in a way to greatly increase and improve this storage or it can be managed in a way to decrease and degrade water storage.



Hornsby Bend Hydrology Research

Dr. Bayani Cardenas, University of Texas Jackson School of Geosciences

The Colorado River and Hyporheic Flows

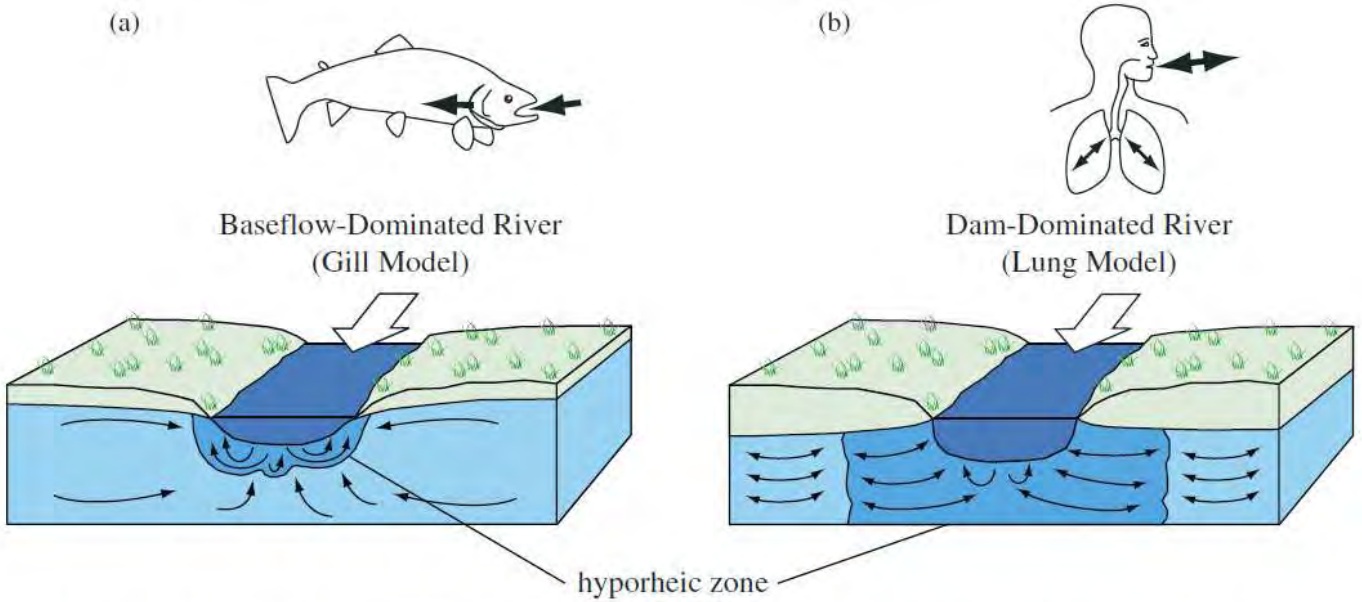


Figure 10. (a) Conceptual model of a natural river-groundwater system in a reach dominated by baseflow. During most of the year, groundwater flows steadily through the riparian aquifer in one direction like water through a gill. Groundwater discharge to the river limits the size of the hyporheic zone. (b) Conceptual model of a river-groundwater system downstream of a dam. Due to frequent stage fluctuations, river water flows in and out of the riparian aquifer like air flowing in and out of lungs. The hyporheic zone includes all flow paths that start and end in the channel

The Hyporheic Zone – Abiotic/Biotic Interface

Streams exchange water, nutrients, and organisms with surrounding aquifers through the hyporheic zone, and it is an important habitat for a number of aquatic organisms and fish spawning.

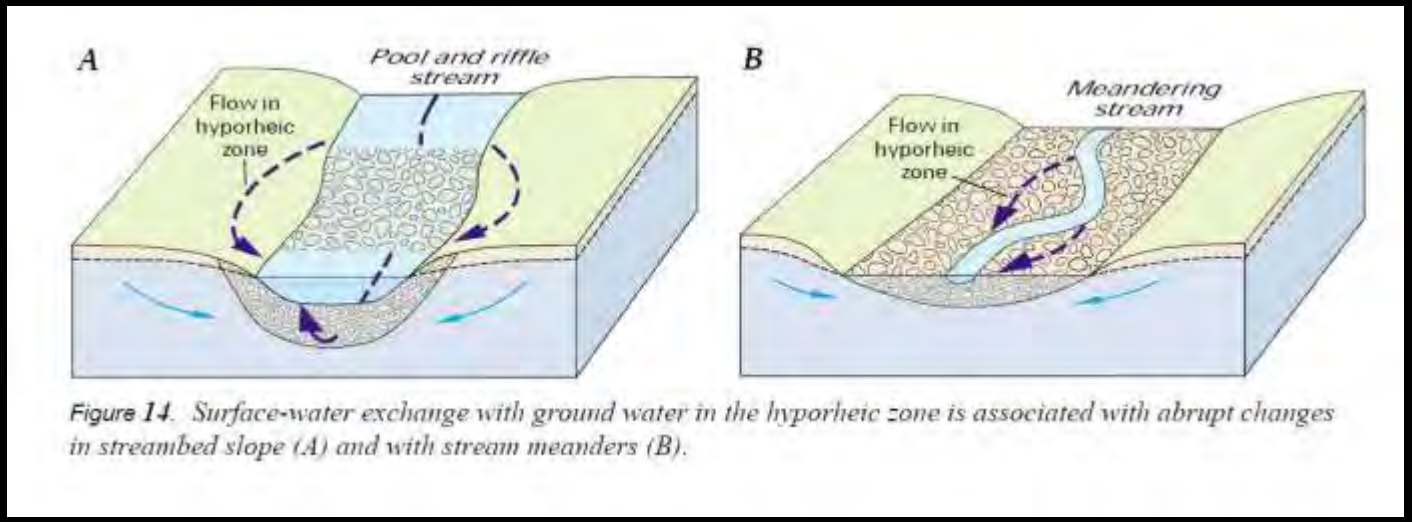
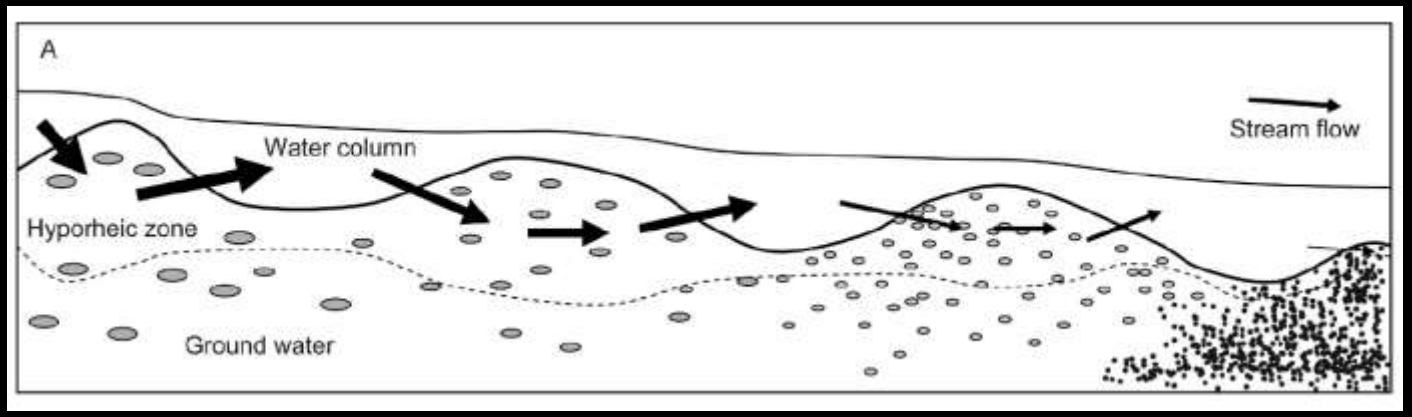


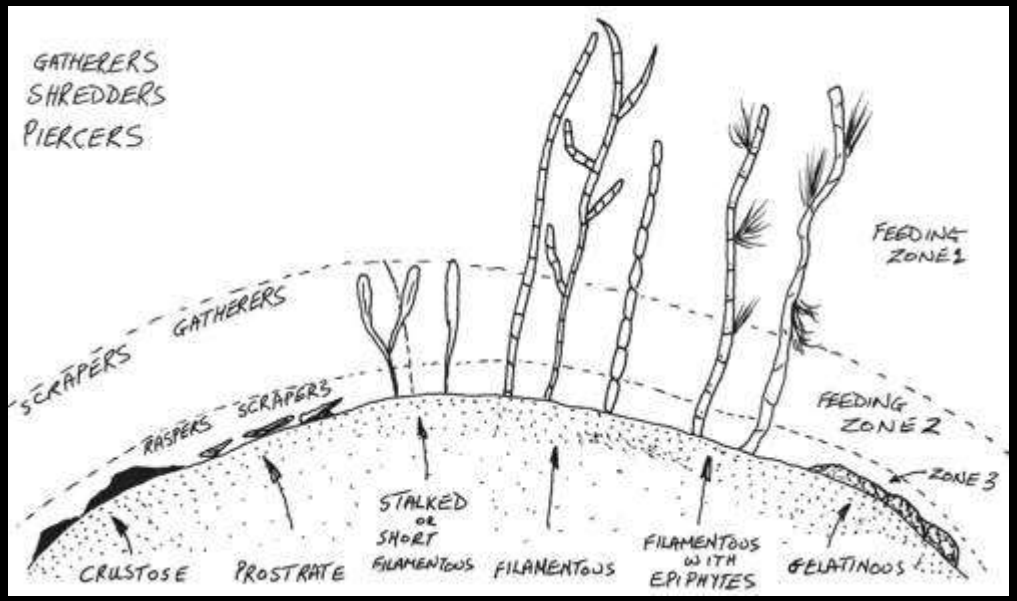
Figure 14. Surface-water exchange with ground water in the hyporheic zone is associated with abrupt changes in streambed slope (A) and with stream meanders (B).



Ecology of Stones - Periphyton

The three zones of Periphyton on stones.

Zones relate to the ability of the animals to consume the material



Freshwater Ecology - Food Webs

Freshwater ecosystems begin with the consumption of living or dead plant material

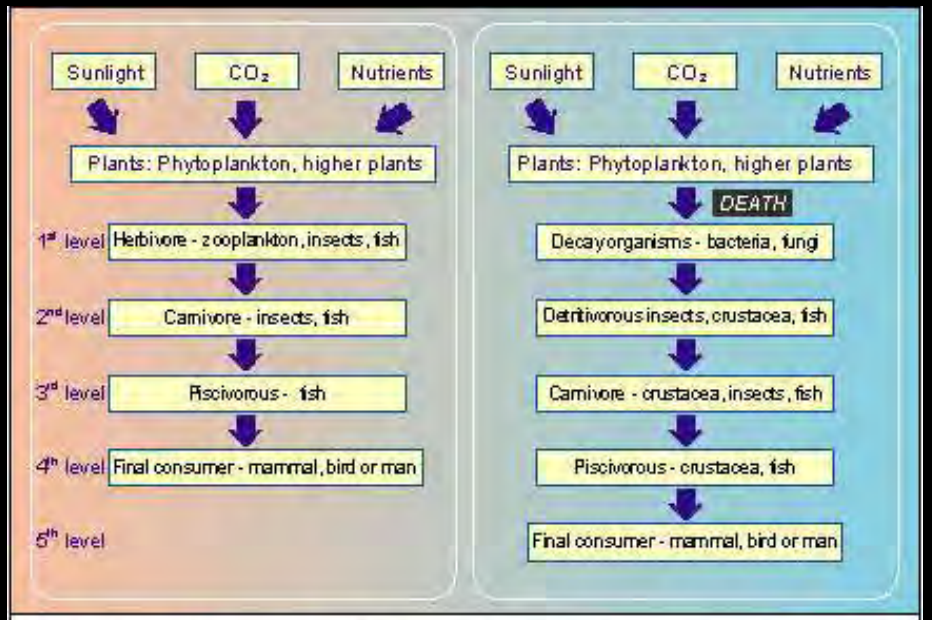
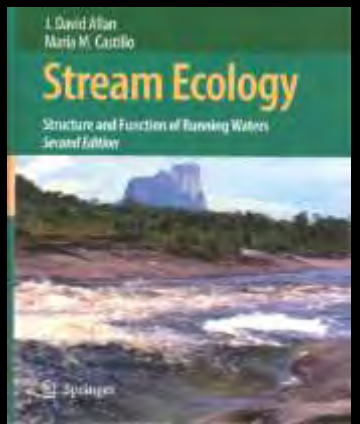


Figure: Alternative pathways for energy and nutrient flow among river organism.



Leaves = Food

Leaf fall from the forest canopy in small streams are used by shredders .

Shredders get nutrition primarily from the fungi and bacteria that colonize the leaf surface. Craneflies, stoneflies, caddisflies and aquatic sow bugs are important members of this group.

Small fragments of leaves and feces from shredders are captured by another group of macroinvertebrates called collectors.

Netspinning caddisflies and blackflies are examples of this group.

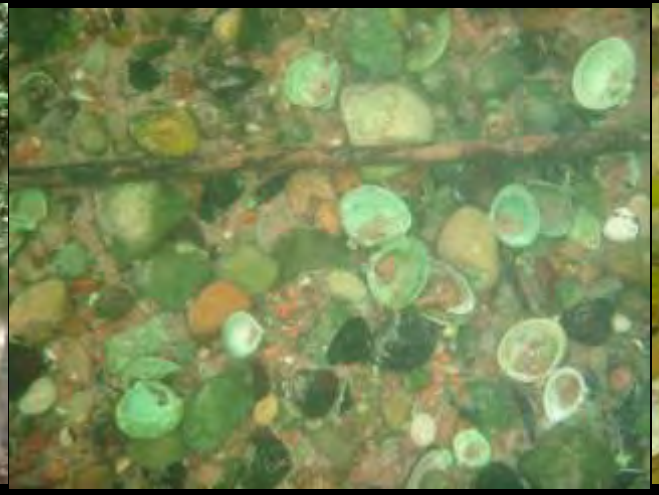
The Leaf Pack Network (LPN) is a network of citizens, teachers, and students investigating their local stream ecosystems.
leafpacknetwork.org

Using the Leaf Pack Experiment Kit, participants:

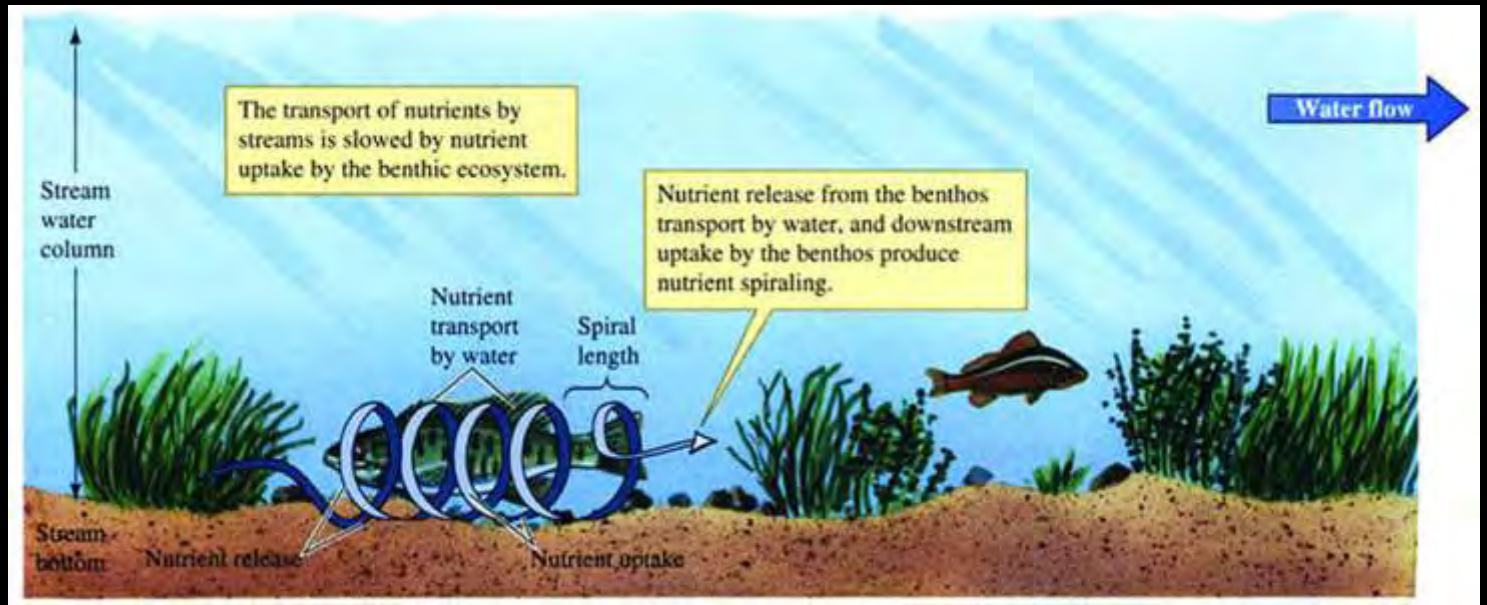
- Create an artificial leaf pack and place it in a stream for three to four weeks.
- Collect and examine the packs in the classroom.
- Share data through the network.

Dissolved Organic Matter [DOM]

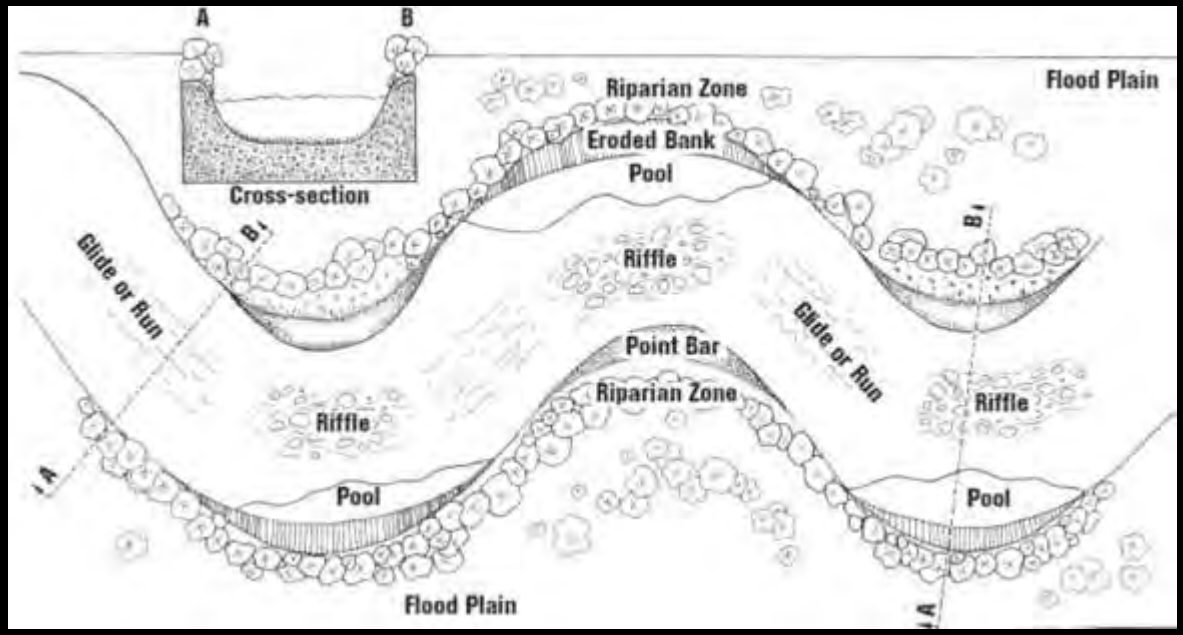
Dissolved Organic Matter (<0.5 microns in diameter) is an important component of the organic material in rivers and streams.

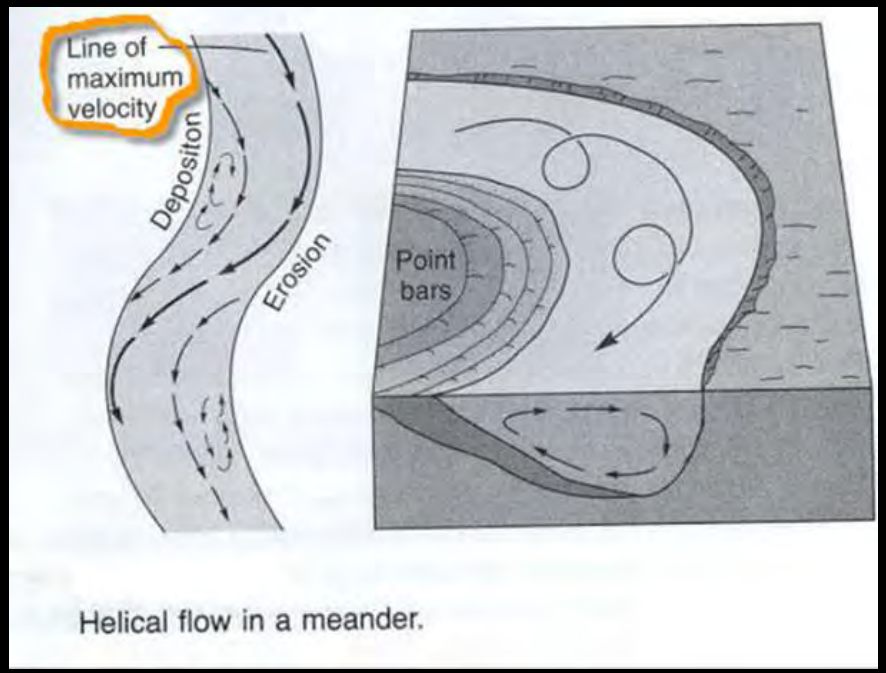




Nutrient transformations in streams are conceptualized to as nutrient "spiraling"



Aquatic Life Worlds: Erosional Zone and Depositional Zone





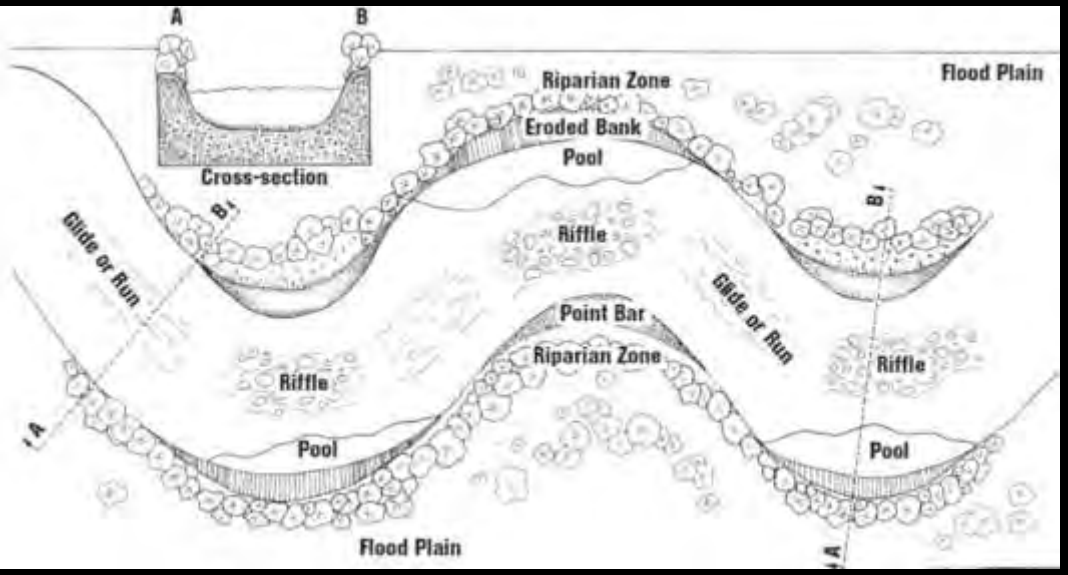
Erosional Zone Habitat – Riffles, Runs, Glides

The erosional zone of a stream is the outer bank where flow velocities and bank erosion are high.

Riffles are the shallow portions of a stream characterized by relatively fast-moving, turbulent water with bottom materials composed of cobble, gravel, or bedrock.

Riffle areas of streams are important habitats for many aquatic insects and small fish that require flowing water for feeding and high oxygen levels.

Riffle areas commonly support those organisms adapted to life in fast-moving waters, such as algae, plants, and invertebrates (mayflies, caddisflies, riffle beetles, water pennies) that can anchor themselves to rocks, logs, and other stream debris.

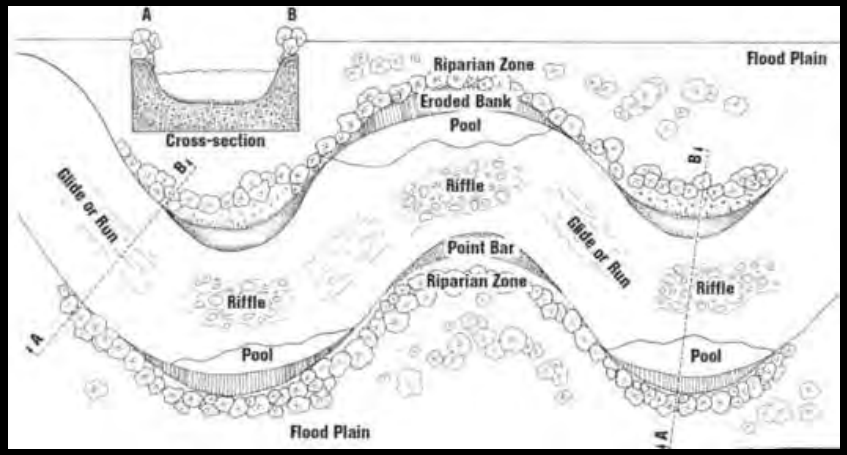


Depositional Zone Habitat – Bars, Pools, Eddies

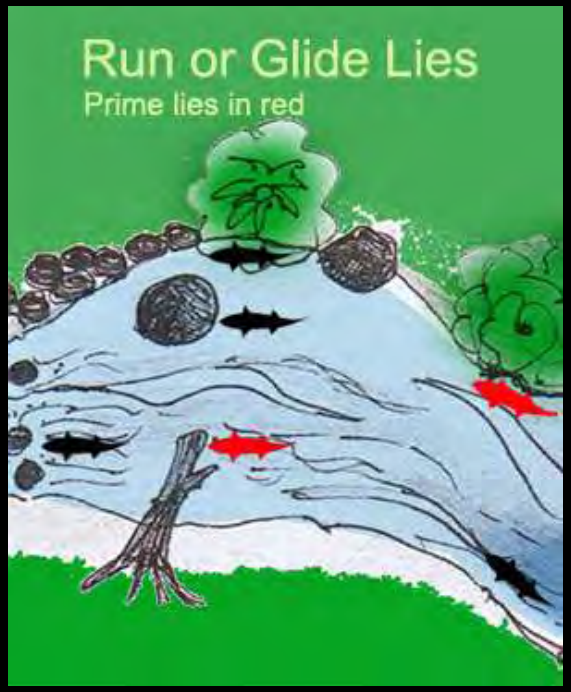
The depositional zone refers to the inner bank of a stream where velocity is at a minimum.

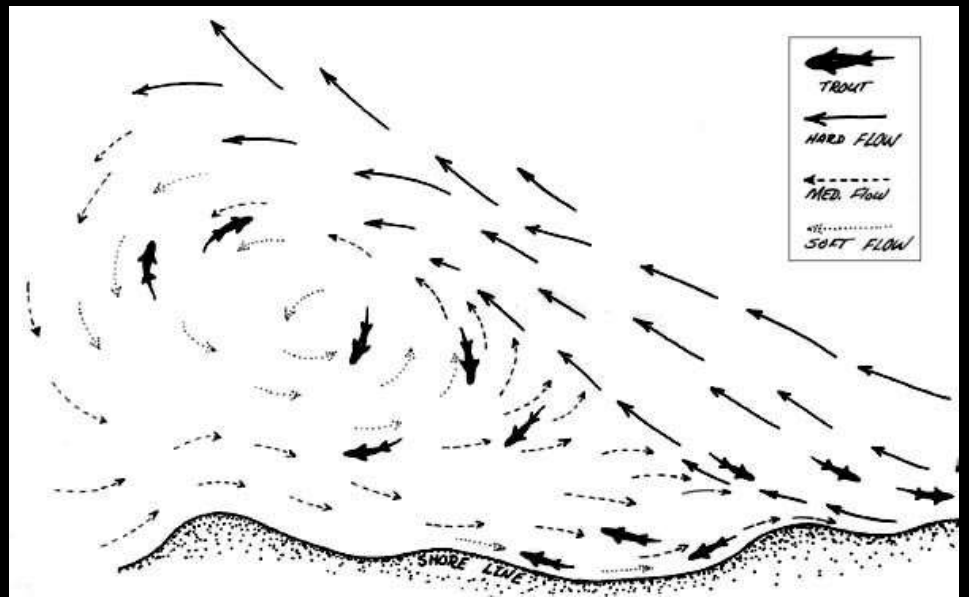
The slower velocities allow for the deposition of suspended sediment and bed materials (gravel, pebbles), which form bars.

These bars often support emergent aquatic vegetation.

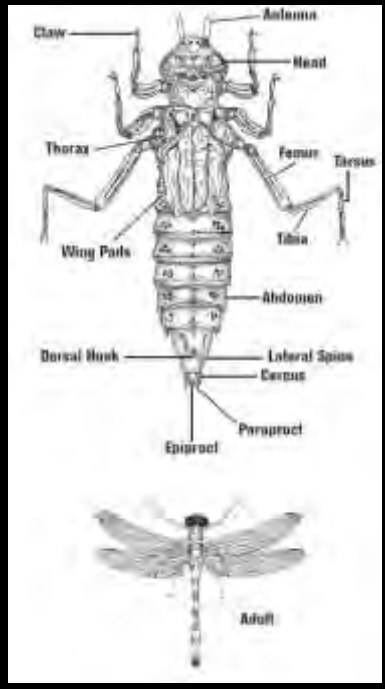


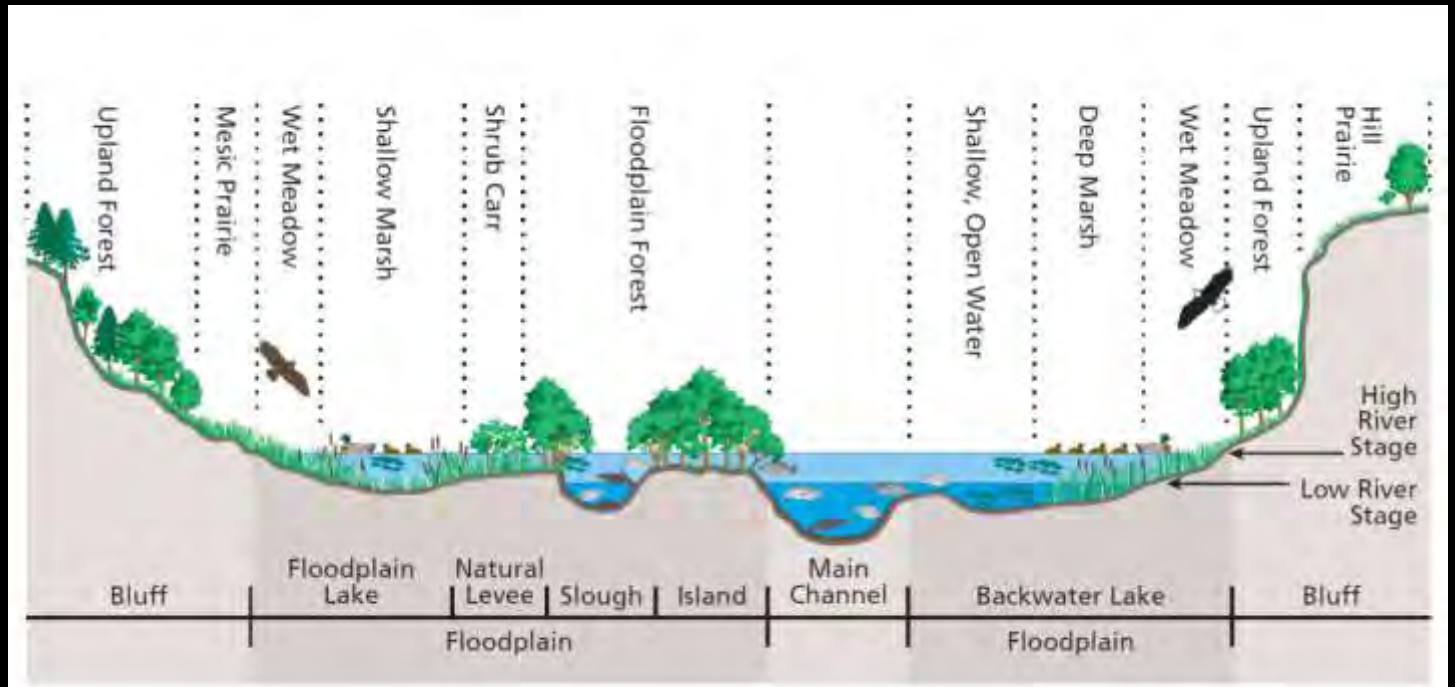
Aquatic Life Worlds: Habitat in Motion

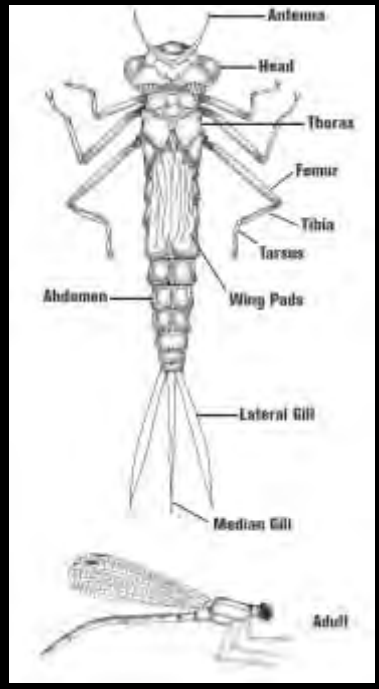


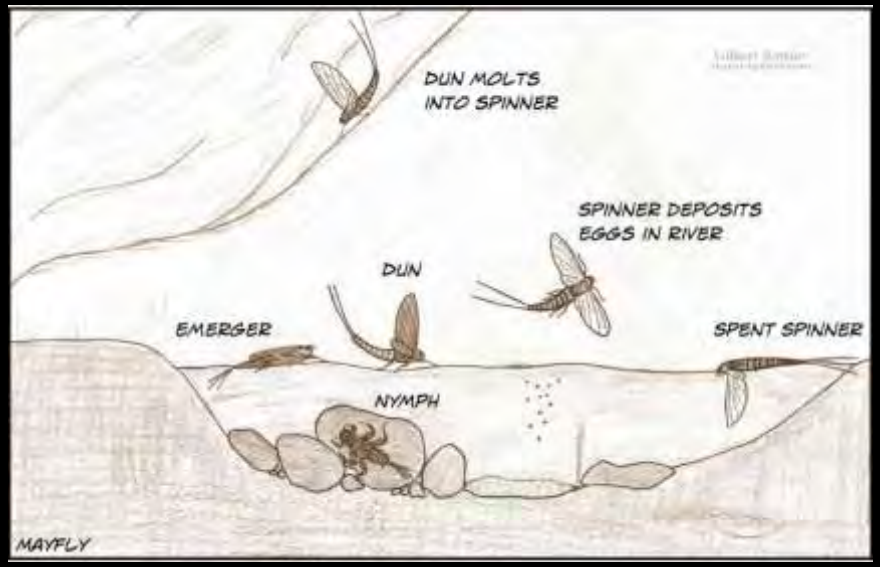


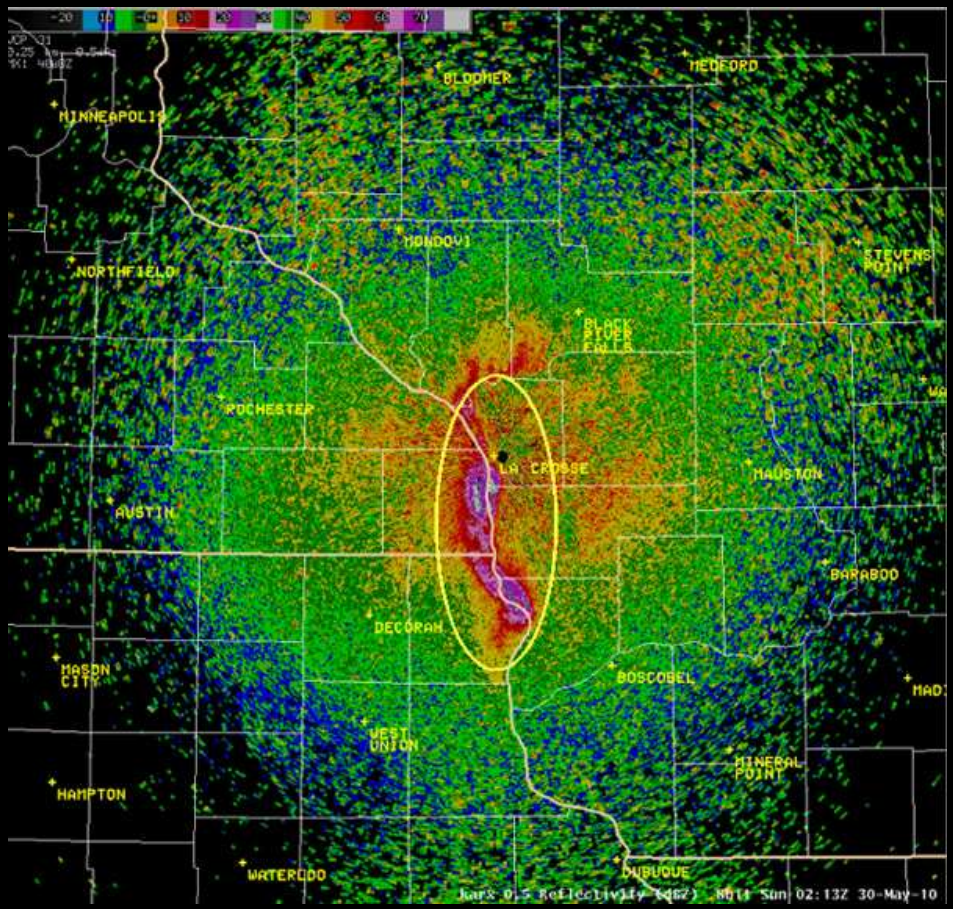
Aquatic Life Worlds: Erosional Zone and Depositional Zone









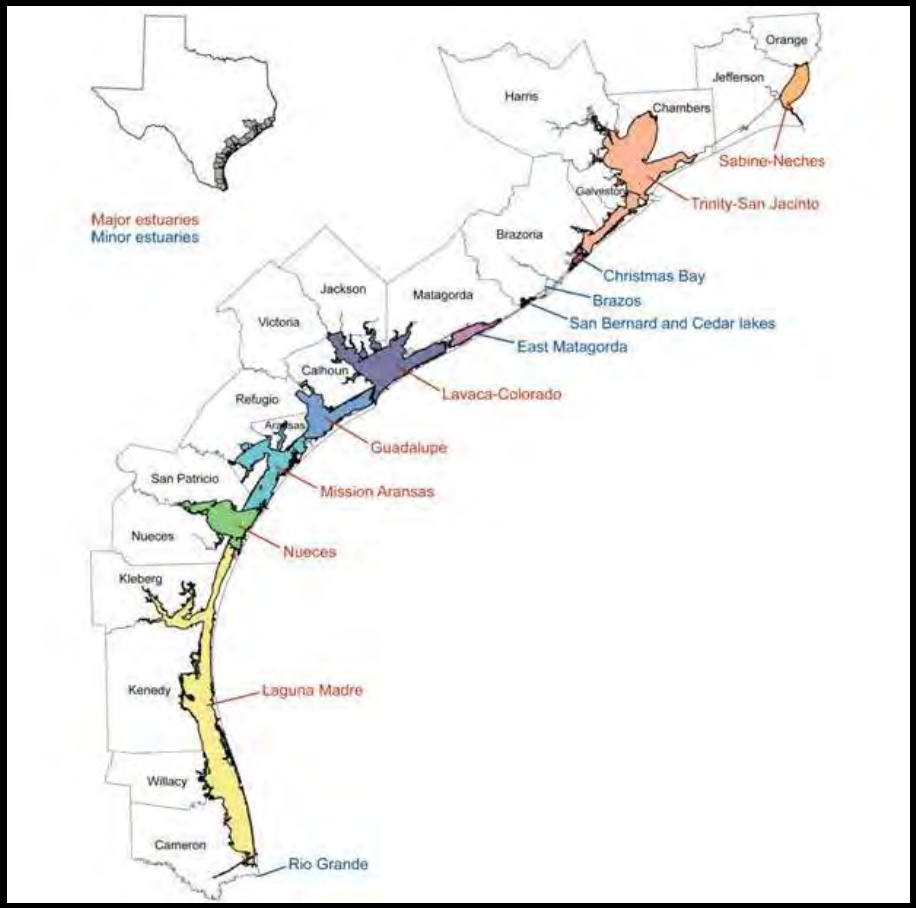


A mayfly mass emergence or hatch from the Mississippi river captured by the National Weather Service Doppler radar in La Crosse Wisconsin (USA) in May 2010.

The adult mayflies in flight are represented by the bright pink, purple, and white.

Old Age - The Delta or – in Texas – The Estuary

"Near its mouth it has reached, in its old age, a nearly level plain through which it wanders in a somewhat aimless course toward final extinction as it joins the ocean that had provided the sustaining waters through its whole life span."



Scientific Models of "Natural" Rivers and Streams

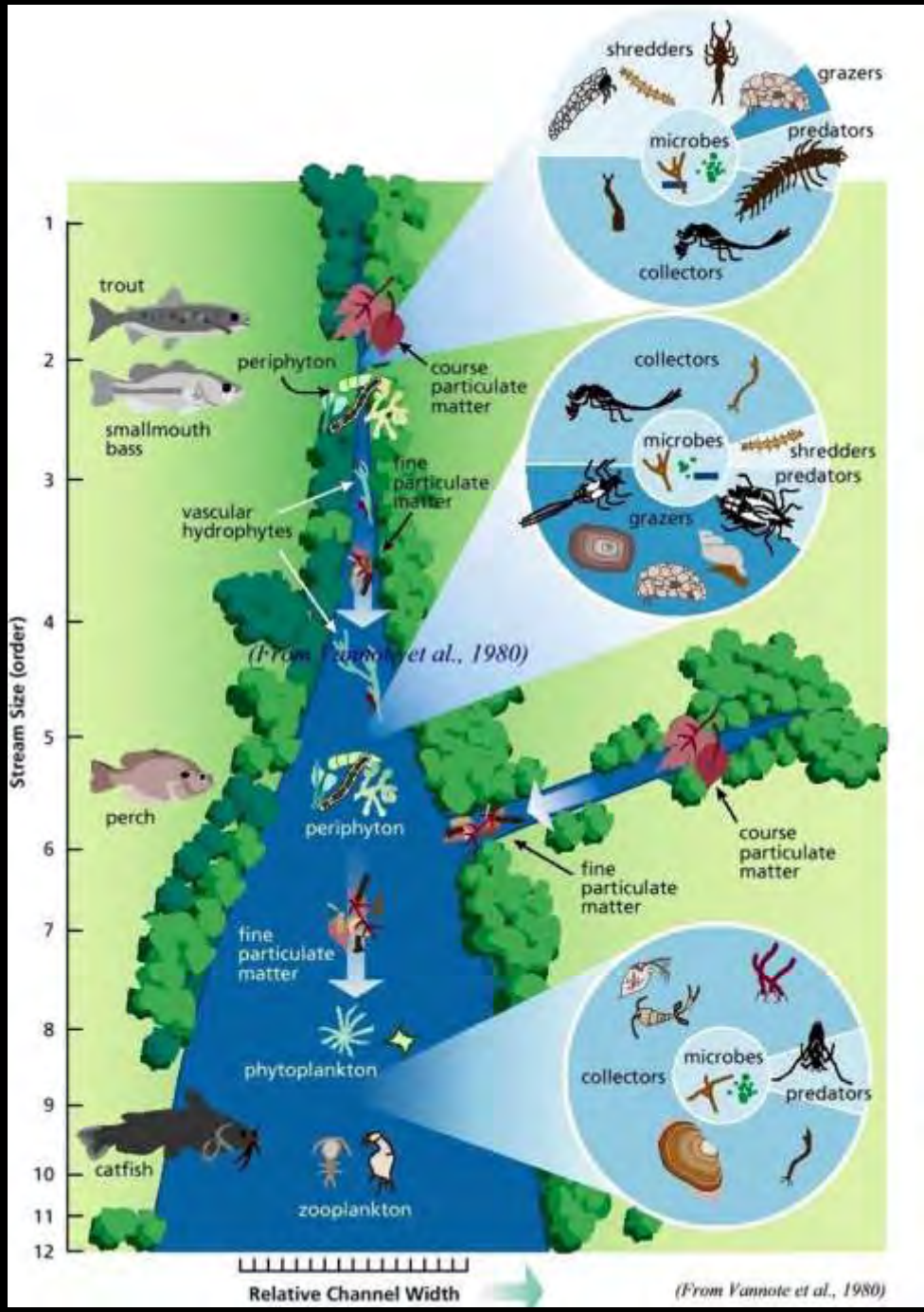
The River Continuum Concept [RCC]

The River Continuum Concept is a model that tries to explain how the physical and biological characteristics of a river change in a downstream direction.

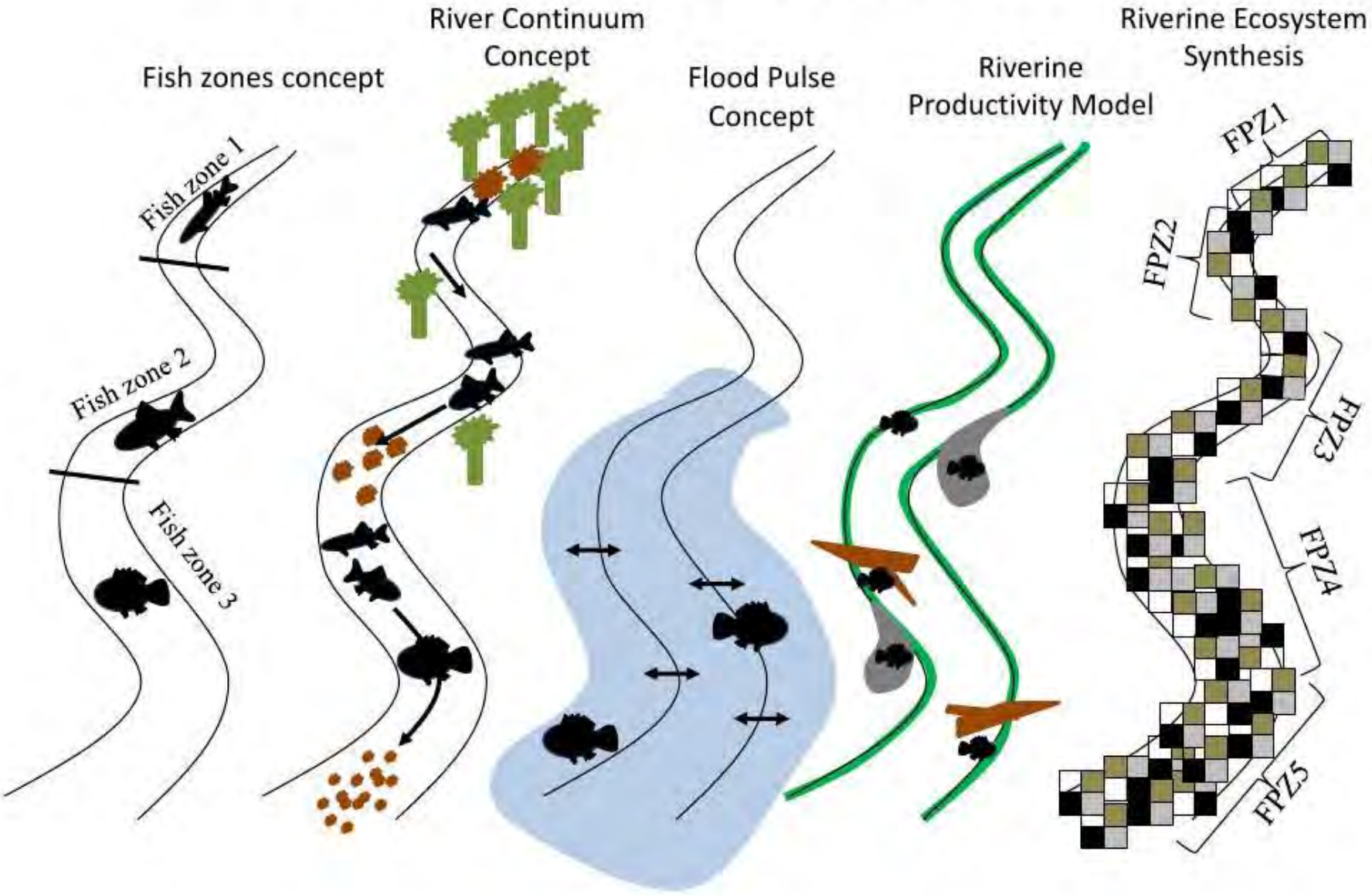
The RCC largely focuses on the interaction of stream invertebrates with their habitat and food resources.

The RCC is a model that might apply to pristine rivers, but few rivers remain unchanged or unaffected by human activities.

Developed by Dr. Robin Vannote - The Stroud Water Research Center - Avondale, Pennsylvania



River ecosystem concepts



Human Disruption and Urbanization
The Serial Discontinuity Concept

Dams are certain to have an impact on the organization of aquatic communities, since the flow is blocked and the longitudinal transition of conditions along the river is altered.

- The dam creates a 'serial discontinuity' in the river because the gradual downstream transition in conditions is disrupted, and the longitudinal transfer of material is prevented.
- Suspended sediments are deposited behind the dam.
- Water released from the dam will pick up a 'normal' sediment load downstream where it may erode the riverbed and banks.

The Serial Discontinuity Concept
Aquatic Ecology Impacts

- Discontinuity in flow conditions is introduced: i.e., standing water behind a dam in what was formerly a flowing-water habitat.
- Movement of aquatic animals is impeded or prevented and populations are fragmented.
- Organic matter transported by the river is deposited in the impoundment behind the dam. The availability of food downstream is therefore reduced.

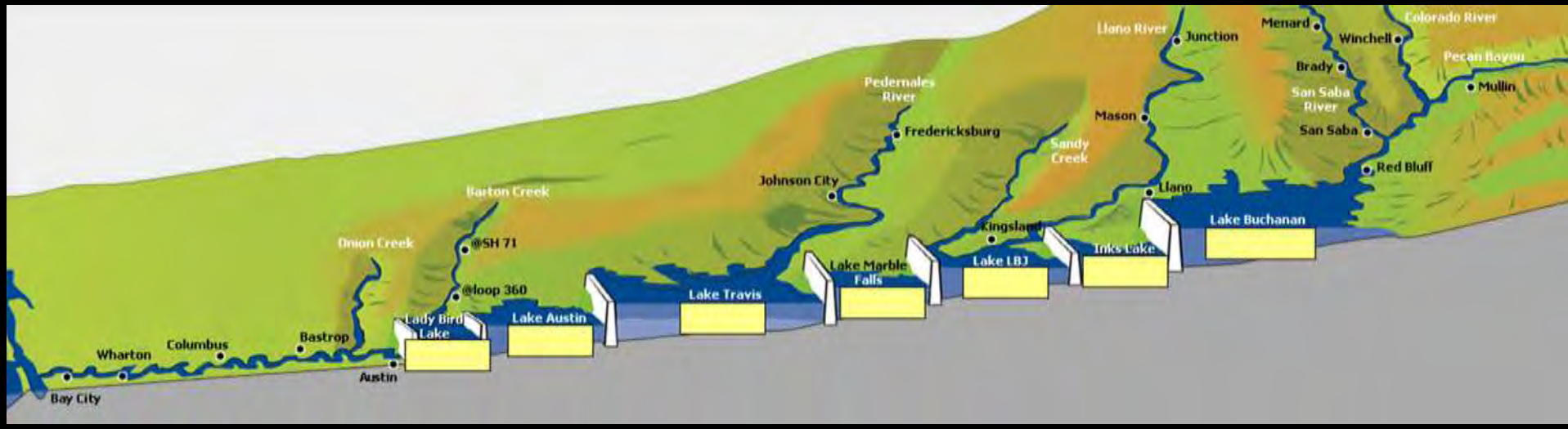
• The downstream transition of water temperature is altered, and water released from the dam may be either warmer (if it is taken from the surface) or cooler (if it is taken from the depths) than natural conditions. Concentrations of dissolved oxygen may be changed also.

• The seasonal patterns of flow will be altered, especially if the function of the dam is to provide water for irrigation (in which case dry-season flows downstream will be reduced) or to control flooding (in which case wet-season flows and floodplain inundation will change).

Taming the Colorado River

The consequences of the introduction of a serial discontinuity depend on its position on the river.

If the discontinuity is in the middle course of the river, it will have a dramatic effect on the transport of material to downstream reaches, and may affect the flood pulse.



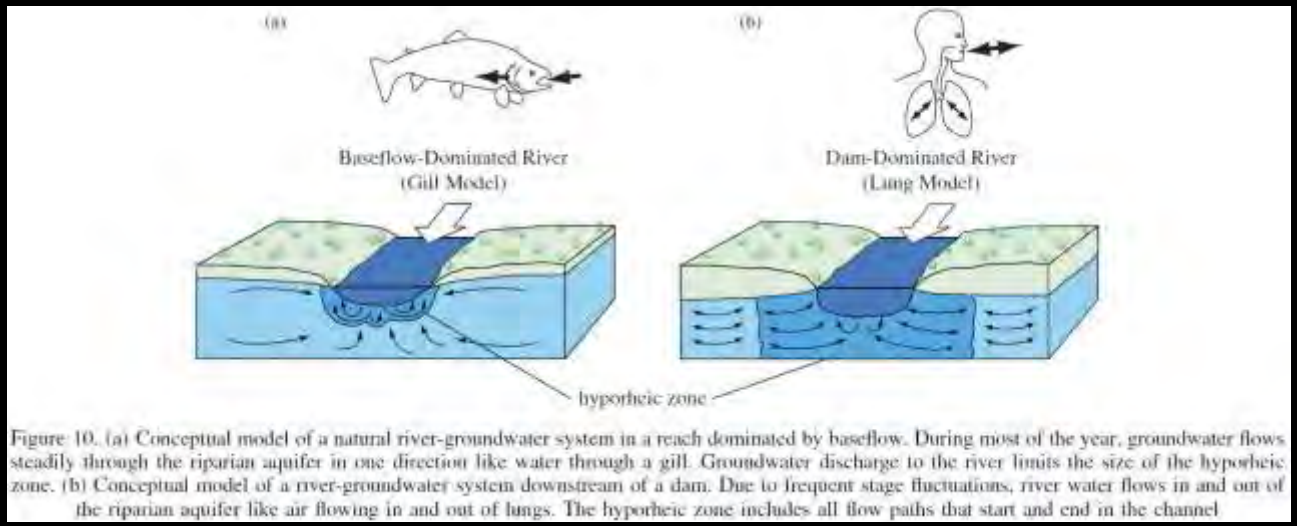
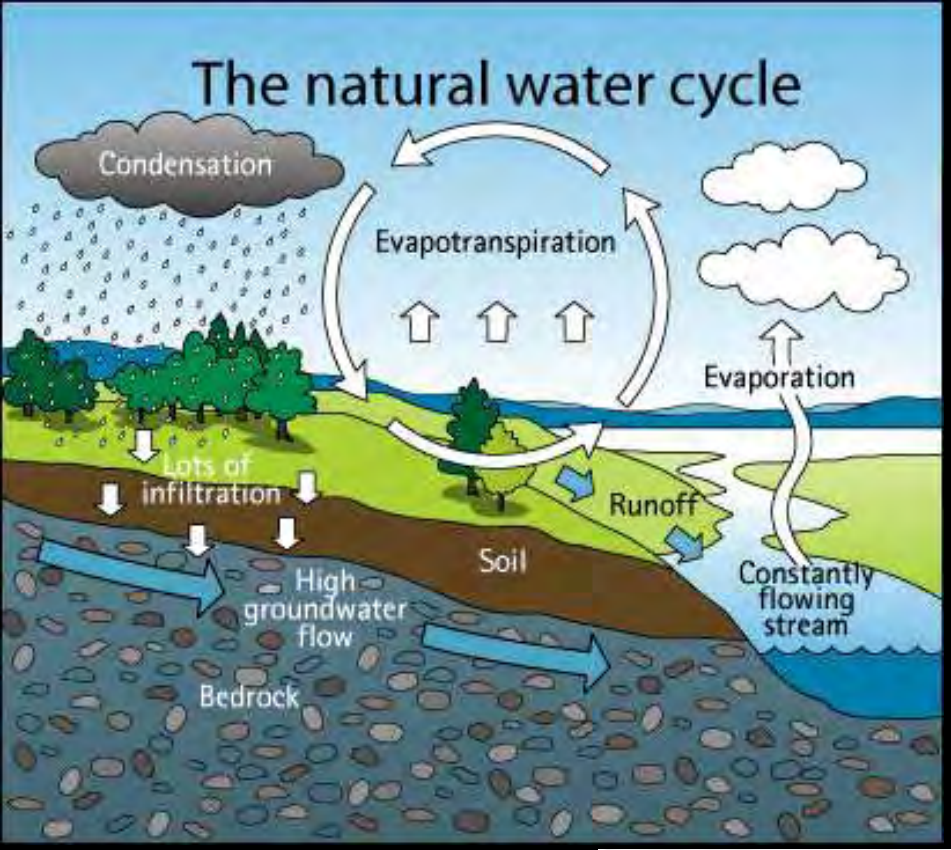
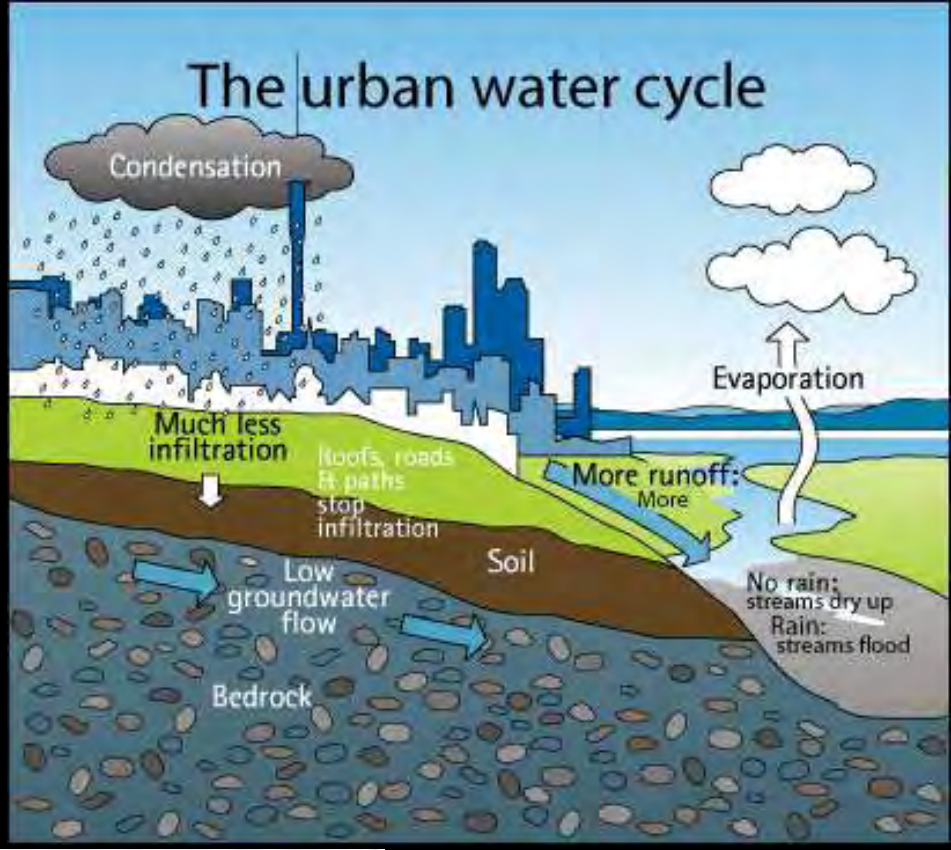


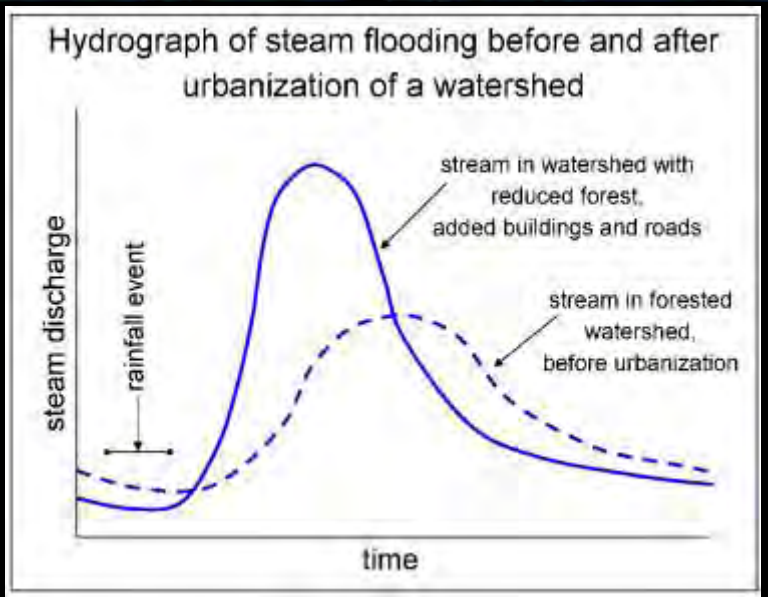
Figure 10. (a) Conceptual model of a natural river-groundwater system in a reach dominated by baseflow. During most of the year, groundwater flows steadily through the riparian aquifer in one direction like water through a gill. Groundwater discharge to the river limits the size of the hyporheic zone. (b) Conceptual model of a river-groundwater system downstream of a dam. Due to frequent stage fluctuations, river water flows in and out of the riparian aquifer like air flowing in and out of lungs. The hyporheic zone includes all flow paths that start and end in the channel

Human Impacts and Urban Creeks





Urban Hydrology



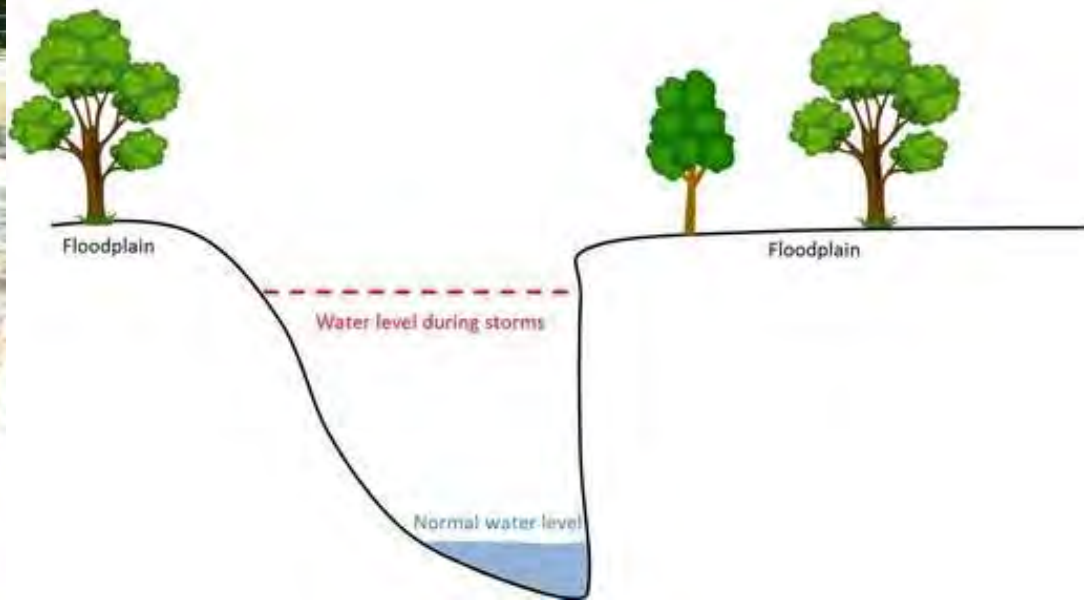
Urban Fluvial Geomorphology

- Urban stream syndrome:
  - High storm flows.
  - Incised channels.
  - Drier riparian zones with lower water tables.

Channel with Incision
Due to Increased Runoff

- Channel Erosion
- Nonfunctional Floodplain
- Dry Riparian Soils

Urban Stream Channel



West Bouldin Creek South 6th Street


before


after

Tannehill Branch Creek Givens Park


before


after

Blunn Creek Stacy Park


before


after

Natural Character with Stream Stability

City of Austin WATERSHED PROTECTION

City of Austin Riparian Restoration

AUSTIN PARKS & RECREATION

Riparian Zone Restoration: Bartholomew Park

1. Persistent mowing in creek

2. Grow Zone intermediate stage

3. Grow Zone mature riparian woodland

2017

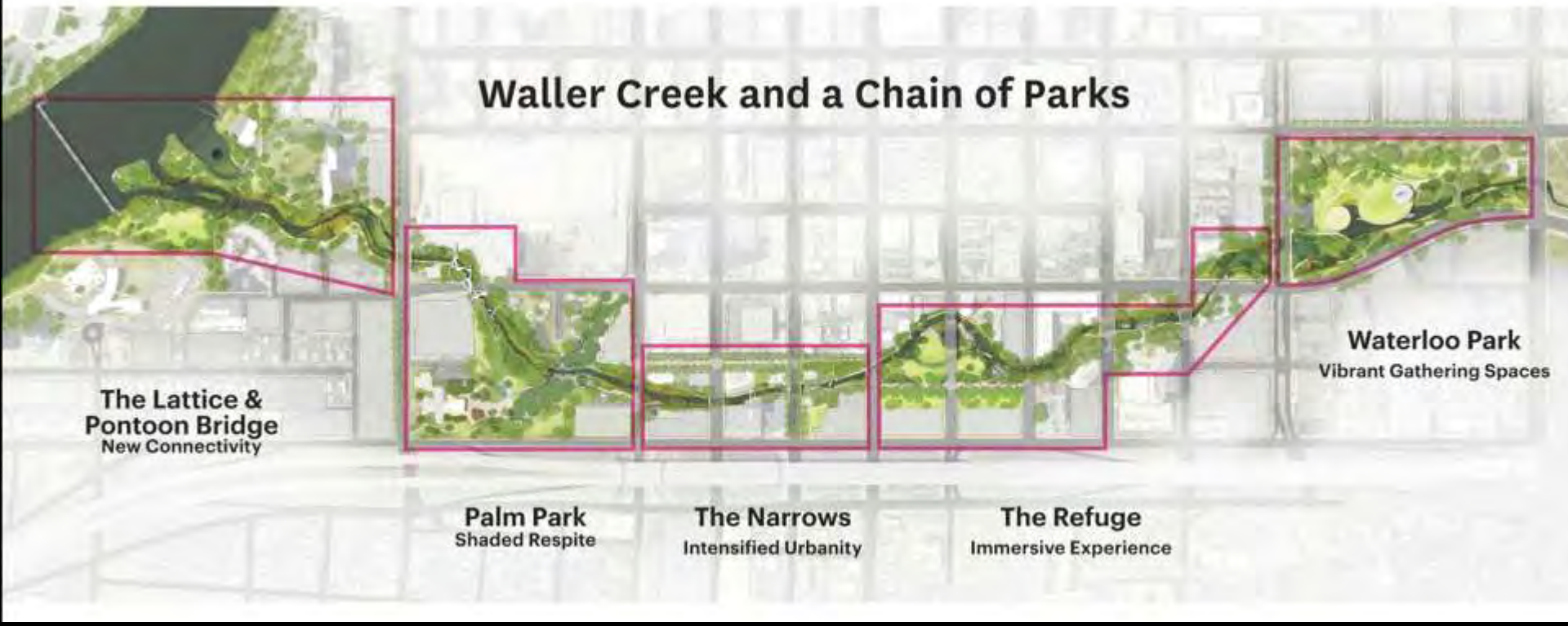
Grow Zone – Wild Waller Creek
A Socioecological Creek

2005

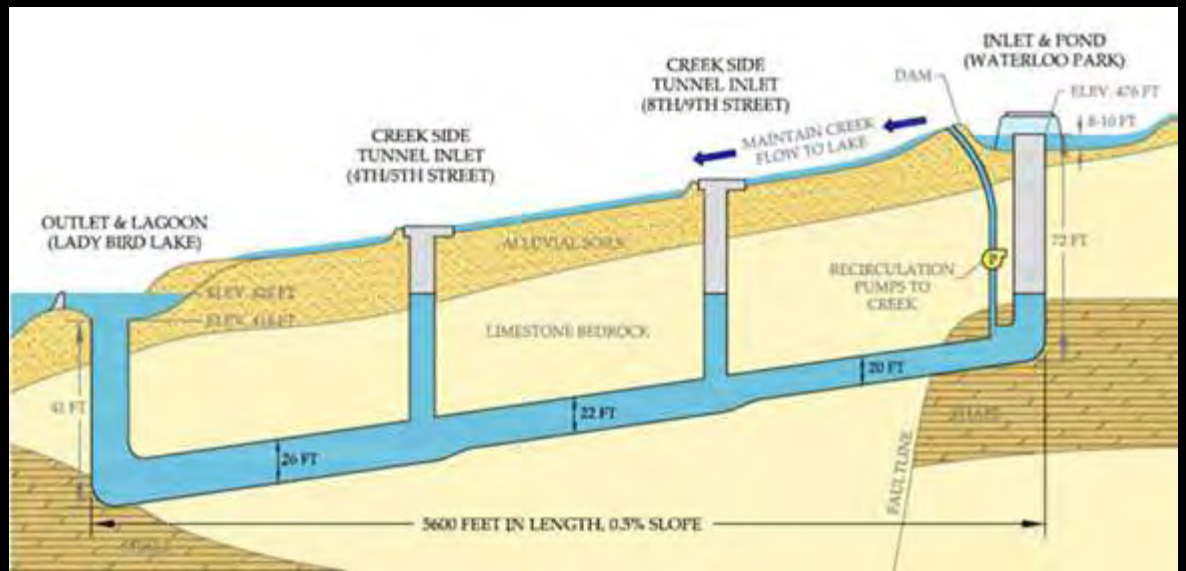
2007

2009

2012



The Cyborg Creek and the Serial Discontinuity Concept

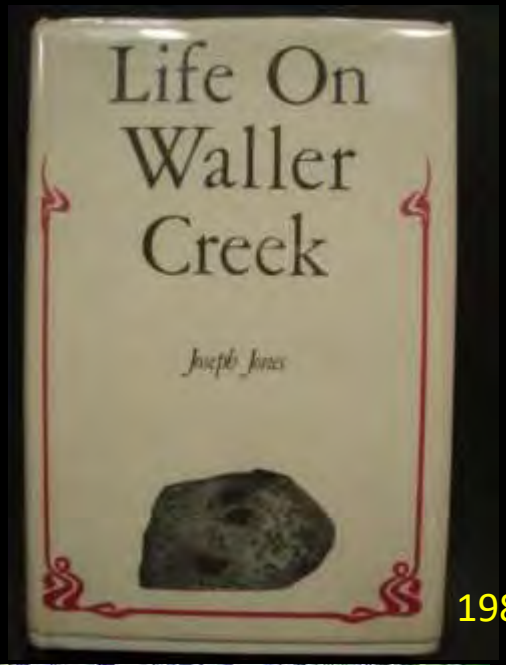


The Cyborg Creek

The Creek is an ever-visible manifestation of continuity, of life…

it is the sum total of many processes, an intricately integrated process in itself…

The fact that it has been interfered with by man, and continues to be interfered with, must be accepted as part of such total process, whatever opinion may be held as to the merits of the interferences.



1982

Joseph Jones 1908-1999

Archeology Going Somewhere to Happen

I would hope also that the reader, if he should tire of being reminded overmuch of what an efficient trash-receiver (up to a point) the Creek has become in our day, will exercise the reader's privilege of imagining what counterparts to an inventory of the 1970s-80s were almost certainly to be found in Waller Creek pretty steadily after 1839 and indeed even before.

But let him first accept himself as part of the continuum and become his own short-term archeologist: such fugitive creek-things as I will be cataloguing here, when carried and buried, might be thought of as archeology going somewhere to happen.

Thus, for example:

Plastic beer cups (Brand X with blue map of Texas) in addition to the ever-ongoing deposit of beer cans…

A grackle's reflection as he flies low over a still pool…

After a flood, young willows keep reminding us, for many days, "It went that-a-way,"…

High-visibility translucent bluish plastic bags – like Portuguese-men-of-war on a Gulf beach, but not biodegradable…

scars of the sewer builders, still evident after twenty, twenty-five years…

A much-twisted-and-battered yellow umbrella.

At Home on the Creek – Natural History

Dr. Travis LaDuc, assistant curator of herpetology for the Texas Biodiversity Center

Since 2006, LaDuc and others, including current and former students from the university's Vertebrate Natural History course, have been capturing and radio-tagging the snakes in Waller Creek to better understand their biology in our urban ecosystem.

Blotched watersnakes (Nerodia erythrogaster) are the most common large snakes in the Waller Creek. The only other large species of snake seen in the creek is the non-venomous Texas ratsnakes (Pantherophis obsoleta).

Small species of snakes seen (infrequently) include the Texas Brown Snake (Storeria dekayi) and the Texas Blindsnake (Leptotyphlops dulcis).

In the intensive surveys, they have never encountered any venomous snakes in the creek, and going back through museum records since 1947, there have been no venomous snakes collected anywhere along Waller Creek.

The Socioecological Creek

To explore Waller Creek and environs is to live intensively in the modern world and at the same time to be aware of how brief an instant modernity has been with us; how brief an instant, indeed, the human presence has been here in any guise to contemplate a very old set of surroundings...

Joseph Jones

The Creek, if we will only let it, will keep reminding us of all this at the same time it offers us other gifts; solitude or limited companionship as needed and wanted;

earth, air, and water in slow procession and interaction under the radiant presence of fire; plants and animals living or present in fossil forms…

Joseph Jones


Applause