Our Backyard Waterways:
Water Quality and Watershed Protection







Topics

- What is a watershed? Who cares?
- Overview of Aquatic Ecology
- Clean Water Act/DEQ water monitoring and assessment activities
- Major sources of pollutants
- Urban Stream Syndrome – Reedy Creek
- Assessing Stormwater Issues
- Solutions – Rain Barrels to Rain Gardens

CREEK CONNECTIONS

Box 10, Allegheny College, Meadville, PA 16335

http://creekconnections.allegheny.edu

What is a Watershed

A Watershed

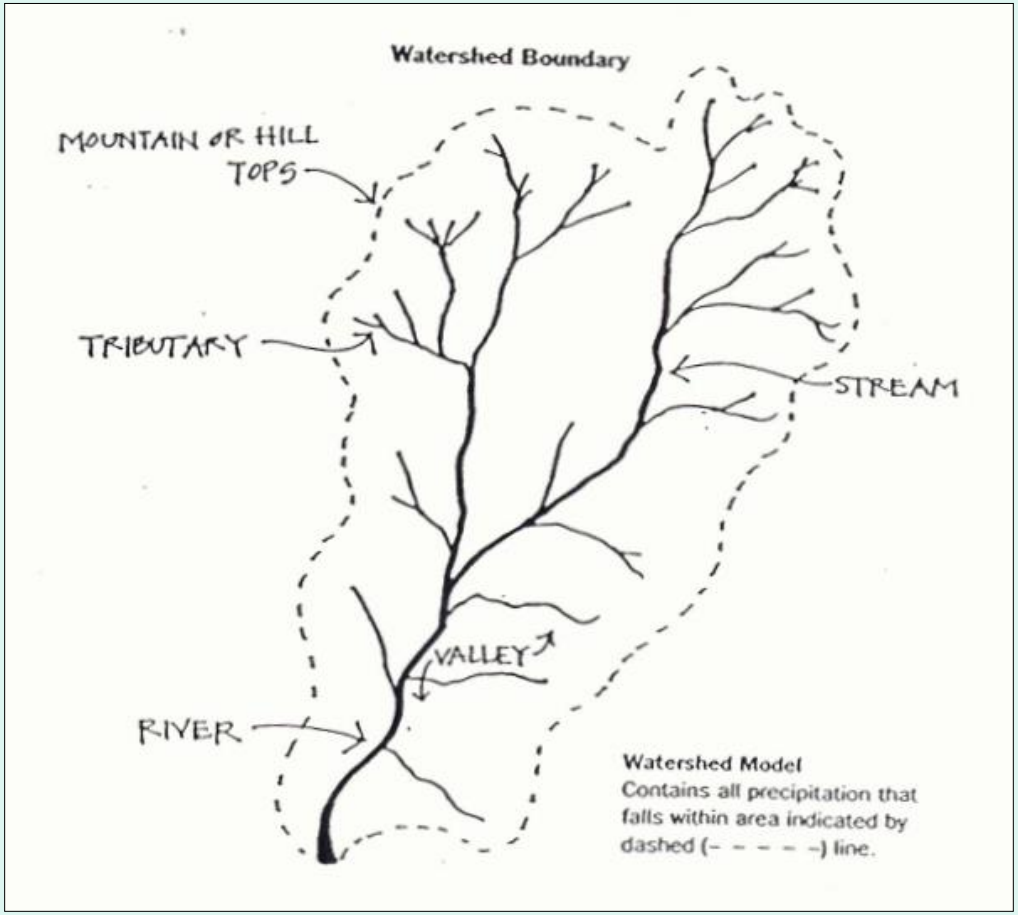
Definition

- The total land area that contributes water (or drains into) a particular waterway.

- Can also be called a “Drainage Basin”

Watershed Boundary

Any water within the boundary of your watershed or precipitation that falls within the boundary will flow into your waterway.



Watershed Address

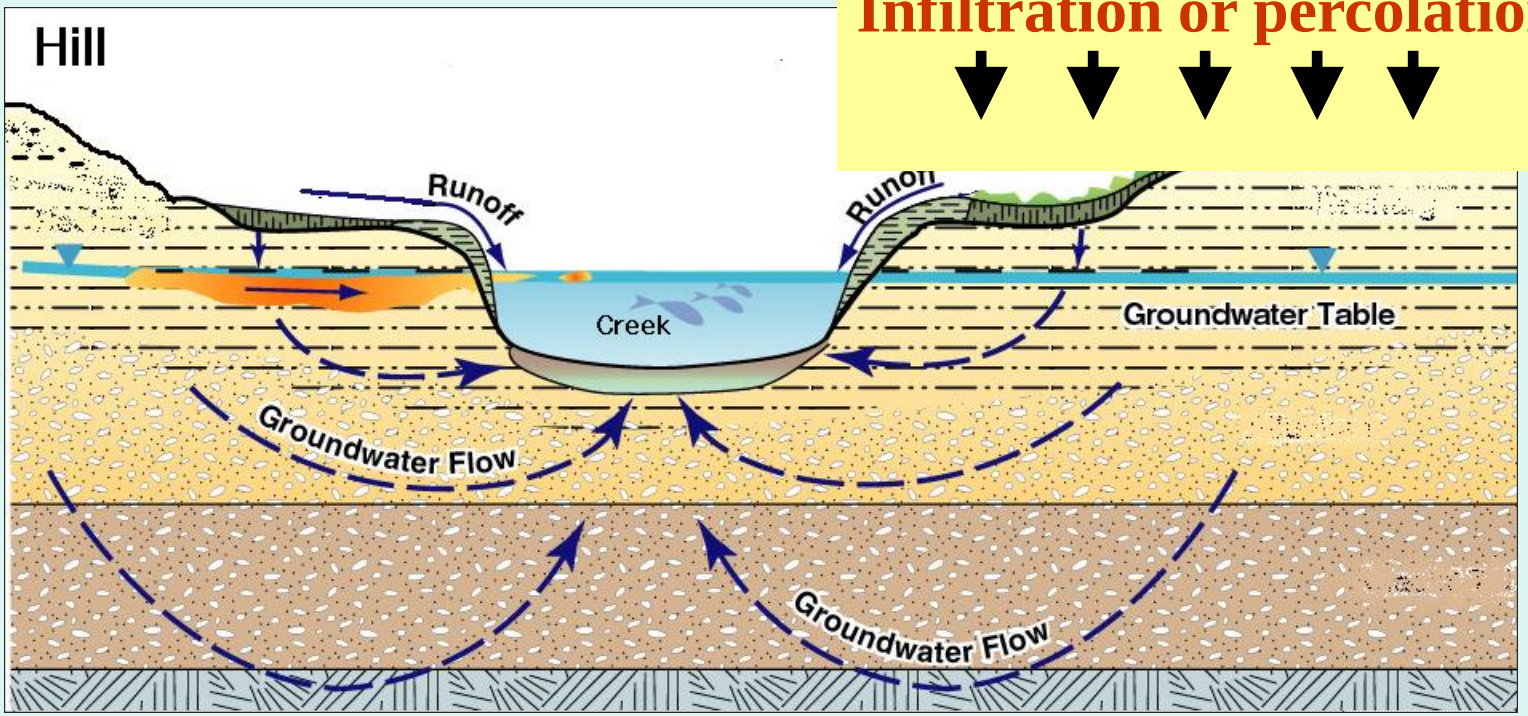
- Lickinghole Creek
- Stony Run
- Chickahominy River
- James River
- Chesapeake Bay


Ashland
Ashcake Rd
Sunny Dr
Melton Rd
Elmont Rd
Stony Run
Maple St
Dow Gil Rd
Johnson Rd
Long Rd
N Lakeridge Pky
Cavell Ln
Karen Dr
Cobbs Rd
Lewistown Rd
Carruthers Way
Brookhollow Dr
Stony Run
Elmont Rd
Patch Rd
Holly Hill Rd
Chiles Rd
Branch Rd
Sethwarner Dr
Old Washington Hwy
Greenwood Rd
Kings Rd
Rebel Rd
Warren Rd
Glen Allen
295
Jeb Stuart Pky
Lakeridge Pky
Kings Acres Rd
Lickinghole Creek
Leadbetter Rd
Egypt Rd
Ceaon Rd
Slayden Creek
Mechumps Creek
Oak Trl
Goddin Rd
Mt Eagle
Mt Hermon Rd
Magpie Ln
Campbell Creek
Stumpy Rd
Peaks Rd
Ashcake Rd
Bugle Ln
New Ashcake Rd
Owl Ln
Lincoln Rd
Linderwood Dr
Sliding Hill Rd
Kings Charter Dr
Guenevere Pl
Ashking Dr
Windy Knoll Dr
Wheeling Rd
Totopotomoy
Cool Spring Rd
Staples Ln
Howard Dr
Chickahominy River
The Crossings Golf Club
Turner Run
Steuben Dr
Jesse Chavis Dr
Crump Park

Flow: Groundwater

Under the surface, GROUNDWATER is on the move

Infiltration or percolation



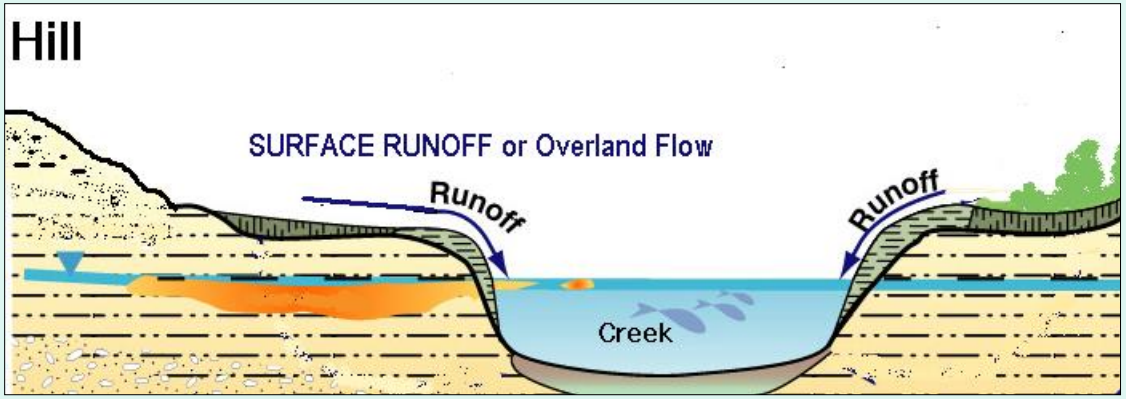
Source of illustration: http://www.epa.gov/region01/ge/thesite/groundwater.html

Flow: Surface Runoff

Surface Runoff can also be called "Overland Flow"

http://h2osparc.wq.ncsu.edu/info/phos.html

http://h2o.enr.state.nc.us/nps/What_is_NPS/urban.htm

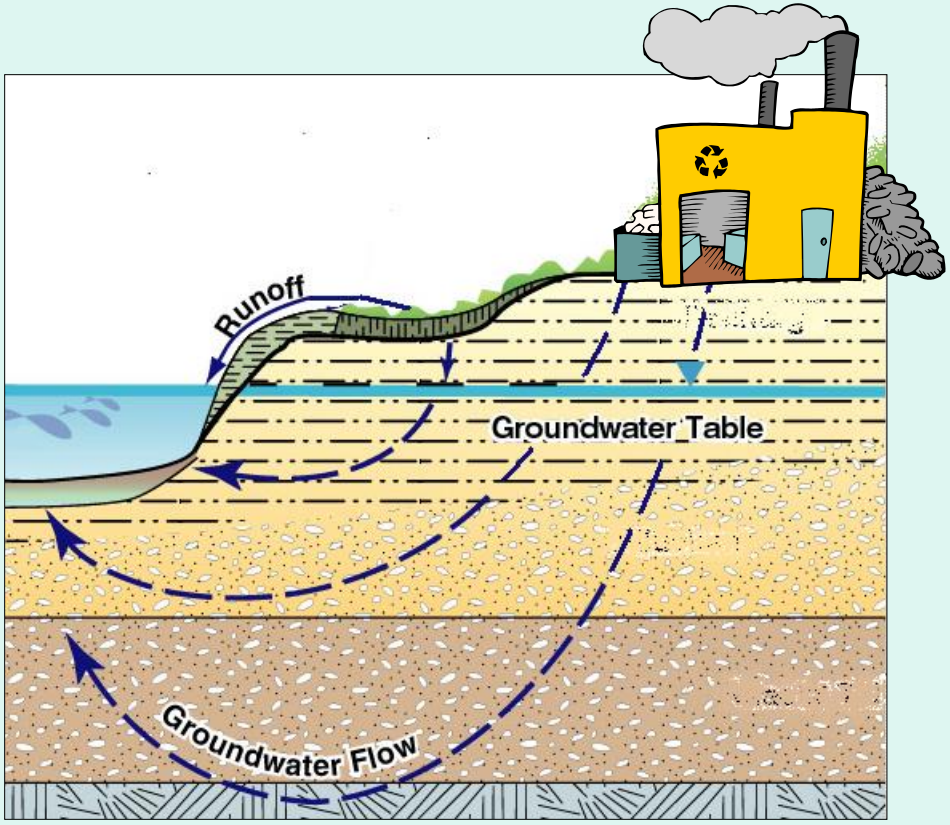


Over forested land, fields, grasslands, even parking lots

Source of illustration: http://www.epa.gov/region01/ge/thesite/groundwater.html

Watershed Impacts

- Land and waterway interaction



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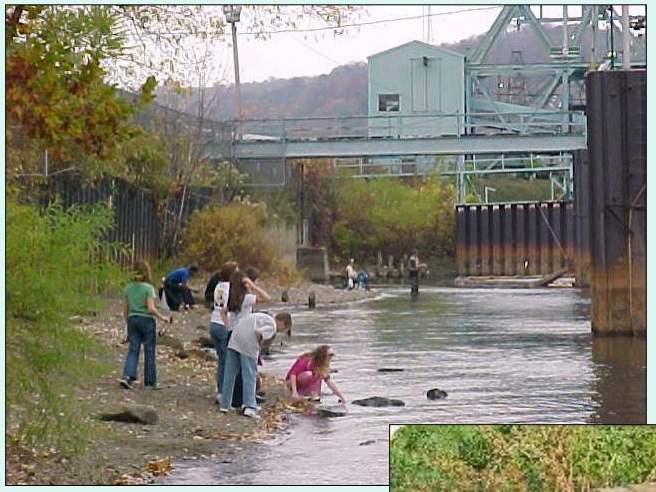
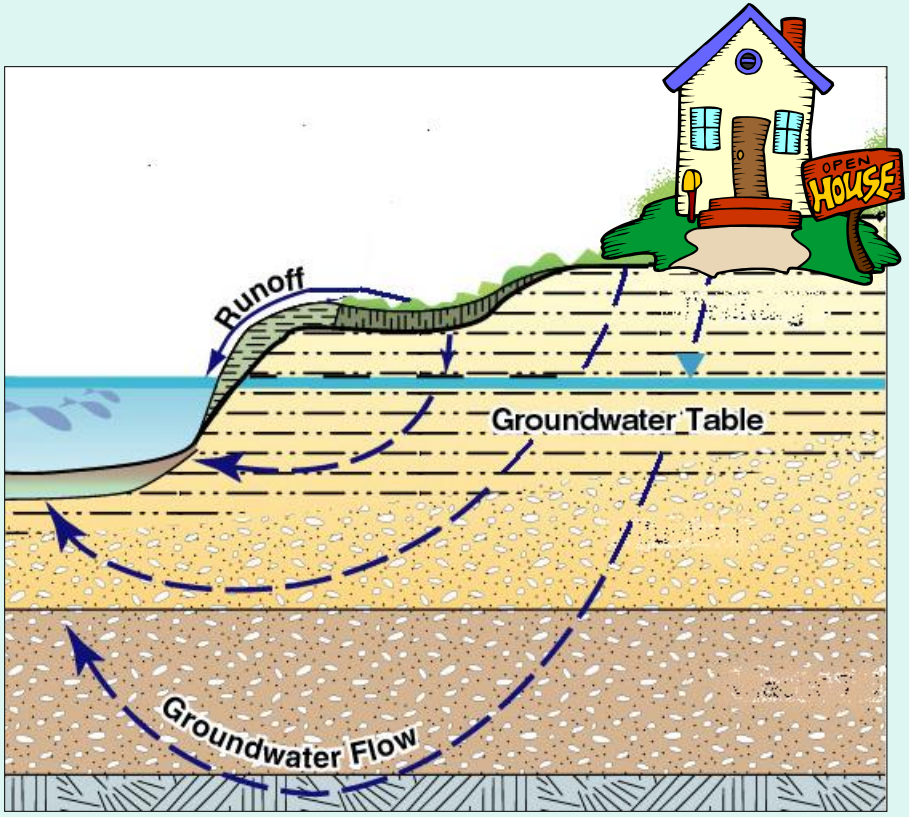


What we do on land affects our waterways

Watershed Impacts

- Land and waterway interaction



Source of illustration: http://www.epa.gov/region01/ge/thesite/groundwater.html

What **YOU** do on land affects our waterways

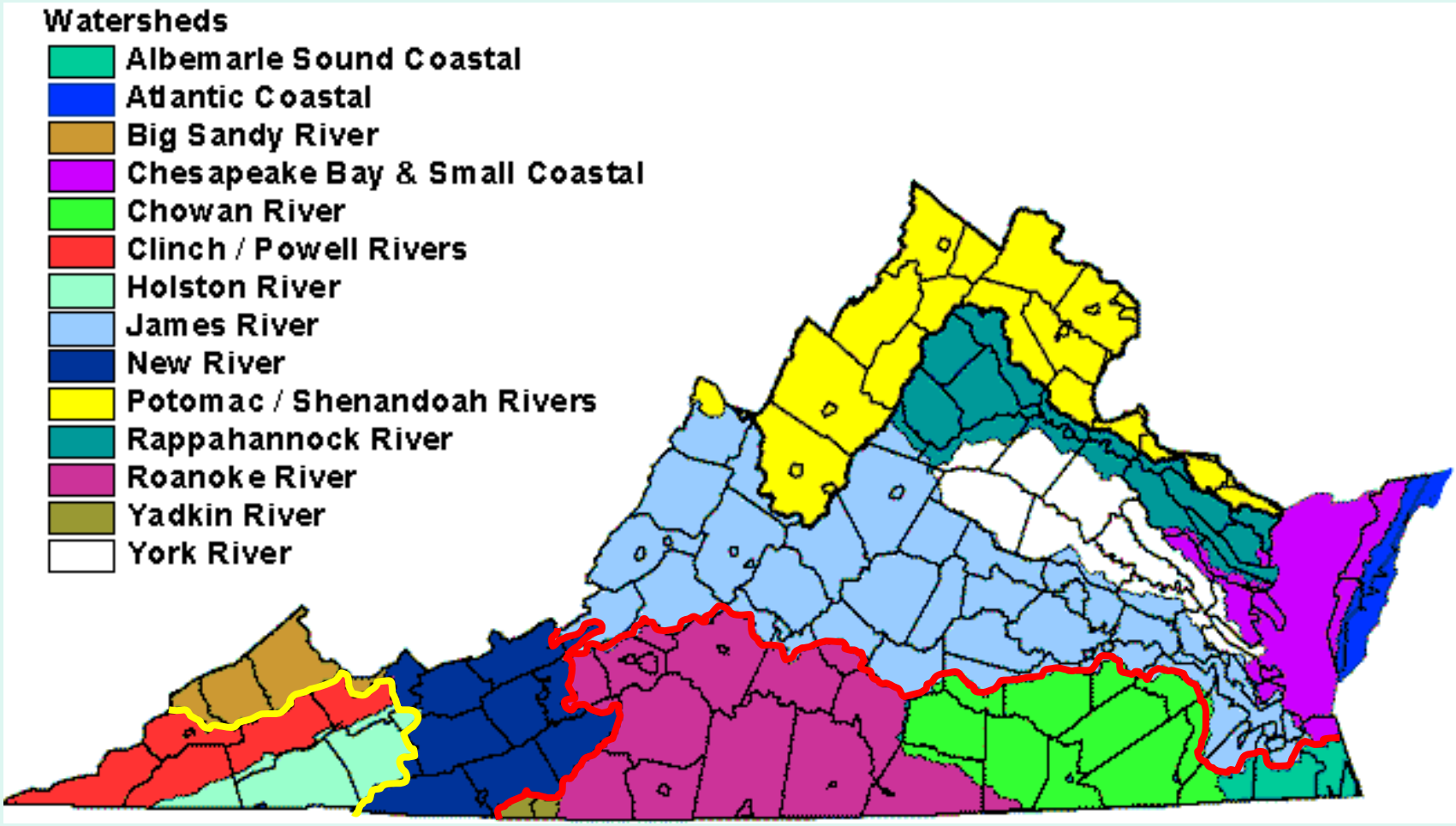
Watersheds – Who Cares?

- All land is part of some watershed
- Surface runoff and groundwater carry pollutants from the land
- Land use determines water quality

Virginia's waters are very diverse

- Geographic location of state
  - 10+ major watersheds
  - Tidal waters
- Geology
  - Mountains
  - Piedmont
  - Coastal Plain

VA Major Watersheds

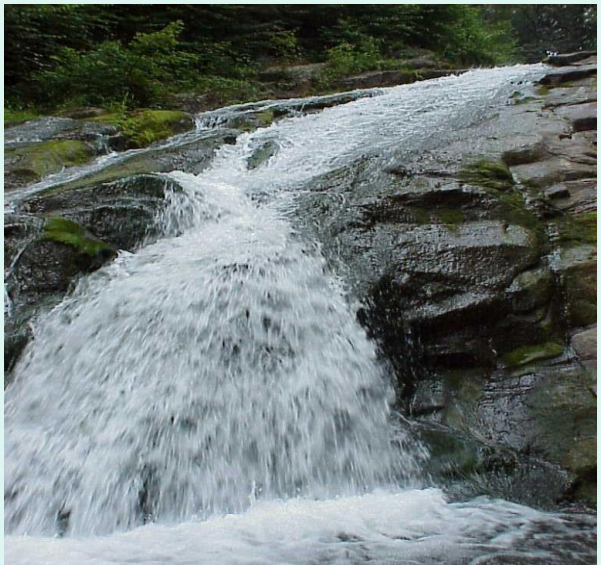


Aquatic Ecology

- Physical/ Geological Factors

- Living Components

Mountain Streams



Characteristics of Mountain Streams

- High gradient leading to high water velocity
- Lots of boulder, cobble, gravel substrate
- High frequency of riffles
- Good oxygenation from riffle areas

Coastal Plain Streams

Characteristics of Coastal Plain Streams

- Low gradient and low water velocity
- Substrate is primarily sand and fine sediment
- Woody debris is most common **stable** substrate
- Dissolved oxygen concentrations generally lower especially in summer
- Low water velocity allows growth of rooted aquatic vegetation

Piedmont Streams

Characteristics of Piedmont Streams Compared to Mountain Streams

- Moderate gradient and water velocity
- Fewer riffles, sometimes none
- Less boulder and cobble substrate – more sand and fine sediment
- Woody debris and undercut banks become important source of stable substrate

Swamp

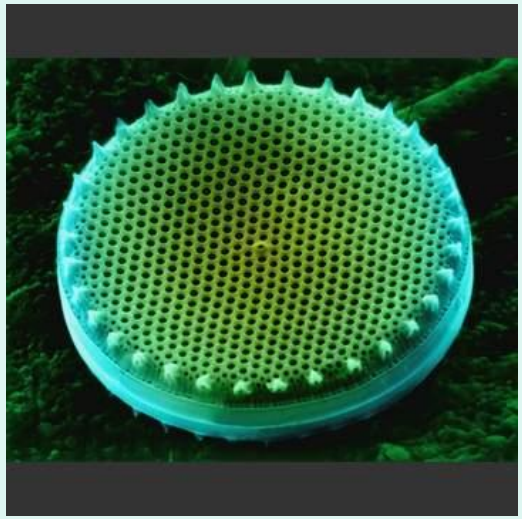
Characteristics of Swamps

- Very low gradient and water velocity
- Substrate is fine sediment and detritus (often “mucky”)
- Lots of submerged and emergent aquatic vegetation
- Low dissolved oxygen and low pH
- No defined channel

Living Components of Aquatic Systems





Primary Producers

- Macrophytes – usually rooted
- Phytoplankton – free-floating, microscopic
- Periphyton – attached microscopic
- Terrestrial plant material – leaves, etc.

Macrophytes

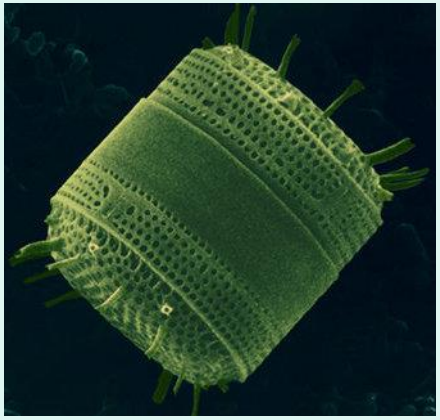
- Rooted vascular plants
- Require slow moving water
- Low density in large rivers
  (Low light)
- Most common in slow,
  medium-size streams
- **NOT** an important food source
- Important as substrate

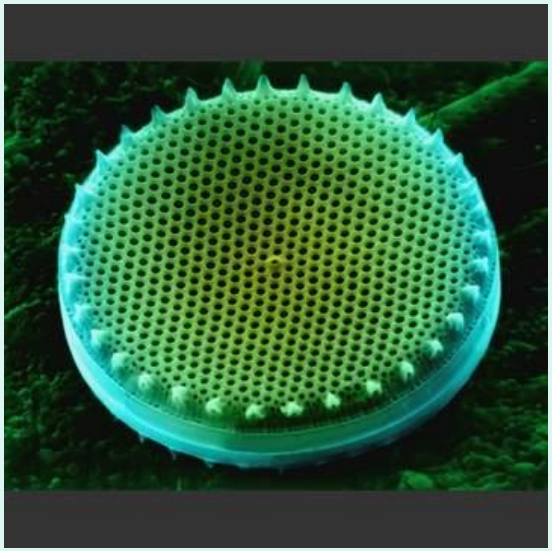
Phytoplankton

- Free-floating cells
- Diatoms, green algae, cyanobacteria
- Low numbers in high gradient streams
- Important in large rivers, estuaries, lakes

3. Periphyton

a. Primarily diatoms, green algae, and cyanobacteria **attached** to substrate
b. Substrate can be rocks, wood, sand





3. Periphyton (Continued)

c. Periphyton is a complex community

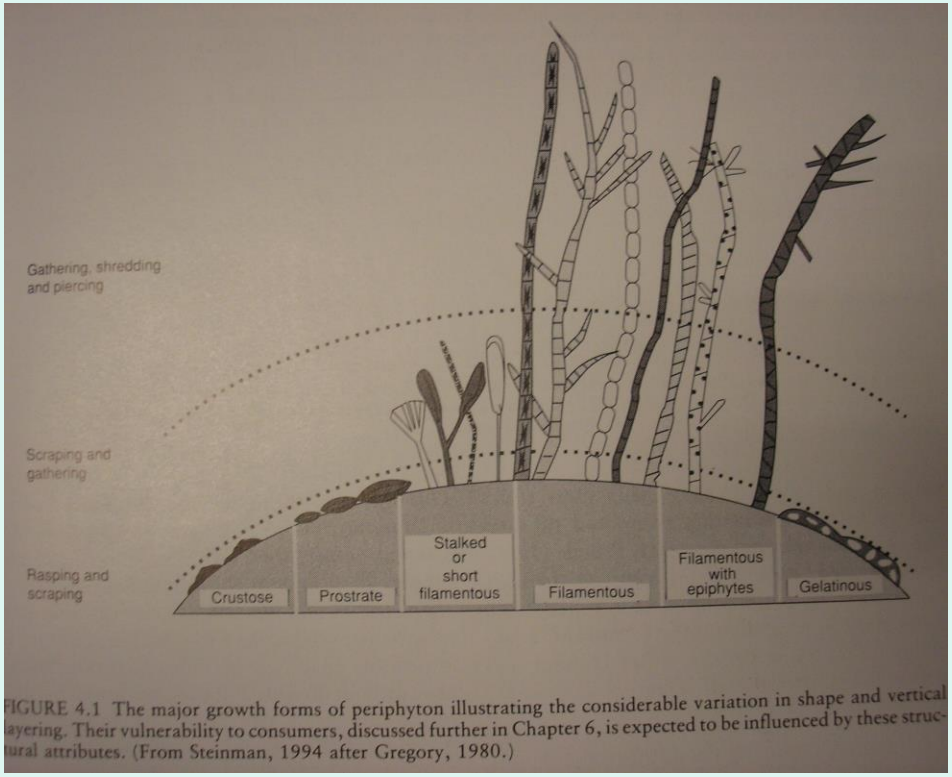


FIGURE 4.1 The major growth forms of periphyton illustrating the considerable variation in shape and vertical layering. Their vulnerability to consumers, discussed further in Chapter 6, is expected to be influenced by these structural attributes. (From Steinman, 1994 after Gregory, 1980.)

Analogous to a forest at a micro-level (ground cover, understory, canopy)

3. Periphyton (Continued)

d. Important food source in many shallower streams
e. Production can be limited by nutrients, light (shading), and grazing.

Terrestrial Plant Parts

- Most important source of carbon in some aquatic systems (e.g. limited periphyton due to shade or low nutrients)

Microorganisms

- Bacteria and fungi – critical role in “conditioning” dead plant material for use by aquatic animals

- Protozoa and Microscopic Invertebrates - links in food web to larger animals

Benthic Macroinvertebrates

- Benthic - associated with the bottom of a water body (includes banks and other stable substrate associated with the bottom such as woody debris and macrophytes

- Macroinvertebrates – Animals without backbones that can be seen with the naked eye (insects, crayfish, snails, etc.)

Benthic Macroinvertebrates

Fish

Aquatic Food Web

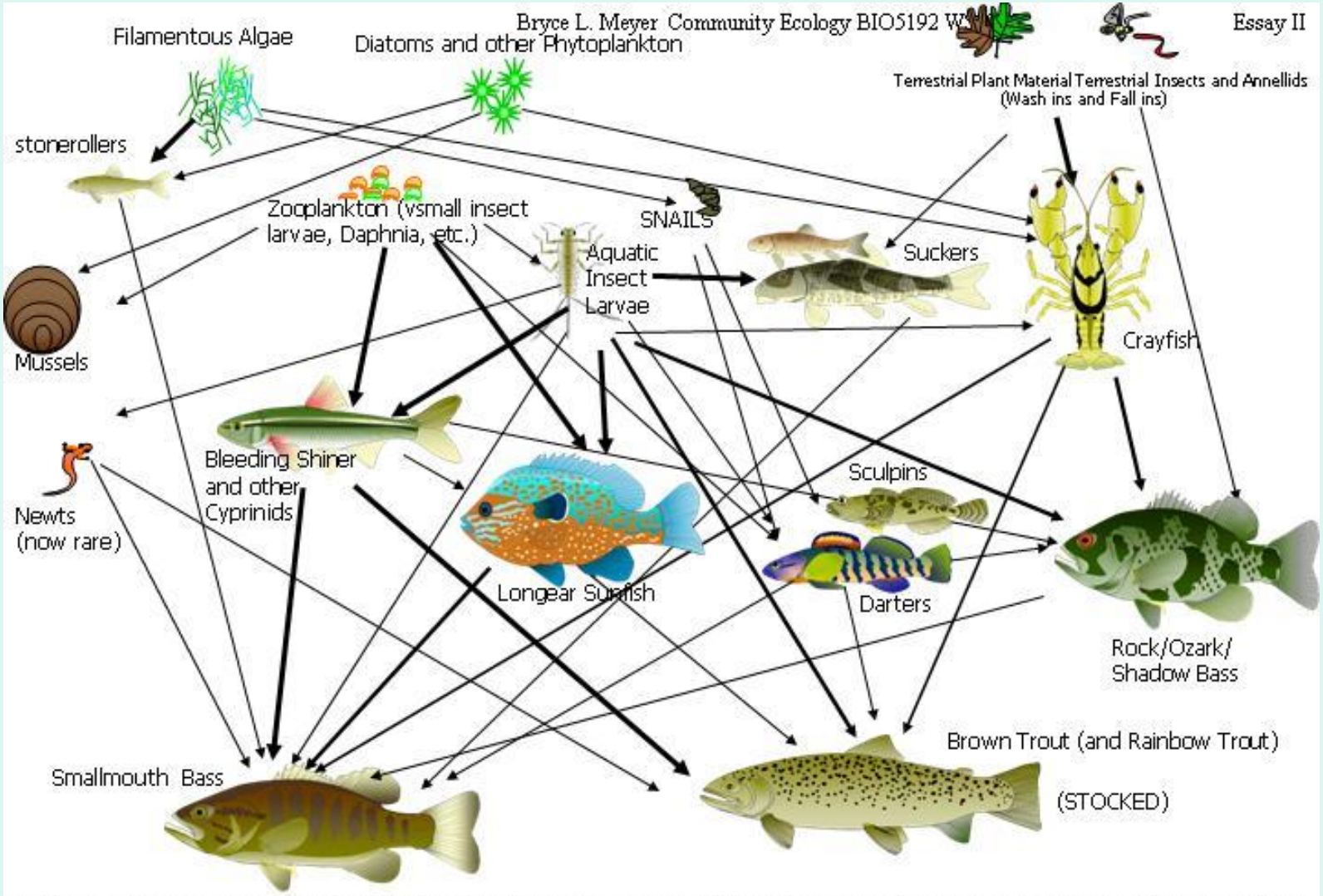


Figure #24: Simplified Food Web (Source Down) similar to Ozark Stream Widening and warming after spring (increasing order). Smallmouth and stocked Salmonids compete as top fish predators. Longear is dominat sunfish, Bleeding Shiners/Ozark Minnows dominate Cyprinids. Nothern Hogsuckers displace White Suckers (who dominate colder water). Sculpins and Darters split the under rock niches (more darters than sculpins). Terrestrial Birds(Ospreys, Herons), Mammals(Humans, Otters, Raccons, Minks), and Reptiles (Turtles and Water Snakes) feed at all levels.

Water Quality Standards

How healthy is this river?

- Primary contact (swimming)?
- Fishing?
- Eating fish?
- Normal healthy aquatic ecosystem?
- Drinking water?

Designated Uses

"**<u>All</u>** state waters…are designated for the following uses: recreational uses, e.g., swimming and boating; ***propagation and growth of a balanced, indigenous population of aquatic life***, including game fish…; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish."

Clean Water Act Requirements

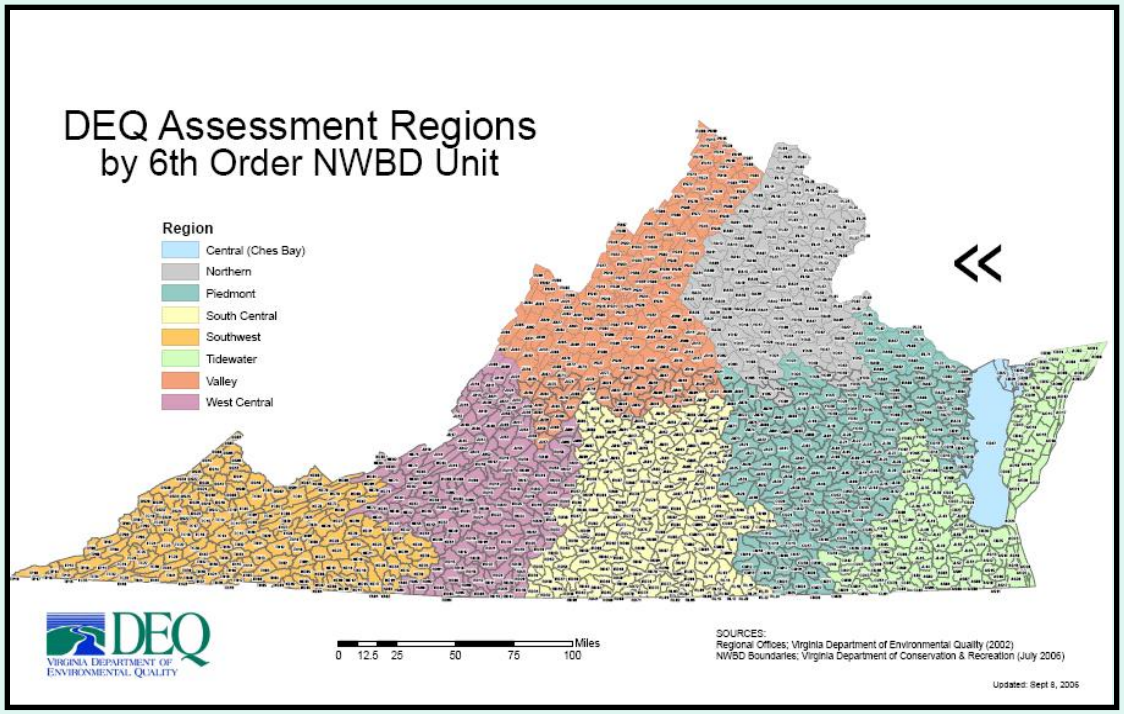
- 305 (b) Report – Assessment of state waters (every two years, includes 6 years of data)
- 303 (d) Report – List of Impaired Waters
- Total Maximum Daily Load (TMDL) Report (Due 12 Years after initial 303(d) listing!!!)
- TMDL Implementation Plan (Required by state law)

Status of TMDLs in Virginia (It's Complicated!)

- Over 2,000 TMDL reports completed
- Over 1,500 TMDL reports need to be done
- 90 Implementation plans completed
- About 300 new de-listings proposed in 2018 Integrated Report
- Many impaired streams are not on the list because they have never been monitored

DEQ Monitoring Strategies

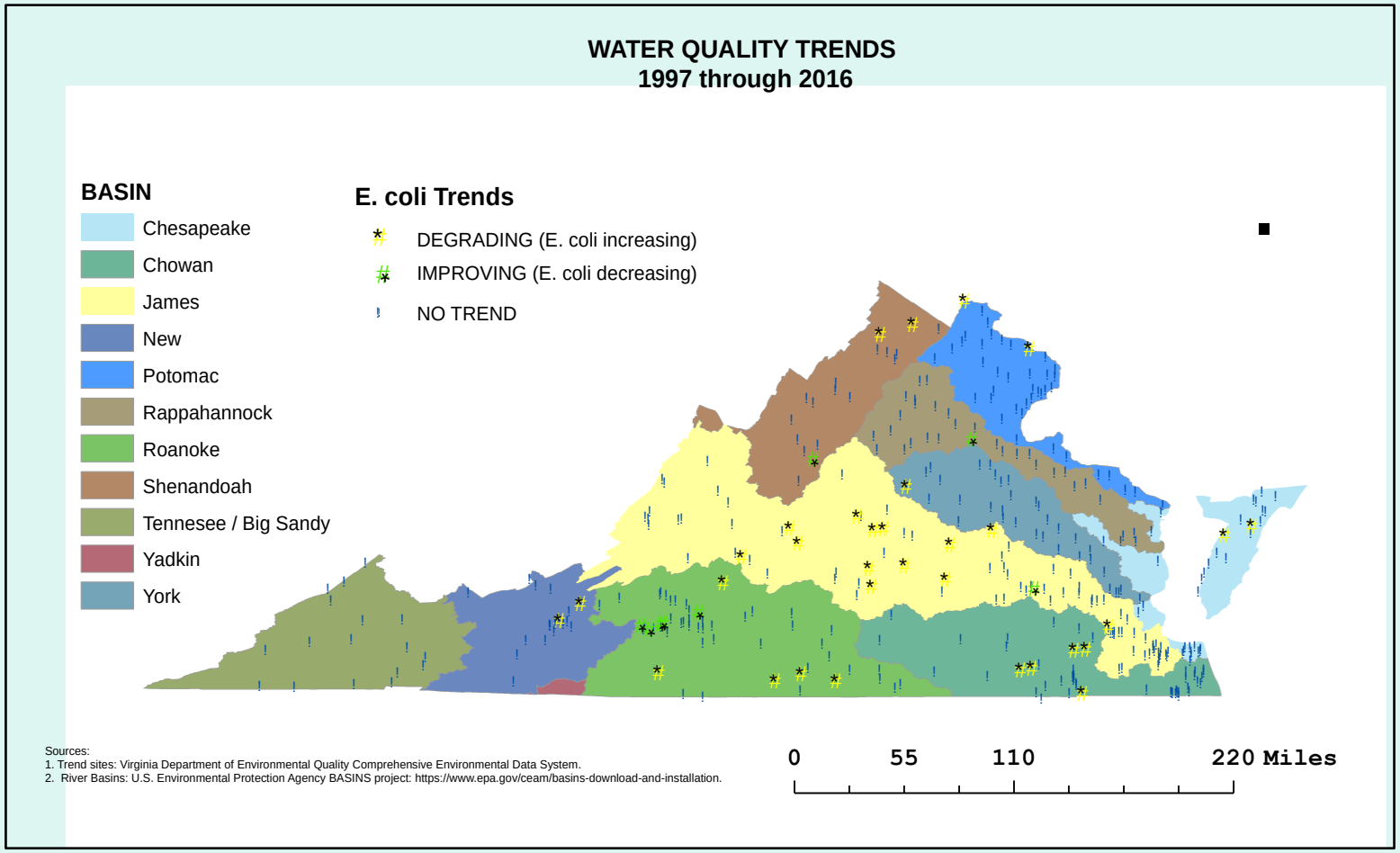
1. Targeted Monitoring – monitor where problems are suspected to occur and provide complete state-wide coverage



More then 1200 sub-watersheds to be assessed in every 305(b) report

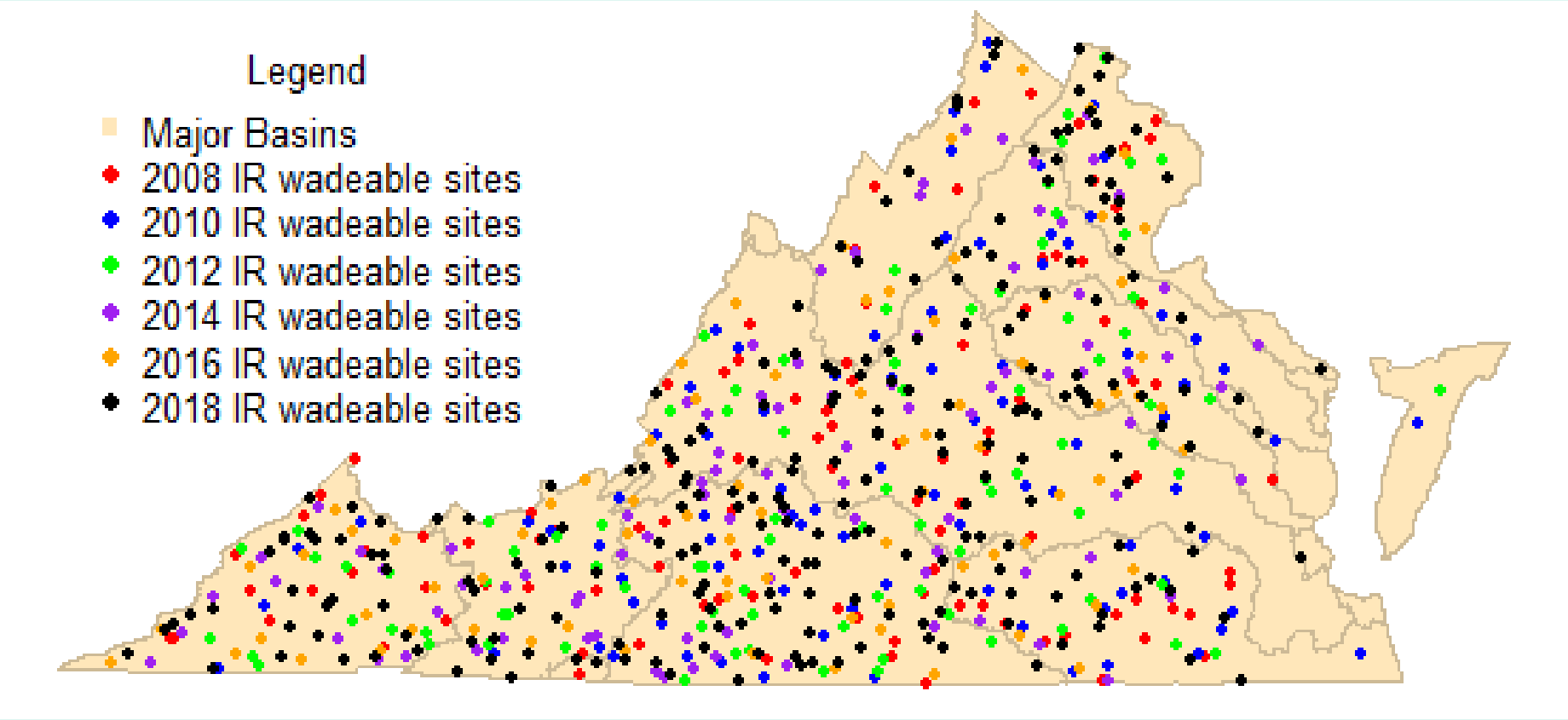
DEQ Monitoring Strategies (Cont.)

2. Trend Monitoring – long-term perspective on changes in water quality over time



DEQ Monitoring Strategies (Cont.)

3. **Probabilistic Monitoring** - monitoring randomly selected sites (2001-2016)



Water Quality Parameters

1. Recreational Use Parameters

- Fecal Bacteria (*E. coli* in freshwater, *Enterococcus* in salt and brackish waters)

2. Edible Resources Parameters

- Fish Tissue Toxics – metals, pesticides, herbicides, PCBs
- Sediment and water column toxics

3a. Aquatic Life Use Parameters (Indirect)

- Temperature (less than 32° C)
- pH (between 6.0 – 9.0)
- Dissolved Oxygen (DO) (> 4.0 mg/L)
- Nutrients (No numerical criteria)
- Sediment (No numerical criteria)

3b. Aquatic Life Use (Direct Assessment)

- Benthic Macroinvertebrates

- Fish and Algae (Near Future?)

Biomonitoring

Advantages of Benthic Macroinvertebrates

- Easy to collect
- Relatively easy to identify
- Provide information on stream health over time (Videotape vs. Snapshot)
- Different tolerances to pollution

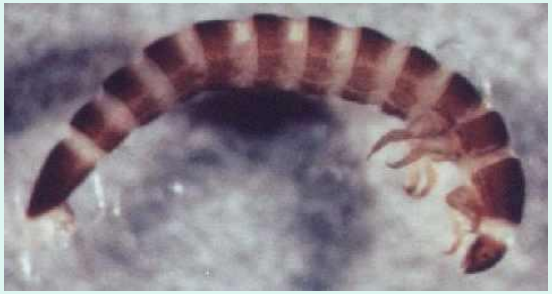

NOV 26 2001

Pollution Intolerant Invertebrates

Mayfly

Stonefly

Water Penny



Riffle Beetle

Caddisfly

Benthic Macroinvertebrate pictures used with permission of Bob Henricks.

Check out his blog at:
http://aquaticinsectsofcentralvirginia.blogspot.com/

Mayfly = Ephemeroptera

Stonefly = Plecoptera

Caddisfly = Tricoptera

Moderately Pollution Tolerant Invertebrates

Crayfish

Dragonfly

Netspinning Caddisfly

Aquatic Sowbug

Cranefly

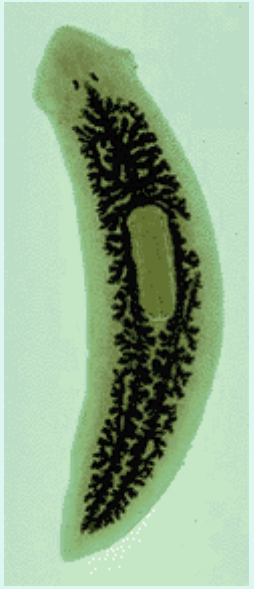
Highly Pollution Tolerant Invertebrates

Midge Larvae

Lunged Snail

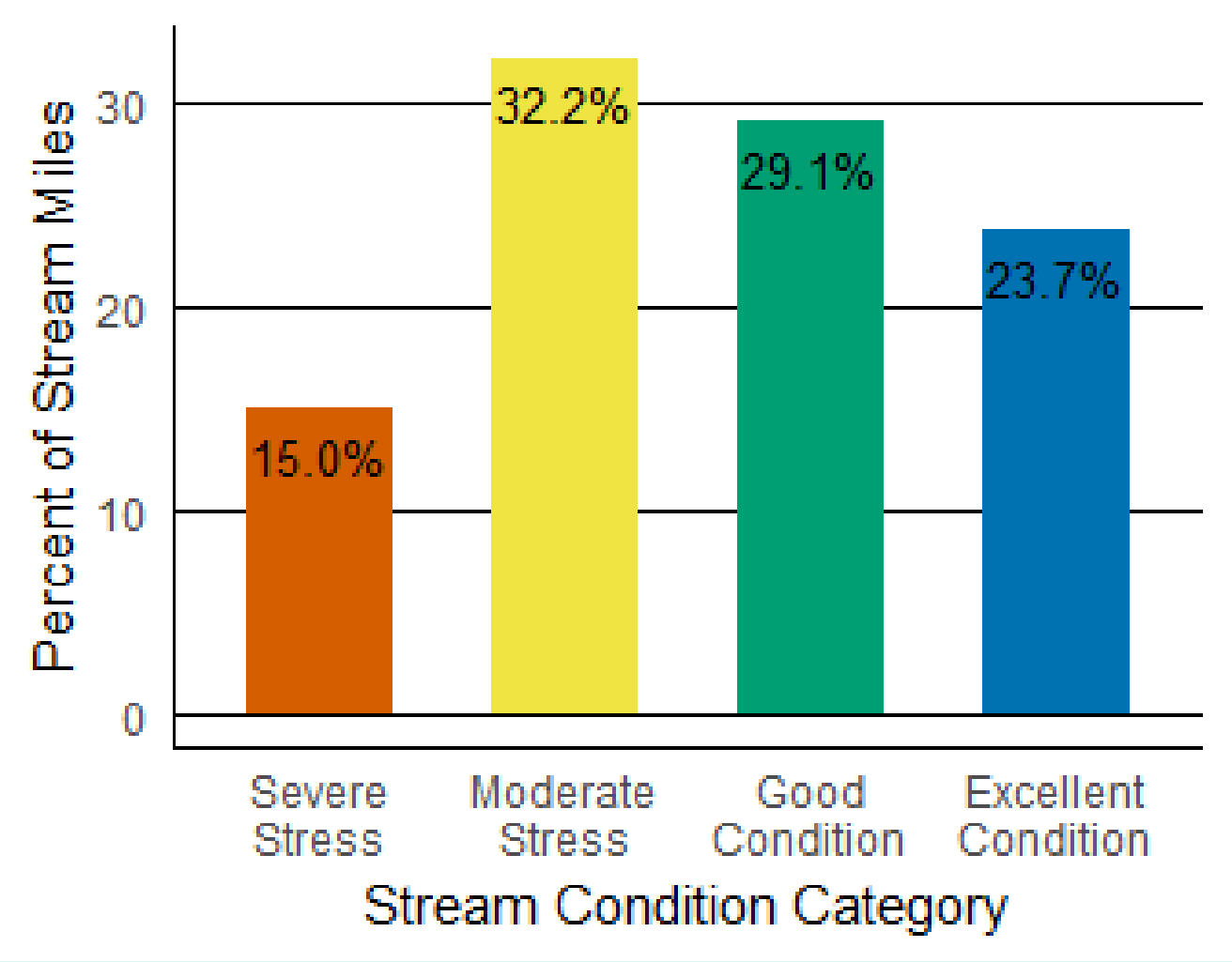
Leech

Segmented Worm

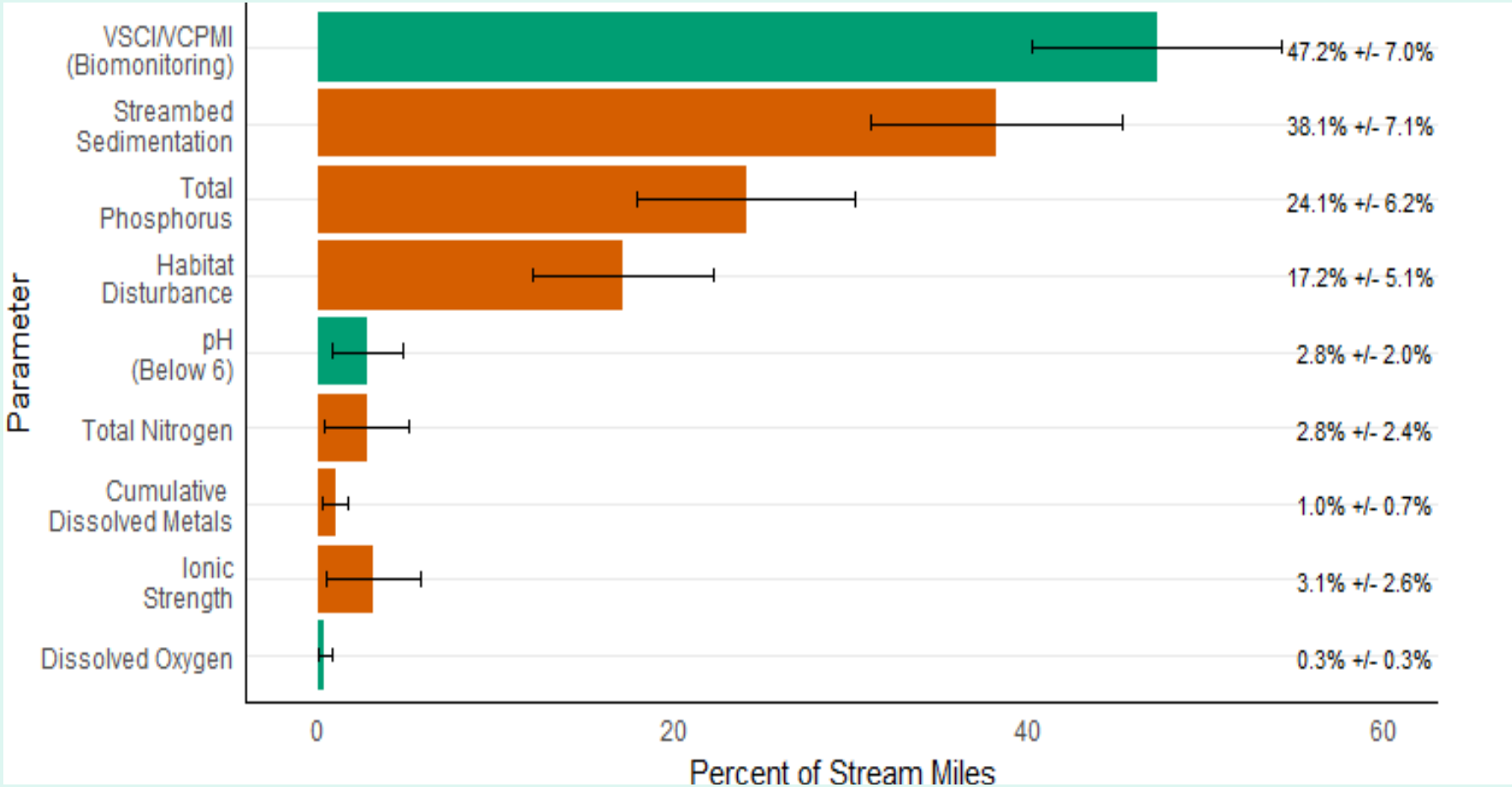


Flatworm

Aquatic Life Use at ProbMon Stations (2011- 2016)



Why are so many streams impaired for aquatic life?

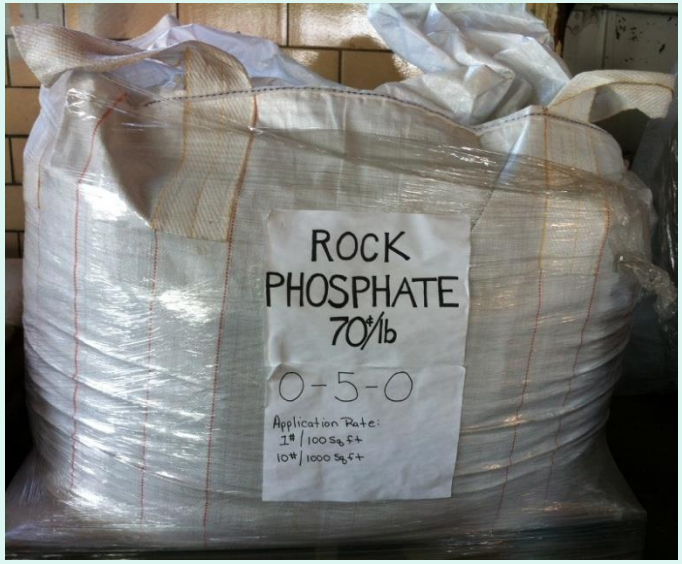


Nutrients

1. **Phosphorous (P)**

   - Growth-limiting nutrient in most freshwater streams (impact of too much P can be local)

   - Inorganic phosphate absorbs tightly to soil particles



Nutrients (continued)

2. Nitrogen (N)

- Ammonia, nitrate, organic nitrogen
- Growth-limiting nutrient in saltwater and estuarine systems

  (effects are often manifested far downstream from input)

Nutrients (continued)

Eutrophication

- Too many nutrients enter aquatic system
- Rapid growth of algae (bloom)
- Algal population crashes and dies
- Microbial decomposition uses up dissolved oxygen
- Fish kills, odors, taste problems in drinking water sources

Eutrophic pond below point source

Nutrient Enrichment in Streams

- Removes habitat
- Changes community

structure of macroinvertebrates

Nutrients (continued)

Human Sources

- Agricultural/suburban/urban runoff
- Loss of riparian areas and wetlands
- Air Deposition (nitrogen from fossil fuels)
- Wastewater effluent (sewage treatment and industrial plants)

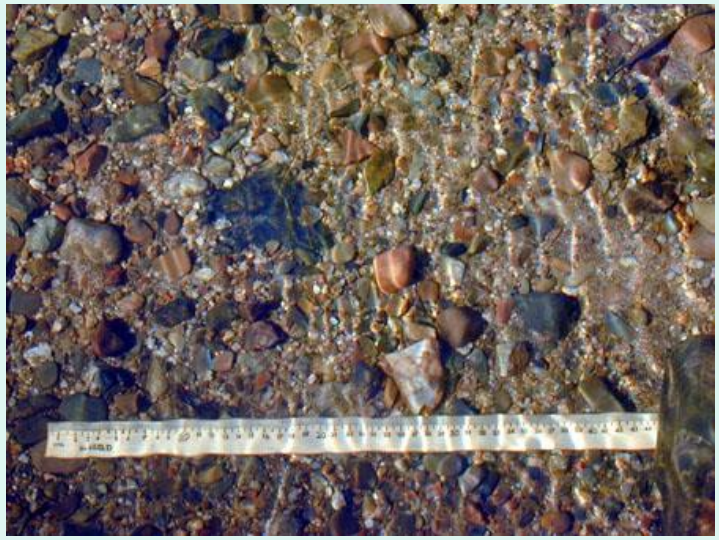
Sediment

- Injures fish and aquatic invertebrates
- Carries phosphorous (nutrients)
- Decreases light penetration (or increases **turbidity)** which decreases SAV
- Removes valuable bottom habitat by filling in spaces between rocks

Effects of sedimentation

Lots of space between rocks for aquatic insects and small fish.

Little space under rocks. Rocks are “embedded” by sediment. Terrible habitat quality.



Roanoke Logperch

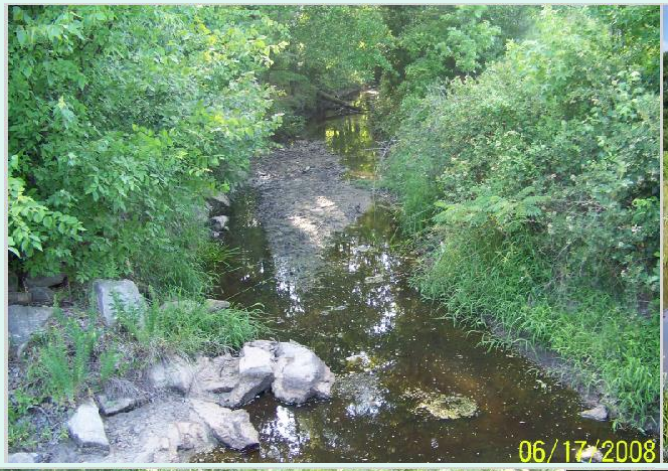
- Elongated snout for rolling stones, insectivorous, gravel/cobble substrate,
- Federally endangered species

Sediment (continued)

Human Sources

- Stormwater runoff from urban/suburban areas
- Runoff from construction sites, agricultural fields, etc.
- Loss of riparian areas and wetlands
- Bank erosion from channelization/stormwater

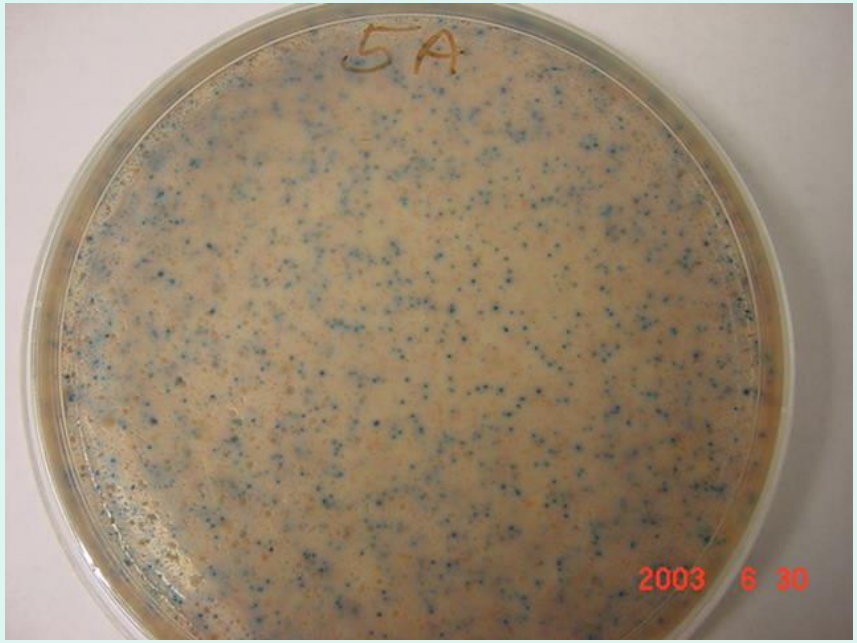
Reedy Creek Case Study



Reedy Creek Watershed

Less Visible Problems

1. Fecal Bacteria – Reedy Creek is on Virginia's "dirty waters" list



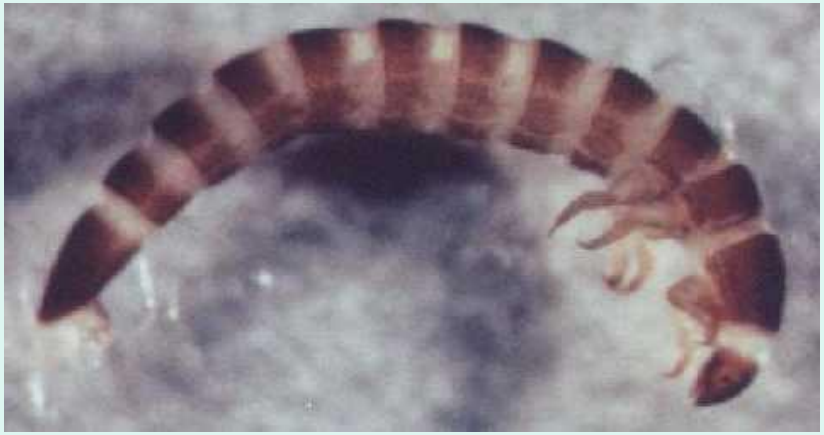
2. Nutrients

3. Sediment

4. Aquatic Life - Citizen data shows the community of aquatic animals is severely impaired.

Too many “tolerant” bugs

Very Few “Sensitive” Bugs



What are the causes?

1. Stormwater Volume – Reedy Creek is “flashy” due to rain water running off rooftops, streets, driveways, parking lots, etc.

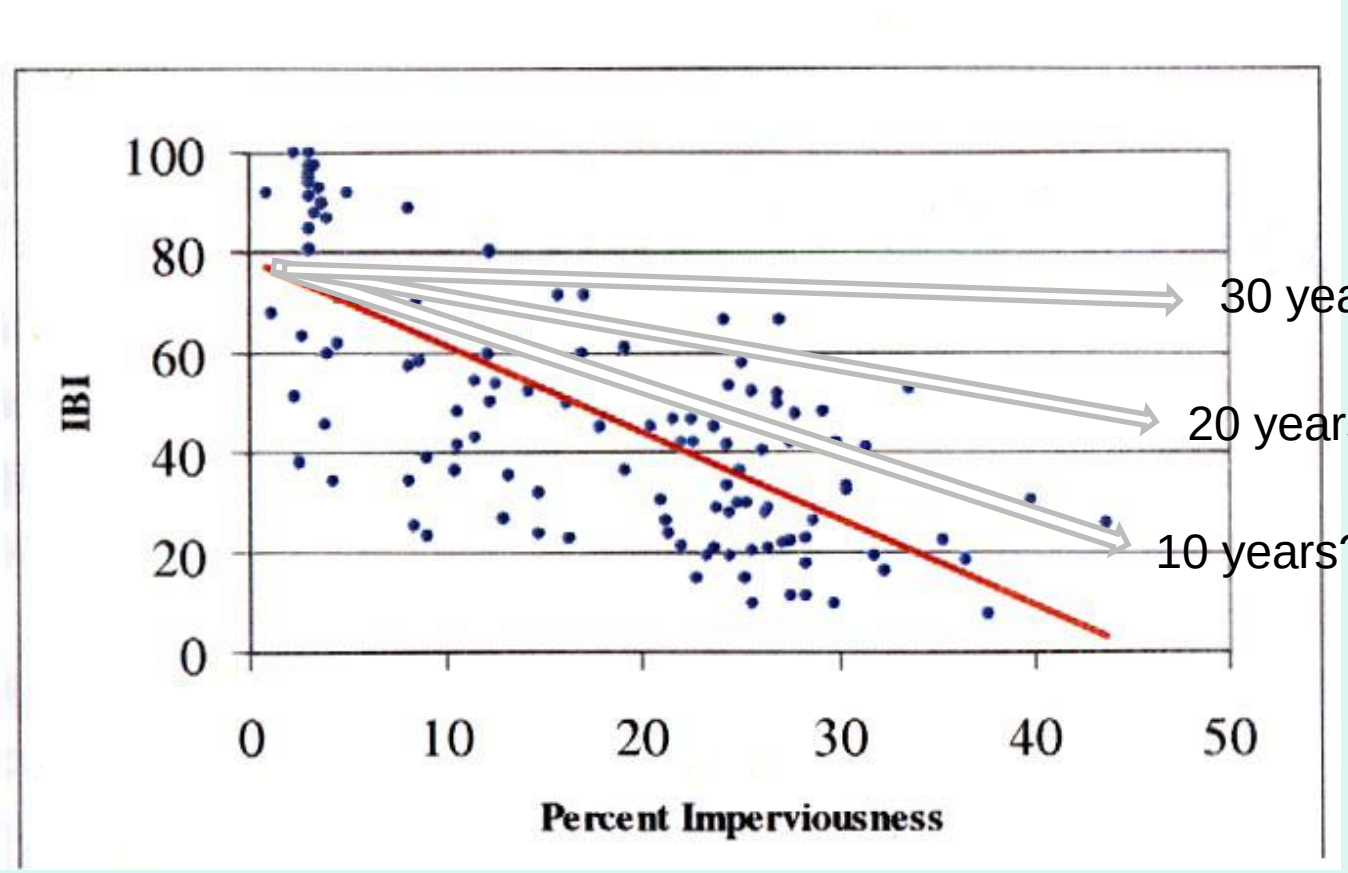
Concrete channels make the problem of stormwater volume worse

Result of too much stormwater – Streambank Erosion

2. Stormwater carries pollutants

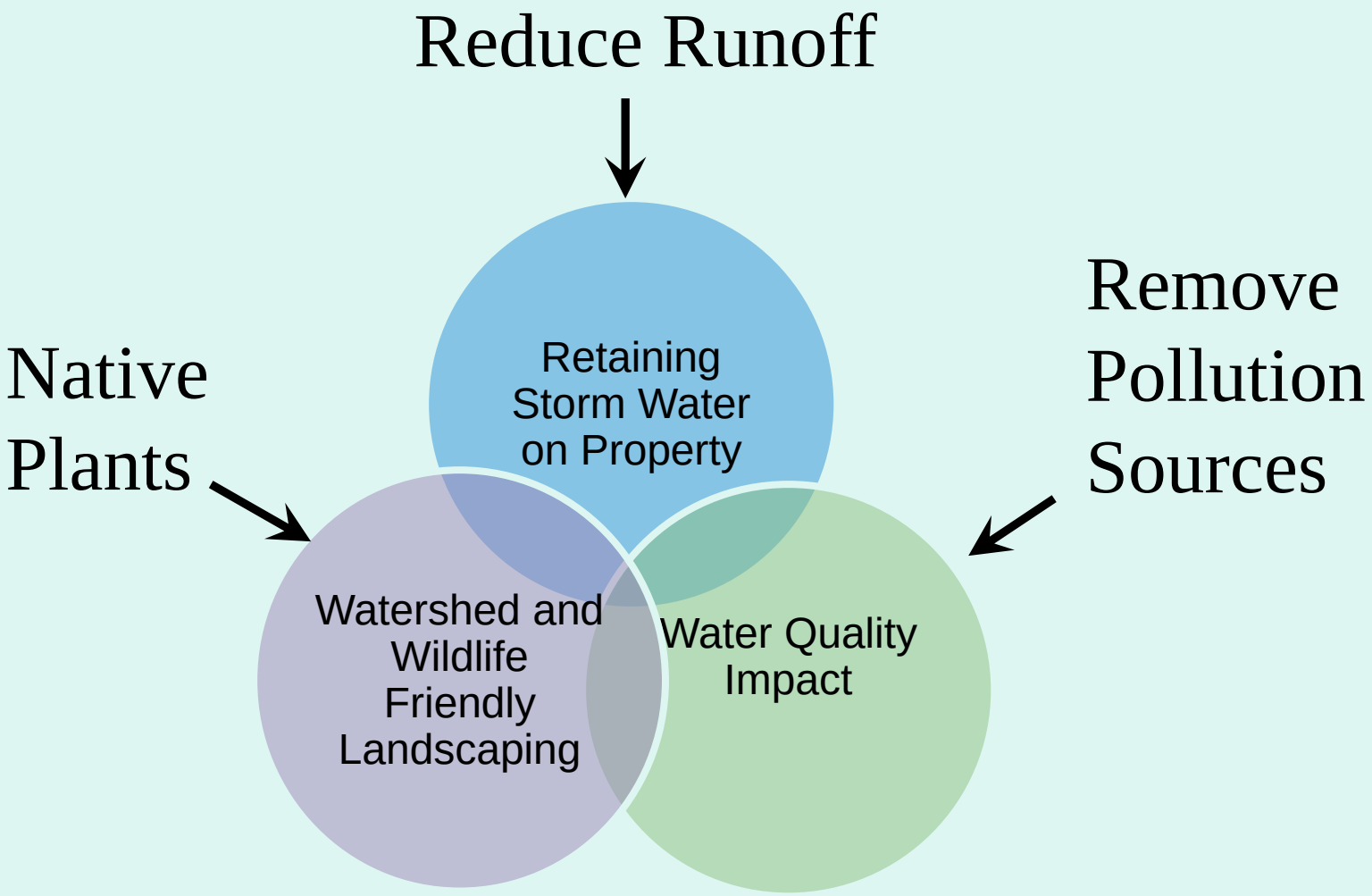
- Sediment
- Fecal bacteria
- Nutrients
- Toxic chemicals – petroleum, pesticides, herbicides, detergents, PCBs, etc.

Index of Biological Integrity vs. Impervious Cover



Reduce Your Watershed Footprint

Watershed Protection Audit Program



Goals

I. Reduce Stormwater Volume

A. Benefits

- Reduce “flashiness” (scouring)/increase habitat stability and quality
- Lower pollutant loading
- Reduce in-stream erosion and its contribution to sediment
- Increase base flow during the summer (reduced stress due to low DO and/or high temperature)

I. Reduce Stormwater Volume

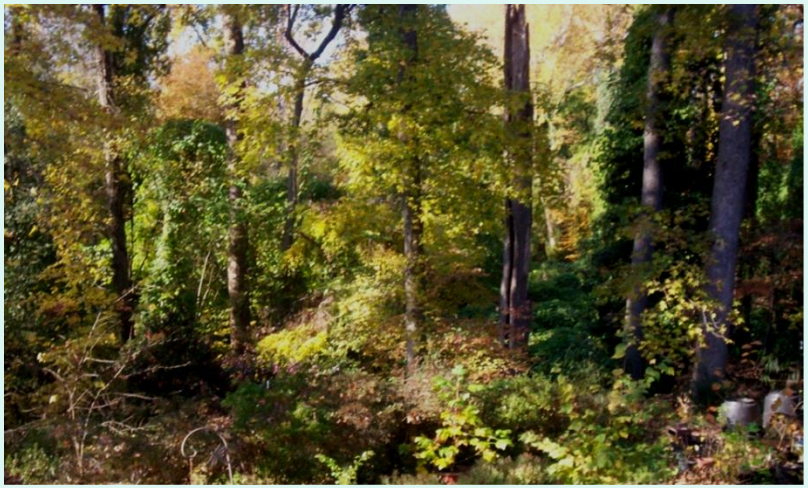
- Impervious Surfaces
- Semi-impervious Surfaces (Lawn)
- Slopes

Goal = no stormwater leaves the property

B. Strategies to Reduce Stormwater Volume

1. Rain Water Harvesting
   - Rain Barrels
   - Cisterns

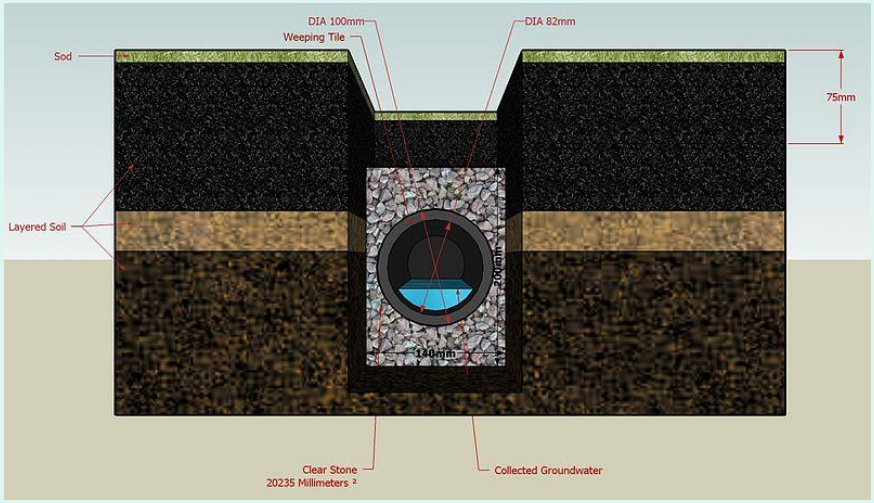
2. Infiltration (Mimic natural system)
   - “Structural” (e.g. pervious pavement)
   - Vegetative



Infiltration – Structural Approaches

1. Pervious Pavers

2. French Drain, Dry well, Infiltration trench



3. Berms, swales, retaining walls

Lawn Facts

1. Lawn covers 9.5% of the Chesapeake Bay watershed – more than all row crops

2. Lawn is often semi-impervious – pathetic topsoil, compaction, and poor management

Lawn Management

1. Mower Height – 3 inches or highest setting
    a. Deeper roots = Healthier lawn
    b. Reduced evaporation
2. Mowing Frequency – as little as possible
3. Improve soil with organic matter
    a. Grass clippings
    b. Mulched or composted leaves

Goals (Continued)

II. Reduce pollutant load in the stormwater that makes it to the stream

- Reduce chemical use (fertilizers, herbicides, pesticides, etc.)
- Use of organic fertilizers and mulch
- Vegetated areas to trap pollutants

Goals (Continued)

III. Use Native Plants in the Landscape

- Improve infiltration and pollutant removal
- Water Conservation
- Restore terrestrial food webs and ecosystem function

Why native perennials and native grasses are better than turf grass for water quality

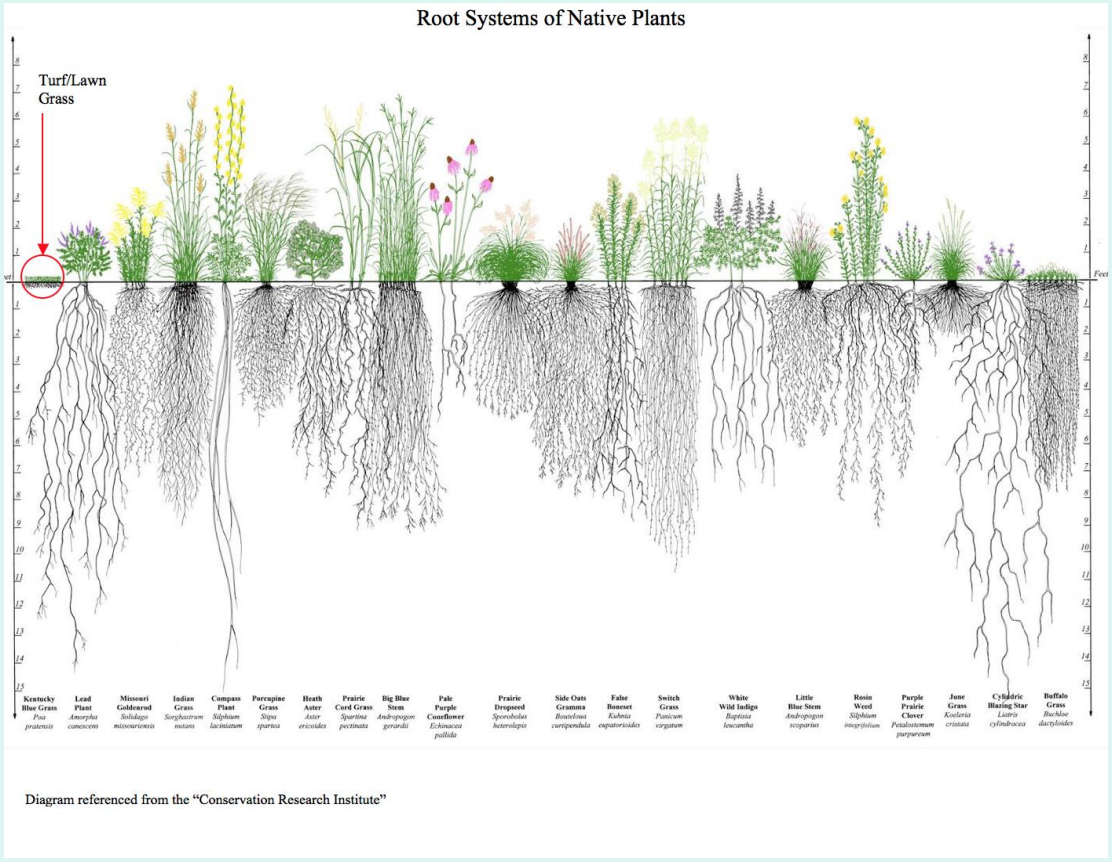


Diagram referenced from the "Conservation Research Institute"

Native Plants are adapted to climate and soils

1. Excellent infiltration of stormwater
2. No irrigation water after establishment
3. No Fertilizer
4. No Pesticides
5. Treatment of stormwater from impervious surfaces

Additional Benefits of Native Plants

1. Carbon storage/Climate change
2. Reduced heat island effect
3. Biodiversity and ecosystem resilience
4. Decreased air pollution
5. Human physical and mental health
6. Educational opportunities
7. Support local food production (Pollinators)

Ilex verticillata – Winterberry Holly

Conservation Landscaping

Landscaping with **native** plants to reduce pollution, provide food and shelter for wildlife, and create aesthetically pleasing spaces (at least to the owner).

Lobelia cardinalis - Cardinal Flower

Monarda fistulosa - Beebalm

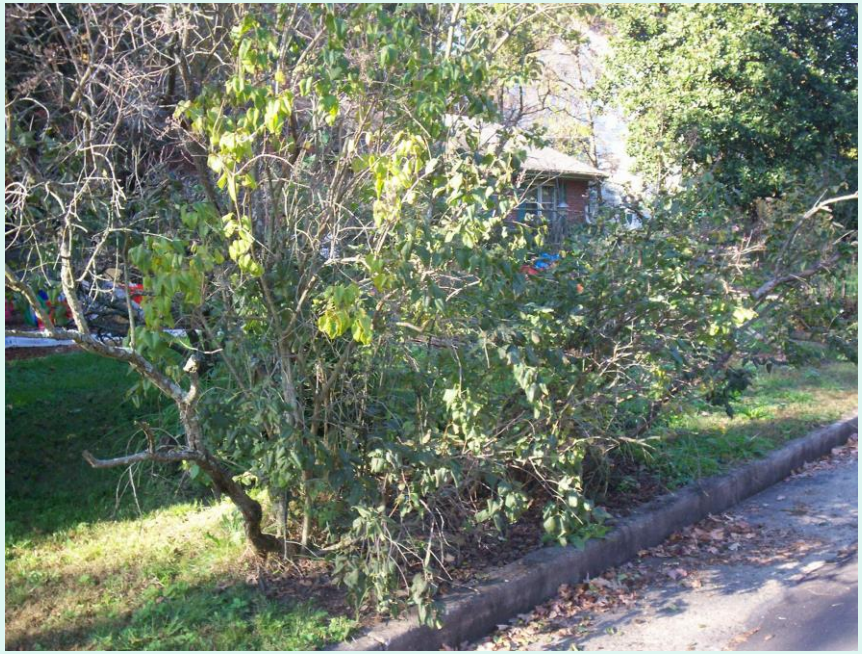
Conservation Landscapes are **Flexible**

- Large or small
- Formal or informal
- Sun or shade
- Moist or dry
- Edible fruits and nuts

Lobelia siphilitica
Great Blue Lobelia

- Combinations of grasses, perennial flowers, shrubs, small trees, large trees
- Endless color and texture combinations

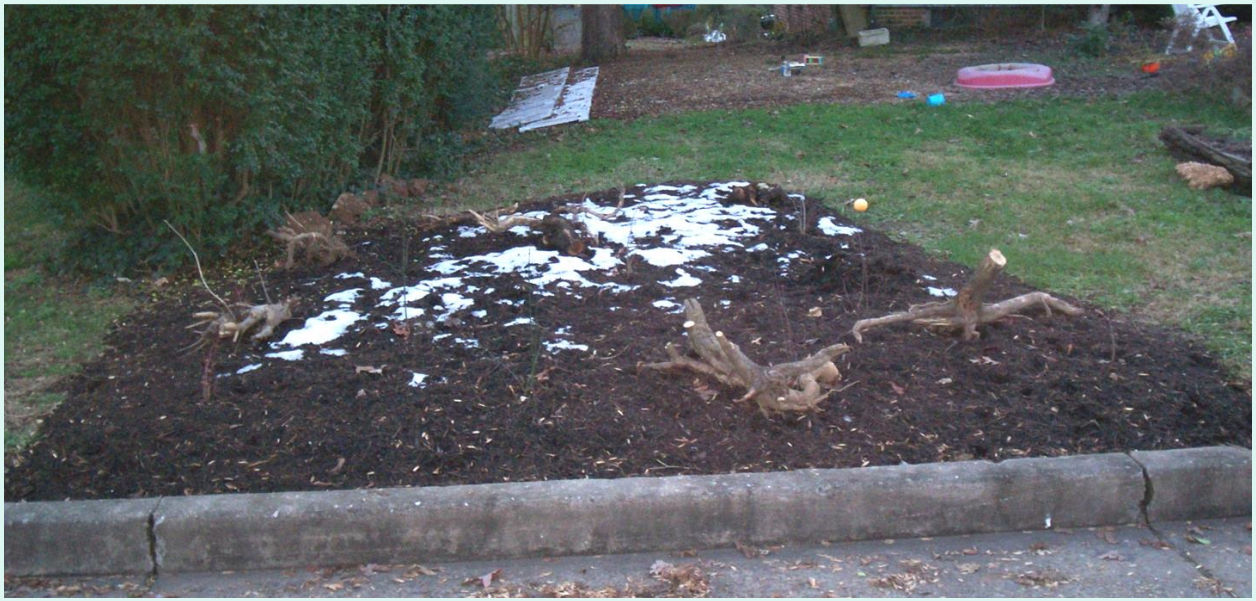
Small Scale Bayscape - Shrubs



Ugly Before:

- Sickly lilacs
- Unwanted rose
- Invasive mulberry
- Other junk

Installation

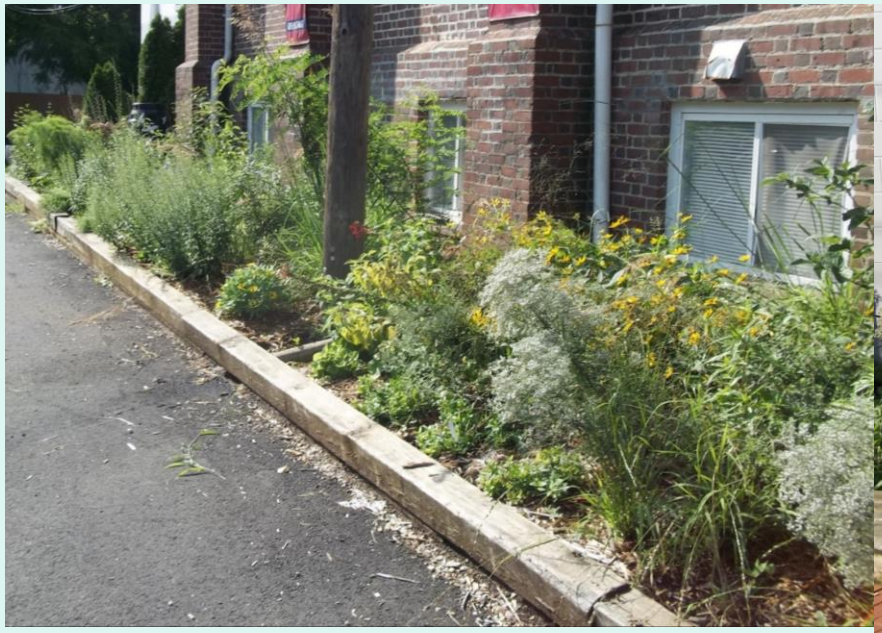


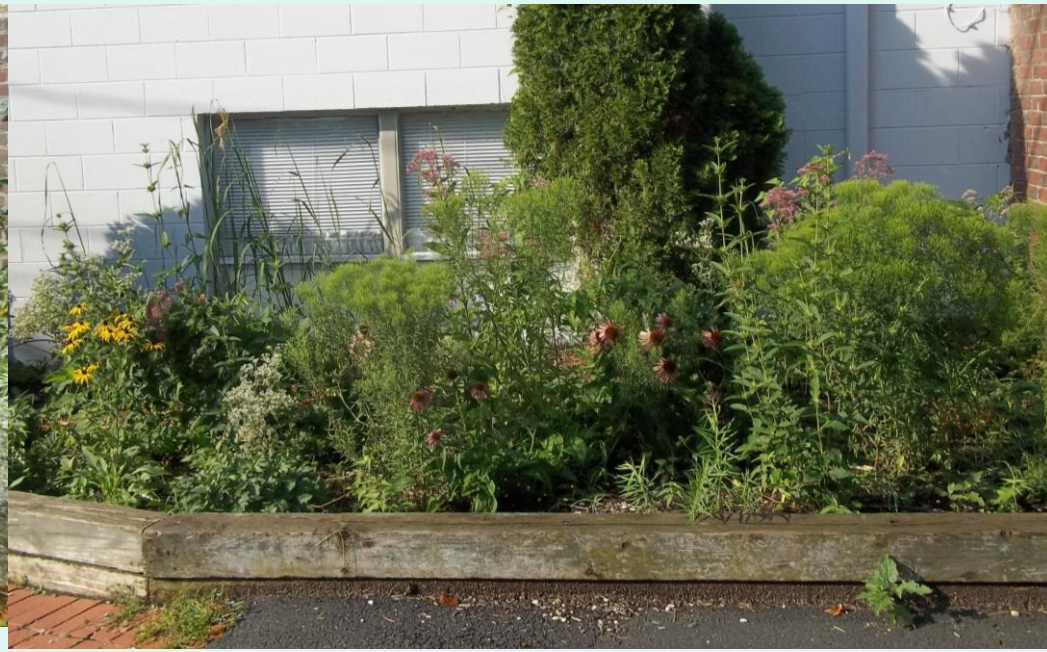
Lawn reduced and area regraded so water runs away from the street to pervious areas.

Third Summer After Installation

Euonymus americanus – Strawberry Bush

Good Shepherd Elementary School





Bayscape with infiltration trench

Before:

During:

Bayscape After

October 2013

June 2015

Rain Garden at PHSSA

BEFORE

Excavation and Fill

Completed Rain Garden

Conservation Landscapes on Slopes

1. Structural elements to retain soil (e.g. walls)

2. Reduce slope
   - Take some off the top
   - Add some to the bottom

3. Retain existing slope and stabilize (plants, mulch, fabric)

Stabilize existing eroded slope

Matting for short-term stabilization

Shrubs and small trees for long-term stabilization

Reduce Slope (Add Soil to base)

Combining BMPs

Just Plant a Tree!!!

1. Much better than grass at infiltration of stormwater
2. Filter out nutrients and other pollutants
3. Improves soil over time
4. Lower Maintenance - time and money
5. Carbon Storage
6. Host plants for high diversity of insects (compared to native perennial wildflowers and grasses)
7. Habitat structure (middle and upper layers)

Site Selection

1. Infiltrate water from an impervious surface draining to street
2. Replace existing area dominated by invasive plants
3. Replace lawn
4. Expand green corridors
5. Educational benefits for community
6. Ease of maintenance (weeding, watering)
7. Visibility = Enjoyment

Centrosema virginianum
Spurred Butterfly Pea

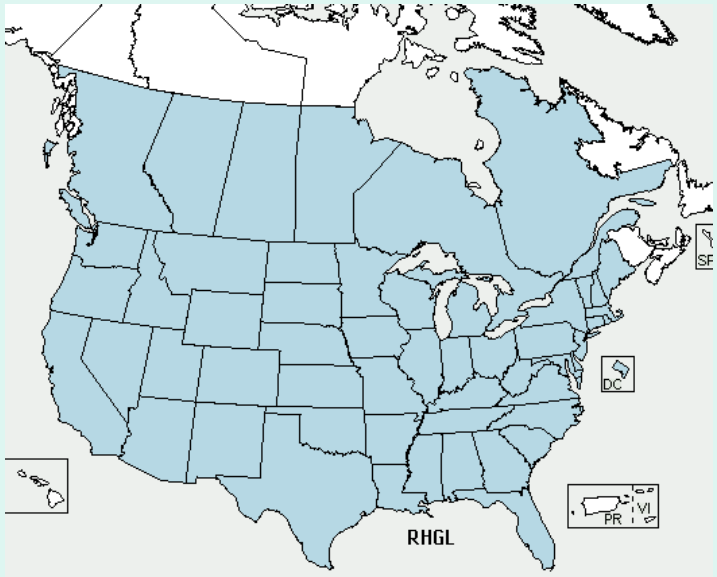
Native Plants of Local Ecotype

Local Ecotype: a collection of plants originating in a specific area and therefore carrying genetic adaptations to that specific environment http://www.iowaprairienetwork.org/org/Positions/position-local_ecotype.shtml

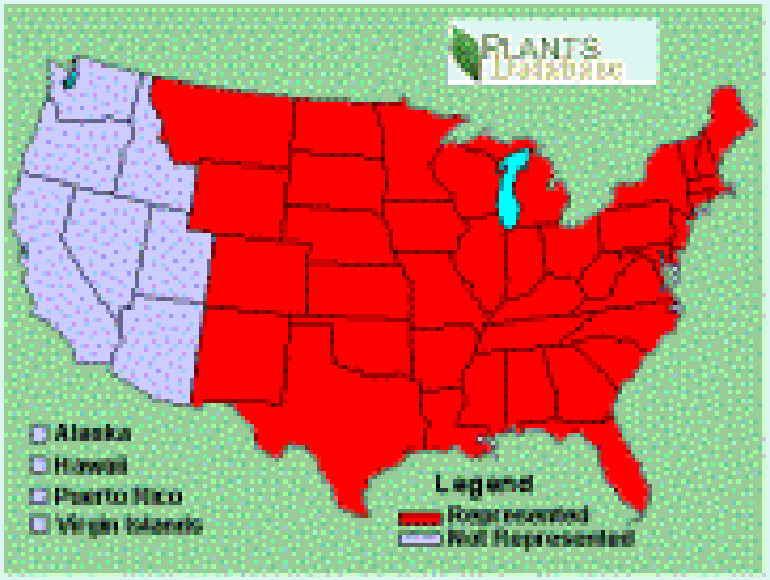
Gentiana saponaria
Soapwort Gentian

Solidago nemoralis
Gray Goldenrod

How far away can it get?



Smooth Sumac



Gray Goldenrod

Cultivar Properties of Concern

1. Lack of genetic diversity
   a. Each plant is genetically identical if it is a **clone** propagated asexually (cuttings)
   b. Extremely limited genetic diversity if propagated by inbreeding

2. Unknown if full ecological value is retained. (Seed, nectar, leaf nutrition, pollinator attractants, etc.)

3. Geographic source often unknown – may not grow well in local environment

4. If cultivar sexually reproduces with native plants of the local ecotype it can potentially damage the gene pool of wild populations, especially if the same cultivar is planted widely.

Other Watershed Activities

- Tree/riparian buffer plantings
- Stream clean-ups
- Tree/Bayscape maintenance – watering, mulching, removal of foreign invasives
- Join/support/start a local watershed group

Citizen Monitoring Activities

- Benthic Macroinvertebrates
- Fecal Bacteria (E. coli monitoring with Coliscan)
- Chemical monitoring – pH, DO, nutrients,
- “Streamwatchers”

Public Meetings

- Local ordinances dealing with land use planning, erosion and sediment control, stormwater issues, etc.
- Zoning variances impacting water quality
- TMDLs
- Water Quality Standards

DEQ Links of Interest

Probabilistic Monitoring

http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/WaterQualityMonitoring/ProbabilisticMonitoring.aspx

Water Quality Standards

http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/WaterQualityStandards.aspx

TMDLs

http://www.deq.virginia.gov/programs/water/waterqualityinformationtmdls/tmdl.aspx

Citizen Monitoring

http://deq.state.va.us/Programs/Water/WaterQualityInformationTMDLs/WaterQualityMonitoring/CitizenMonitoring.aspx

Watershed Organization Websites

- Alliance for the Chesapeake Bay- https://www.allianceforthebay.org/
- Center for Watershed Protection – https://cwp.org/
- Earth Sangha (plants of local ecotype) - http://www.earthsangha.org/
- James River Association - http://jrava.org/
- Reedy Creek Coalition – https://reedycreekcoalition.org/
- Richmond Tree Stewards - https://richmondtreestewards.org/

Contact Information

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