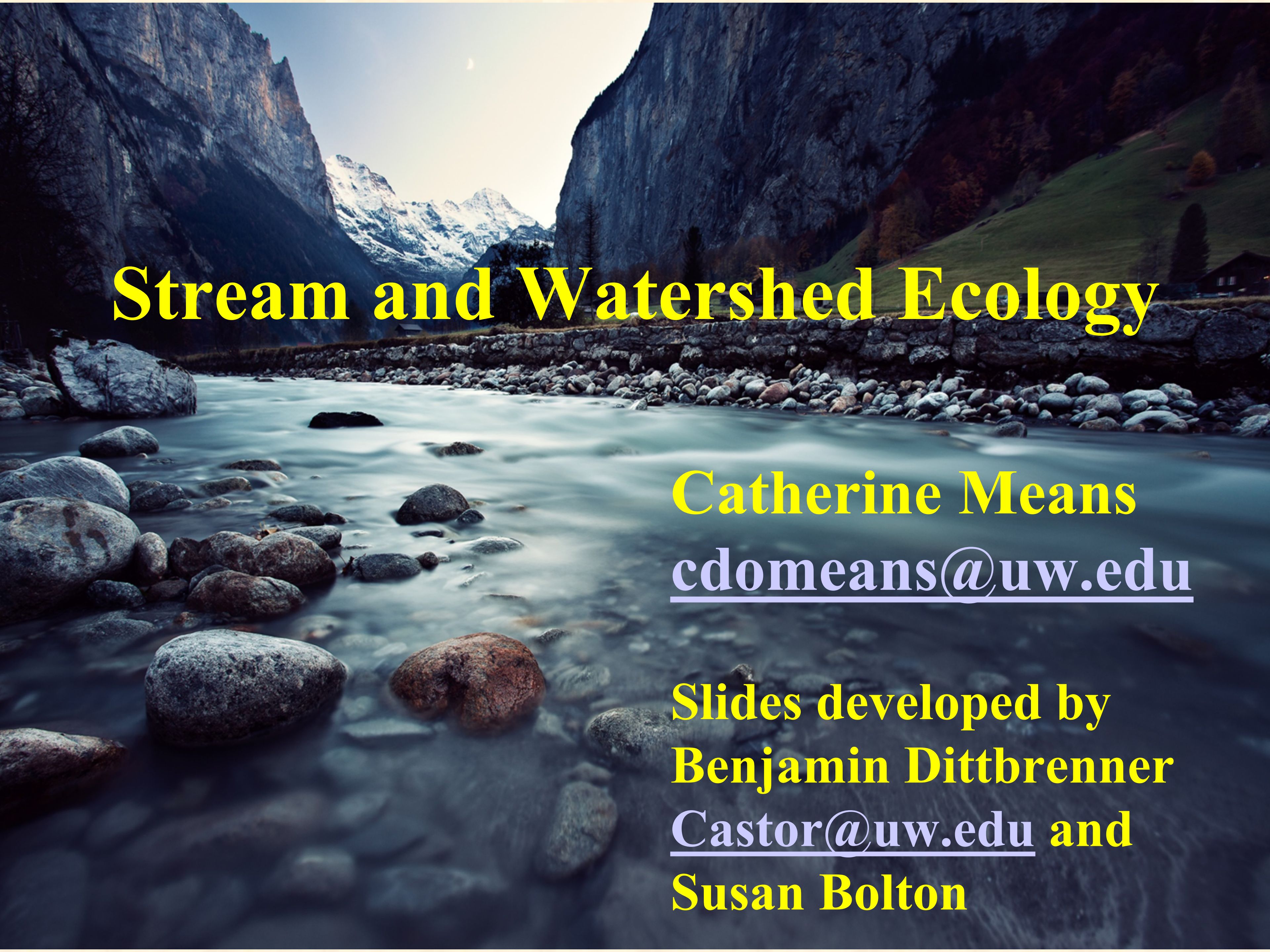

Stream and Watershed Ecology

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Slides developed by
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Castor@uw.edu and
Susan Bolton

Stream and Watershed Ecology

- Ecology is the interaction of the biotic (living) environment and the abiotic (non-living) environment

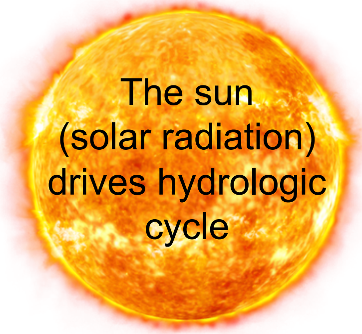
- In this module we will learn about important stream habitat-forming processes and how to do a quick assessment of these processes

- More specifically students will learn:
  - what a watershed is
  - who typically collects data
  - what kinds of data are collected
  - how to collect and analyze watershed data
  - human effects on streams and hydrology

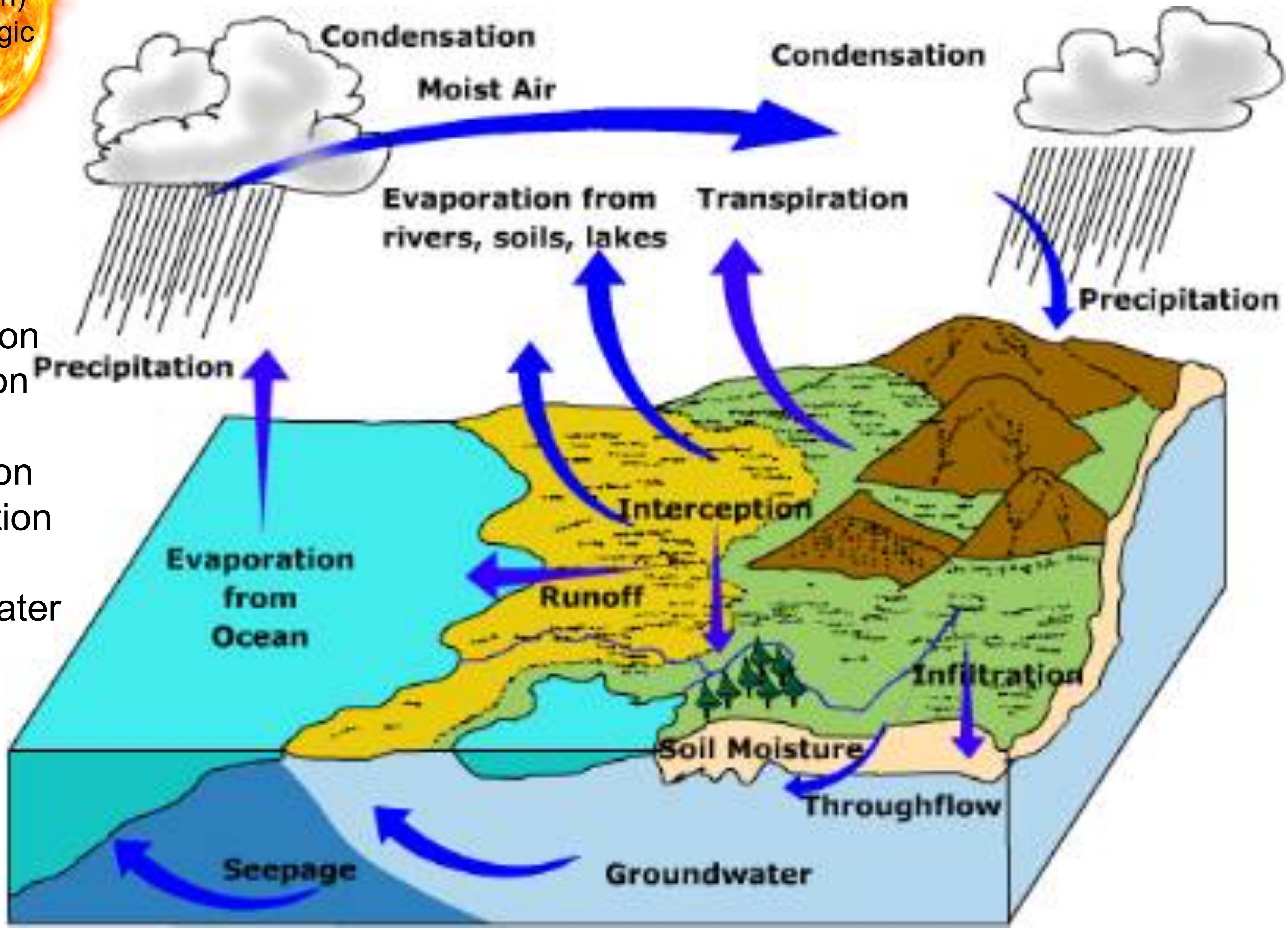
Learning Objectives

- **What is a watershed?**
- Who measures water and watersheds?
- What do they measure?
- How do they measure and analyze it?
- Human effects and management of watersheds

The hydrologic cycle?

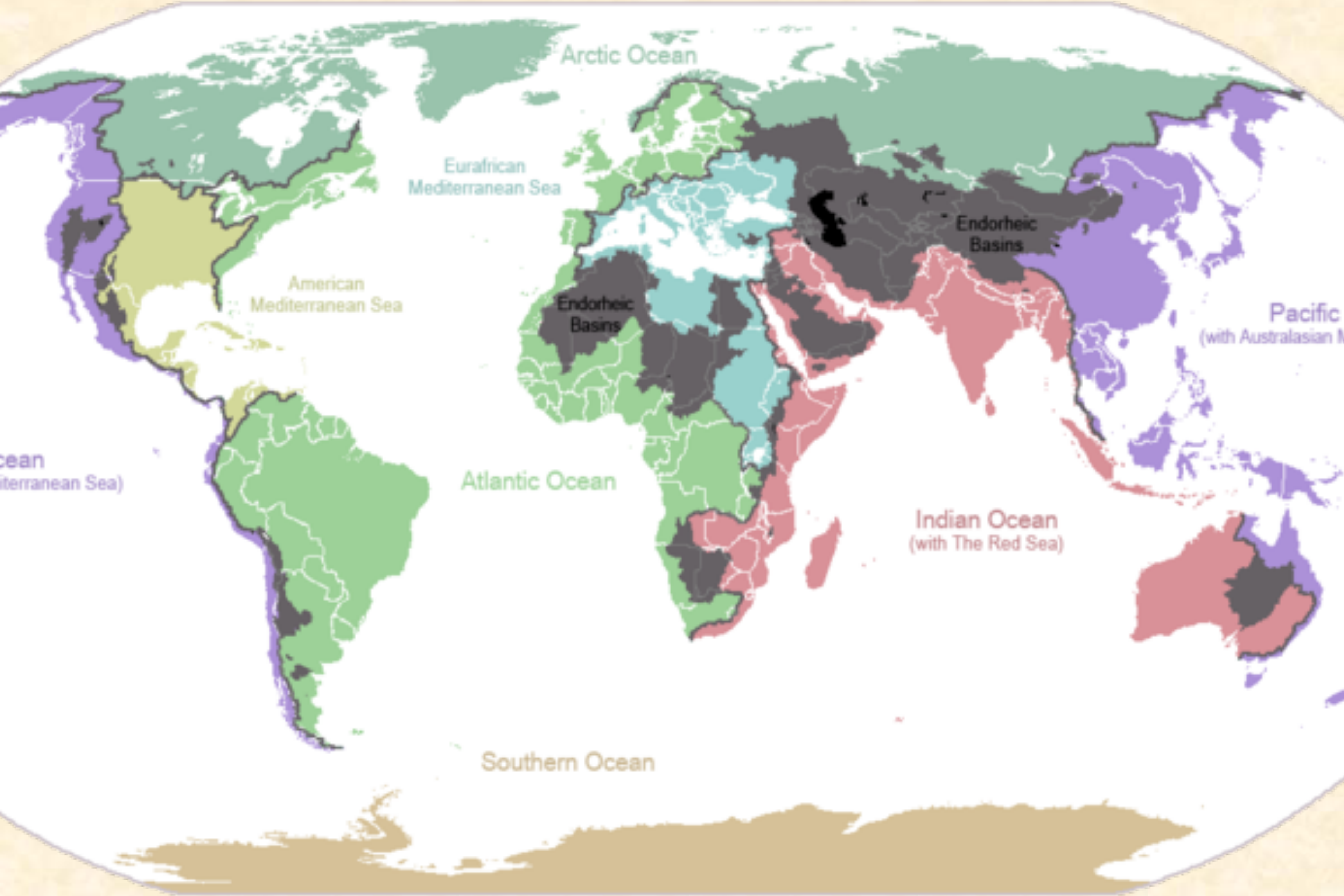


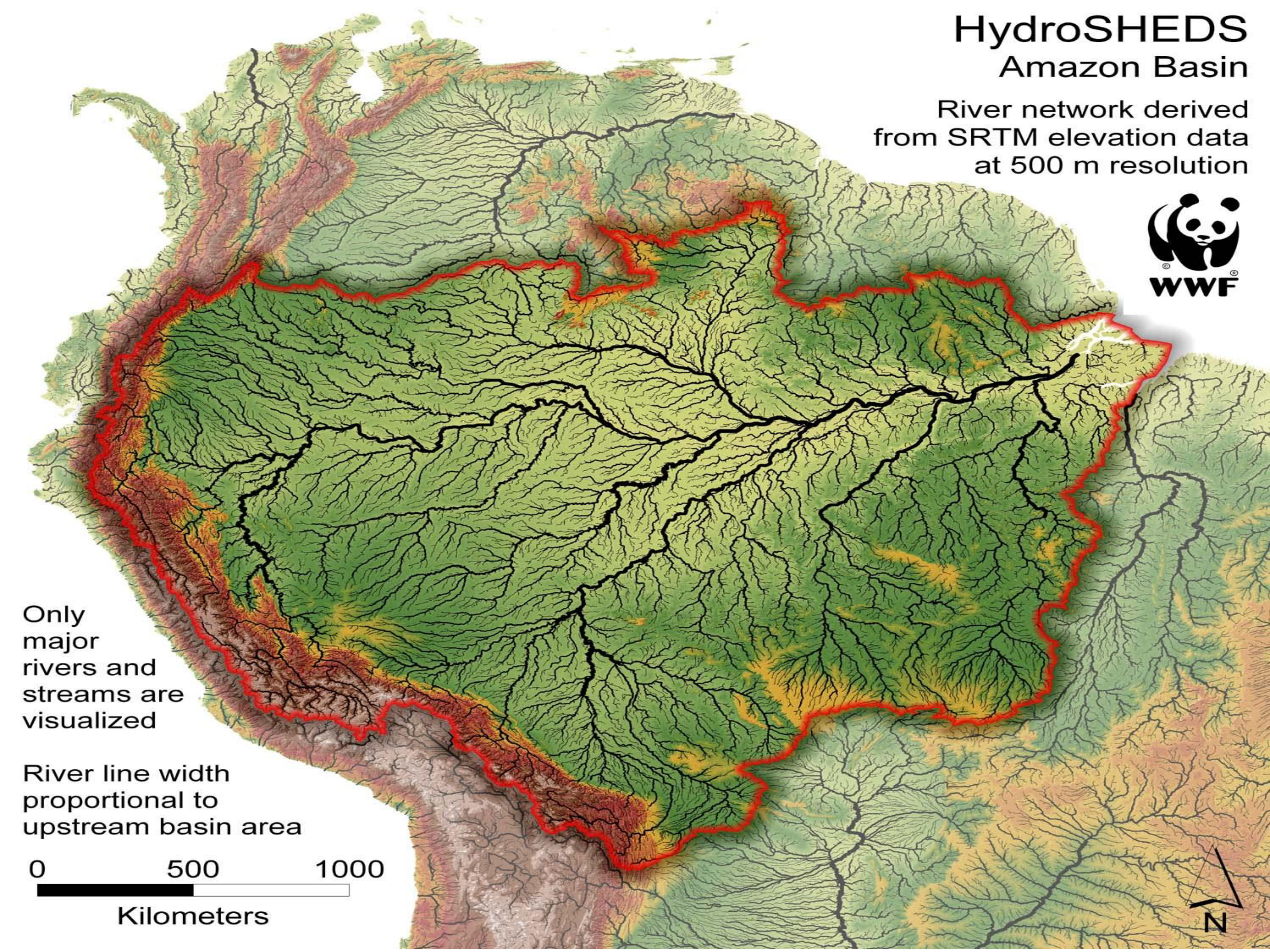
- Precipitation
- Interception
- Infiltration
- Evaporation
- Transpiration
- Runoff
- Ground water



What is a watershed?

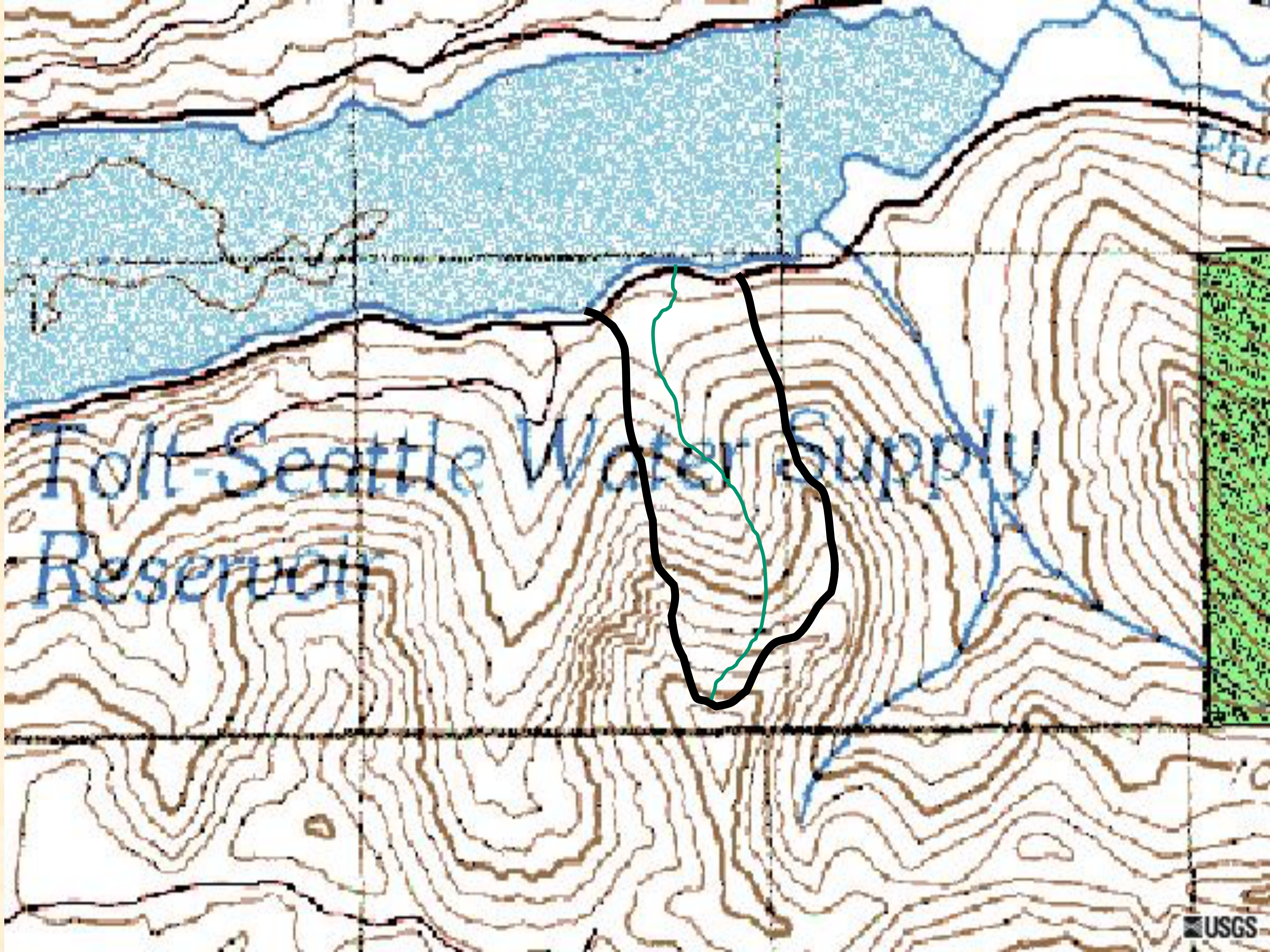
- The land area that drains into a selected stream point or water body
- Can by very small or very large
- Called catchments in the rest of the world
- Usually based on surface topography- subsurface features may not mimic surface ones as far as drainage is concerned


Arctic Ocean
Eurafrican
Mediterranean Sea
American
Mediterranean Sea
Endorheic
Basins
Endorheic
Basins
Pacific
(with Australasian M
cean
iterranean Sea)
Atlantic Ocean
Indian Ocean
(with The Red Sea)
Southern Ocean


HydroSHEDS
Amazon Basin
River network derived
from SRTM elevation data
at 500 m resolution
WWF
Only
major
rivers and
streams are
visualized
River line width
proportional to
upstream basin area
0
500
1000
Kilometers
N

Watersheds within watersheds

Watersheds of King County


Tolt-Seattle Water Supply
Reservoir
USGS

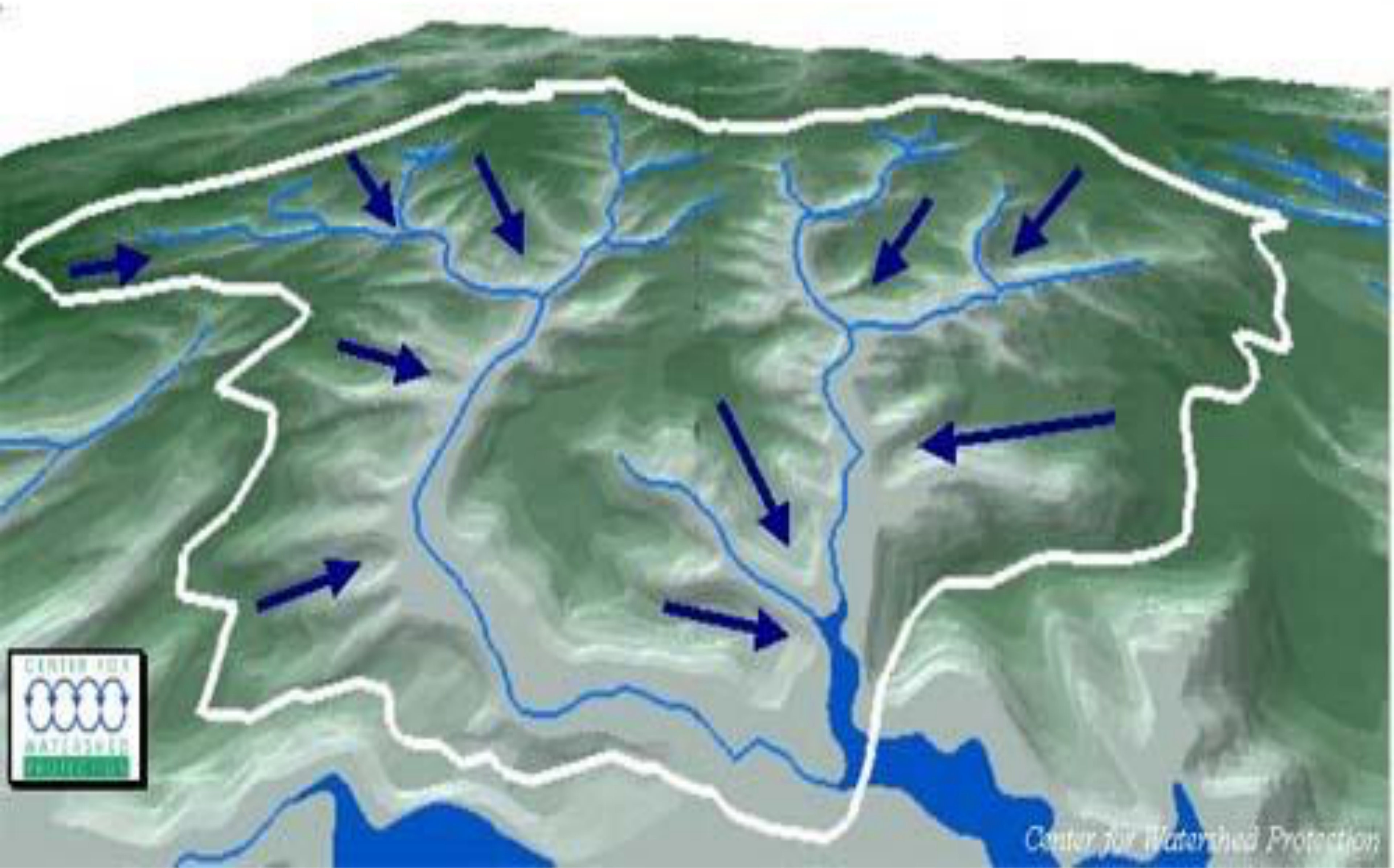
Various measurement methods for determining watershed area

- Can trace, cut and weigh your watershed
- Can trace watershed on graph paper and count vertices (crosshairs)
- Can trace your watershed using a planimeter
- Can use GIS or other electronic methods if you have the data layers
- Can do a site survey with a level and rod or GPS

Why determine a watershed area?

- Area is a basic piece of information that one needs for many purposes, e.g.:
  - Trees /area
  - Runoff / area
  - Soil nutrients / area
  - Watershed area defines the area that delivers water, sediment, organic matter and nutrients to a water body

Who measures watersheds?



Who measures water and watersheds?

USGS –	US Geological Survey
USBoR –	US Bureau of Reclamation
USACOE –	US Army Corp of Engineers
USFS –	US Forest Service
NRCS –	National Resources Conservation Service
USEPA –	US Environmental Protection Agency
USFWS –	US Fish and Wildlife Service
NOAA –	National Oceanic and Atmospheric Administration
NMFS –	National Marine Fisheries Service
NWS –	National Weather Service

TRIBES

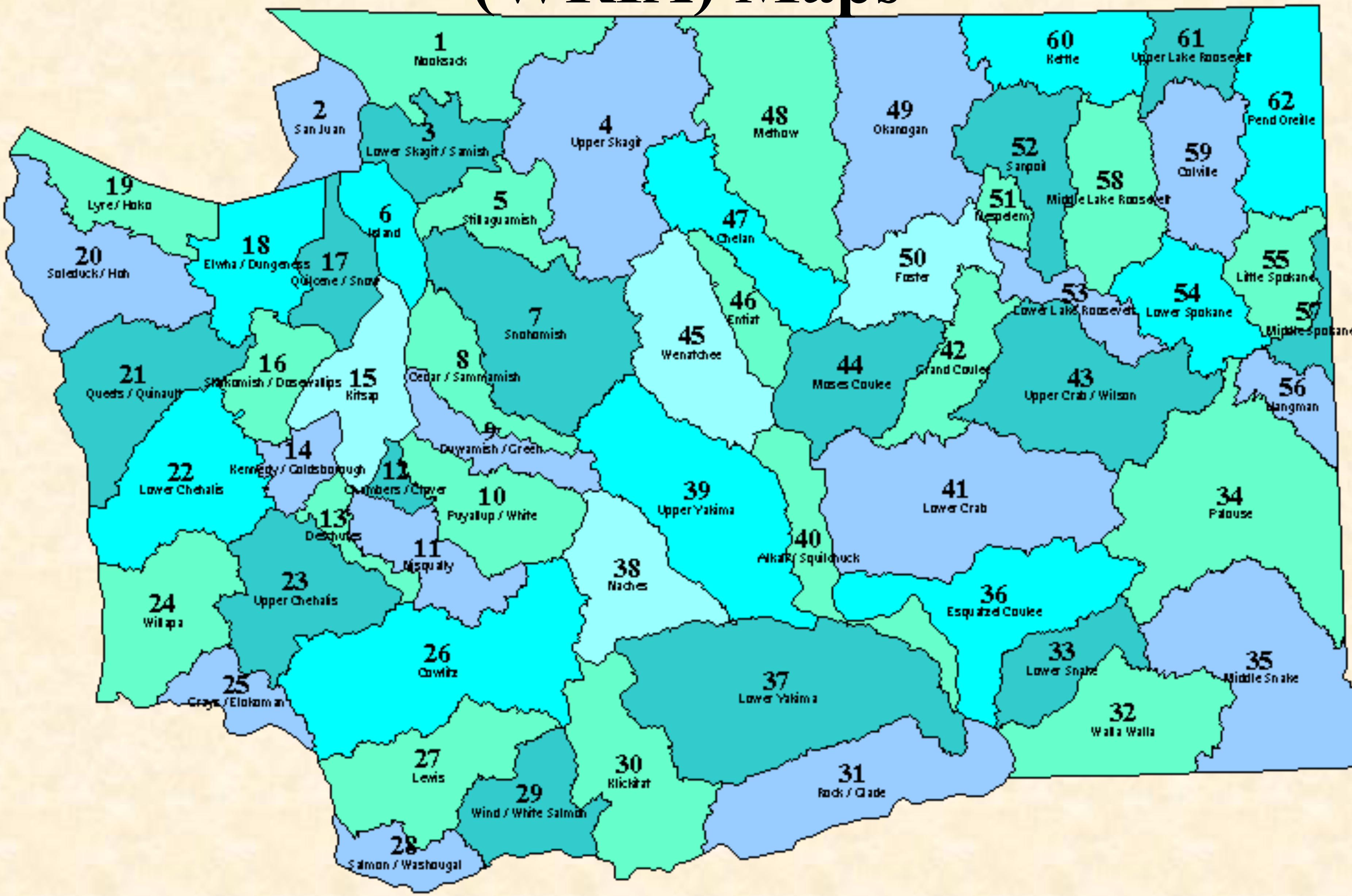
Cities, counties, states, schools

You!

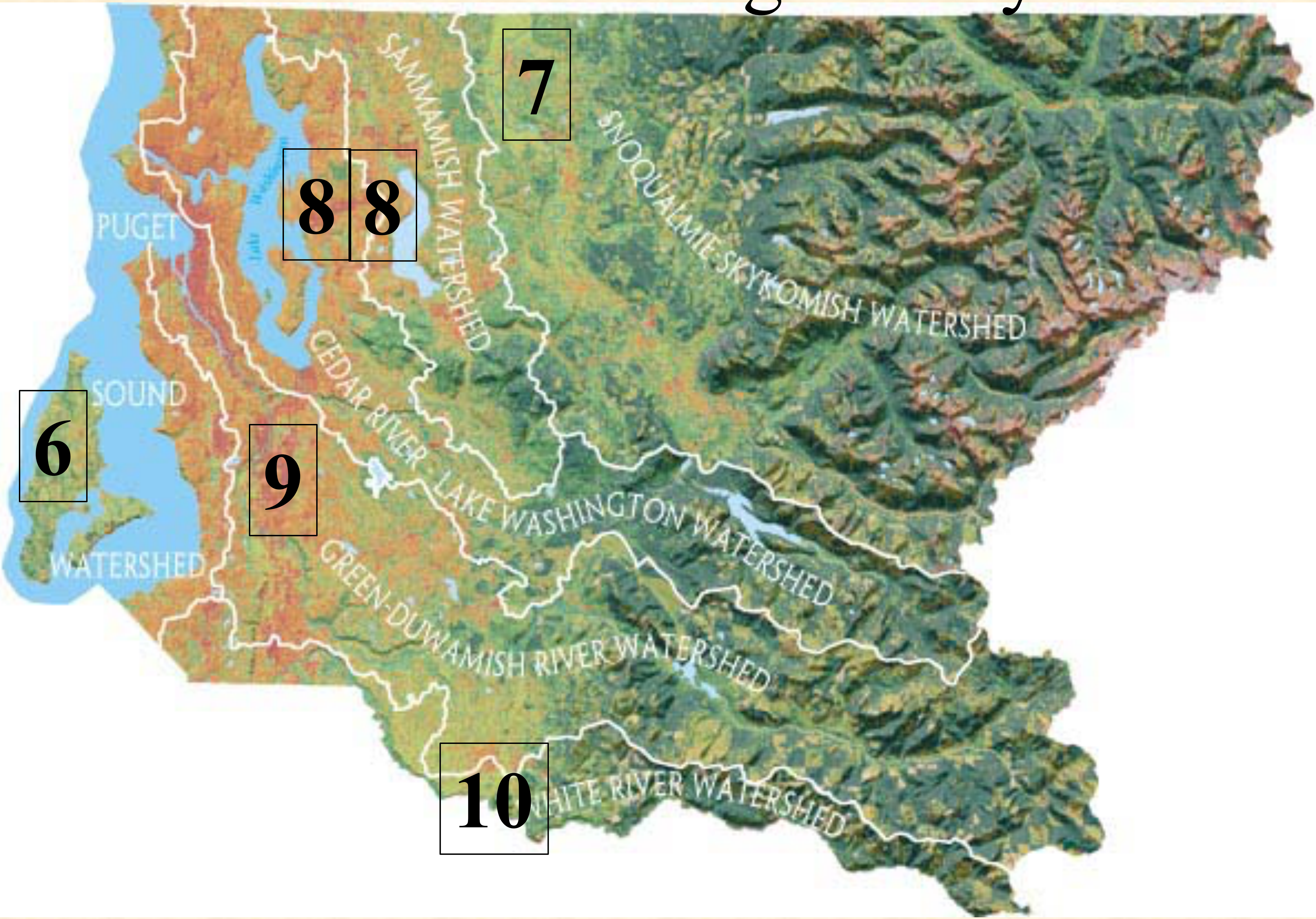
Watershed assessment methods

- ***Many organizations use some sort of watershed assessment technique to characterize landscapes***
  - Each organization has slightly different procedures.
  - There are many examples on the web
    - E.g., any of the 62 Washington state WRIA (Water Resource Inventory Area)
      - http://www.ecy.wa.gov/services/gis/maps/wria/wria.htm
  - WA Dept of Natural Resources (DNR) – Stream Type
    - http://www.dnr.wa.gov/BusinessPermits/Topics/ForestPractices HCP/Pages/fp_hcp.aspx

Washington Water Resource Inventory Area (WRIA) Maps



WRIAs in King County



Watershed assessment methods

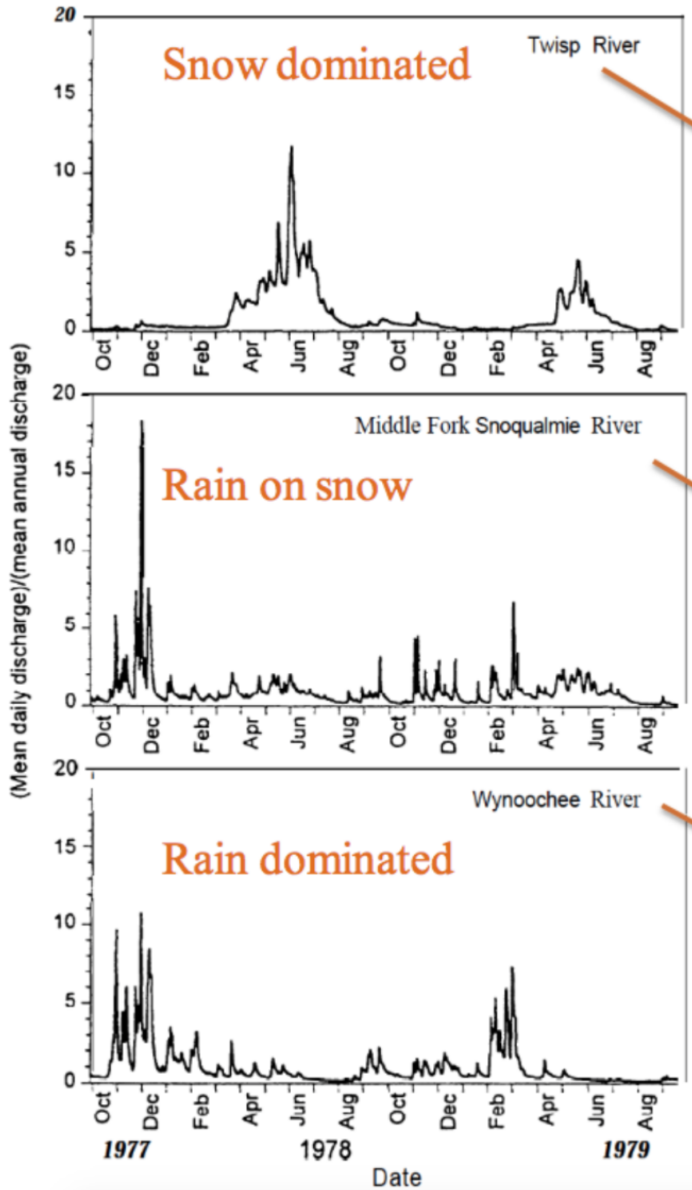
What processes are we interested in?

Wait, what's an ecosystem process?

- ***1. Hydrologic regime***
  - Analyze flow records for
    - changes in **peak flows** (maximum),
    - **flow durations** (how long a flow lasts),
    - **base flows** (normal low flow), etc.
    - Seasonal changes in flow
  - Compare flow records with precipitation data
  - Assess connectivity changes in watershed e.g. dams, diversions, levees, impervious area

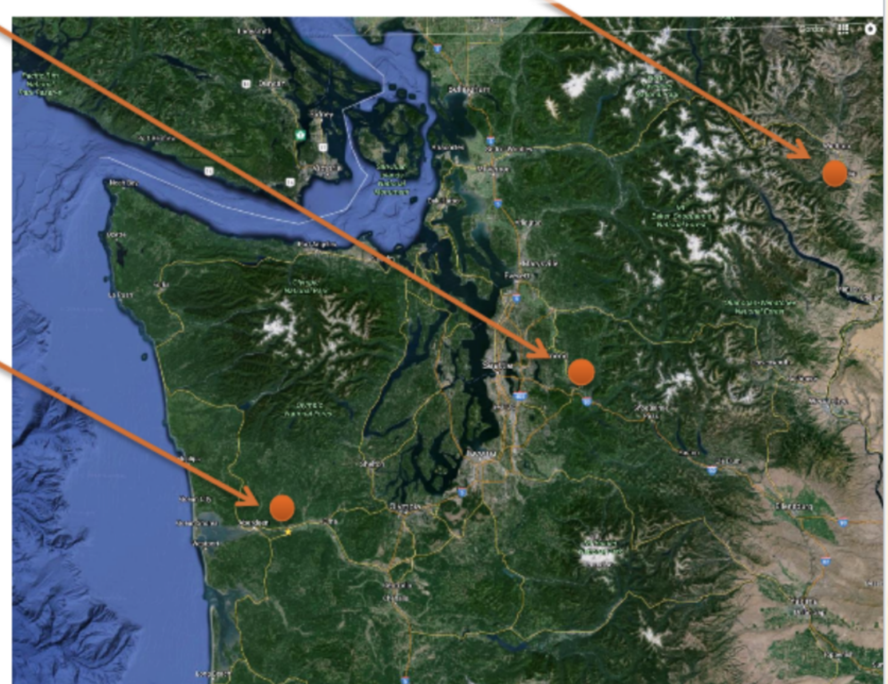
• *1. Hydrologic regime cont.*

Slide by Gordon Holtgrieve (Watershed ecology class)



Seasonality of River Discharge

The amount of water in a river at any given time is a function of both *the amount of precipitation* and *the form of precipitation.*



Watershed assessment methods

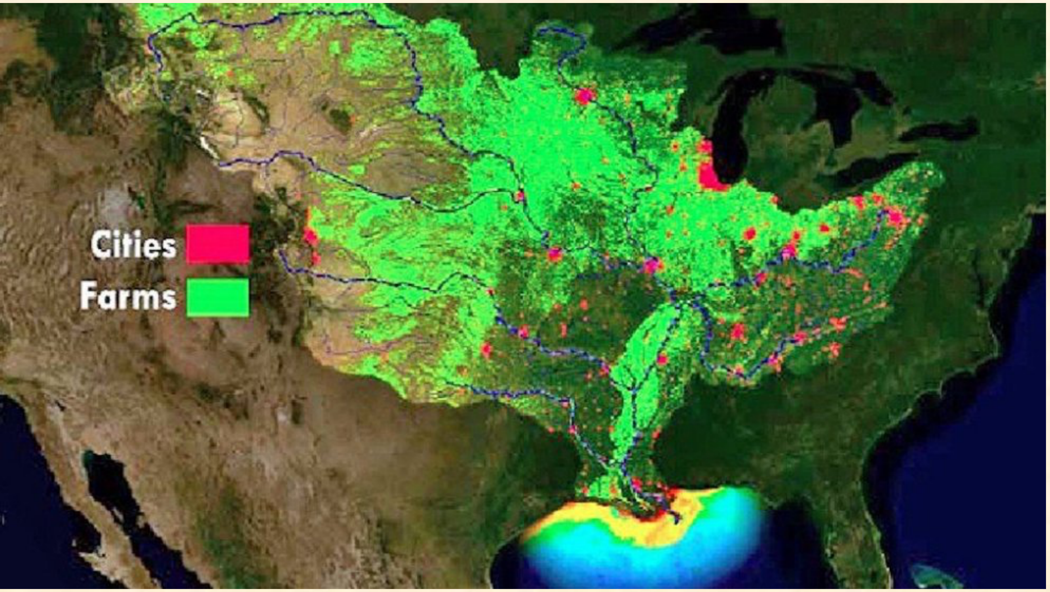
- ***2. Organic matter input processes***
  - Assess riparian and floodplain forest/vegetation conditions
  - Identify current and historic fire return patterns

  PNW data source on fire history

www.fs.fed.us/pnw/fera/research/climate/fire_history.shtml

Watershed assessment methods

- ***3. Nutrient input processes***
  - Assess inorganic inputs based on geologic and soils maps
  - Assess inputs from anthropogenic sources
  - Point and non-source inputs
  - Current or former seasonal inputs e.g. spawn



Eutrophication

Watershed assessment methods

4. Sediment supply and erosional processes

- Quantify landslides and estimate sediment budgets
- Assign landslide hazard ratings to roads and hillslopes
  - DNR
  - Seattle
- Map surface erosion areas e.g. unpaved roads, bare areas, construction zones

WA landslide haz: http://www.dnr.wa.gov/BusinessPermits/Topics/LandslideHazardZonation/Pages/fp_lhz_review.aspx
Seattle landslide haz: http://www.ecy.wa.gov/programs/sea/landslides/maps/maps.html

Watershed assessment methods

- ***5. Light and heat inputs***

  - Assess current and historical shade/canopy conditions in stream and floodplain
  - Assess current and historic turbidity levels in streams

*

What do we typically **measure** in streams and watersheds?

General categories

Land cover/land use

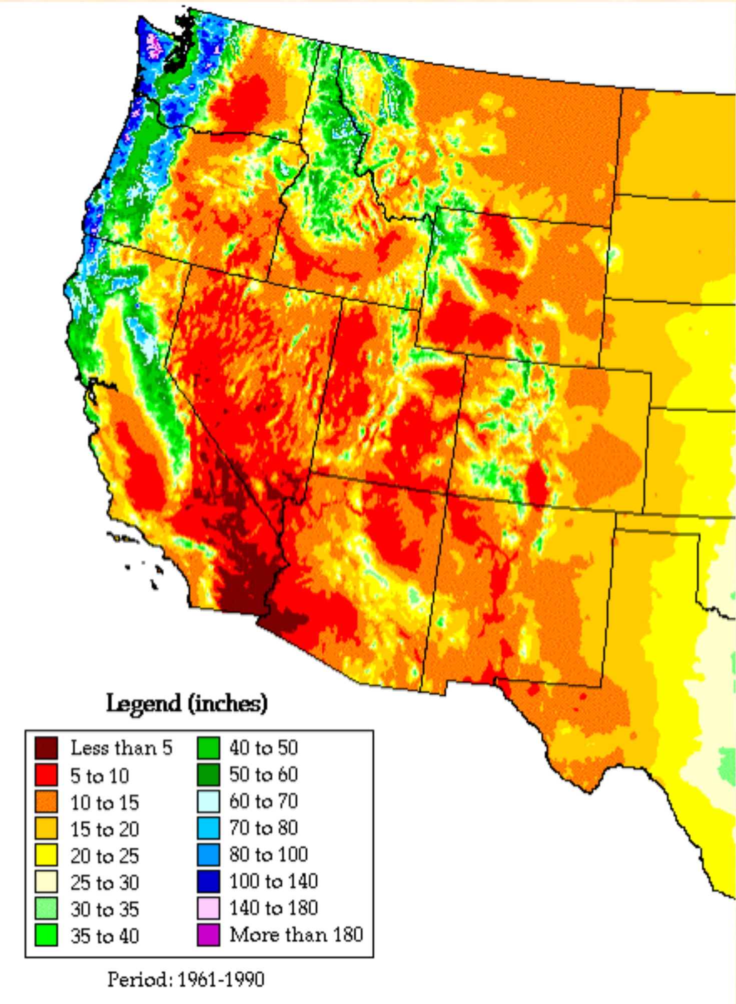
(e.g. vegetation, impervious area, agricultural/urban/undeveloped)

Physiography

(soils, geology, topography)

Climate

(precipitation, temperature, wind, humidity, streamflow, etc.)



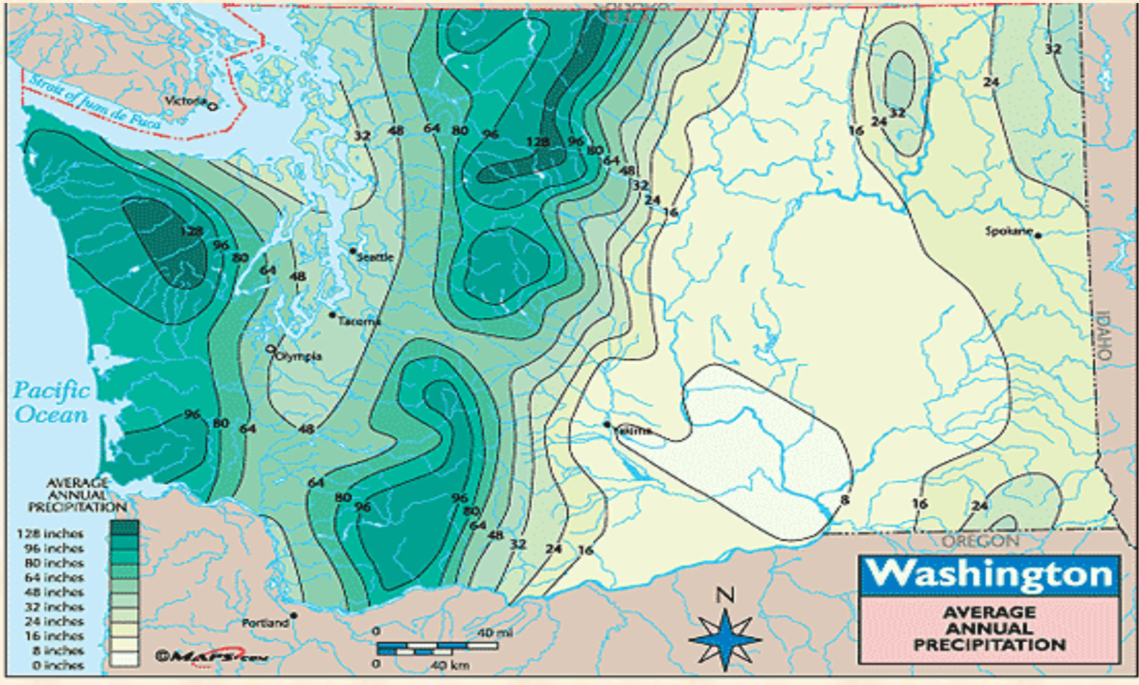
Examples of more specific measurements related to stream ecology

- Precipitation
- Organic input to streams – LWD
- Nutrient input to streams- leaves, salmon
- Sediment input to streams
- Light and heat inputs to streams
- Biological communities in or adjacent to streams
- Streamflow – quantity, timing, duration and quality
- Channel characteristics –

  slope, bankfull width, substrate, pools, riffles

What do we want to know about precipitation?

- Quantity (how much)
- Intensity (rate) (how much over how long)
- Temporal variation (how much, when)
- Spatial variation (how much, where)
- Form (solid, liquid)



Precipitation gage

Watersheds collect precipitation and deliver it to streams

Discharge Measurement aka Streamflow

How do we measure how much water is in a stream?

- Volumetric measurements-
  - Works for very low flows, collect a known volume of water for a known period of time

  Volume/time is discharge = Q
- Cross-section/velocity measurements
  - Velocity Area
  - Float Method
- Dilution gaging with salt or dye
- Artificial controls like weirs

Velocity – Area discharge measurement method

By measuring the cross-sectional area of the stream and the water velocity you can compute discharge

$Q = VA$

Q = discharge

Where Q is discharge

V is velocity

A is wetted cross-sectional area and depth = width x depth

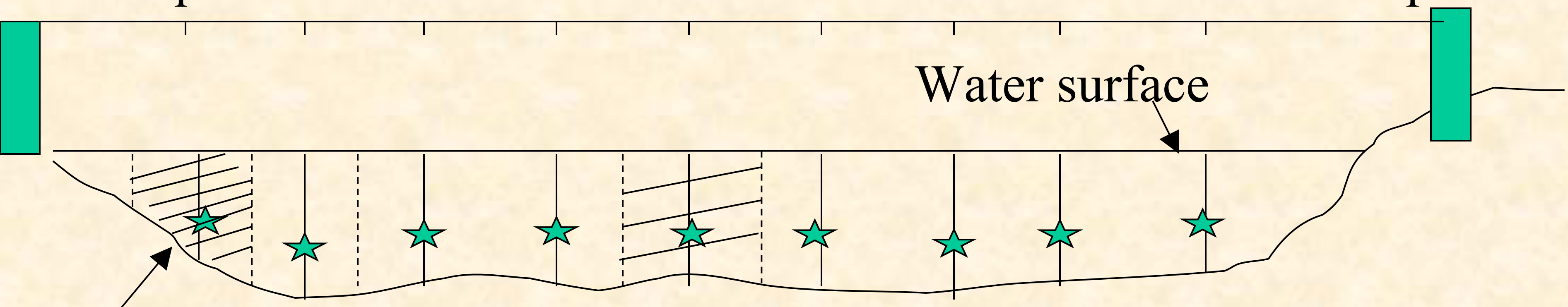
units are ft^3/s or L^3/t (volume / time)

This is a continuity of mass equation

$\uparrow A * \downarrow V = Q = \downarrow A * \uparrow V$

Velocity – Area method of discharge measurement

Tape measure- horizontal location of measures taken from tape



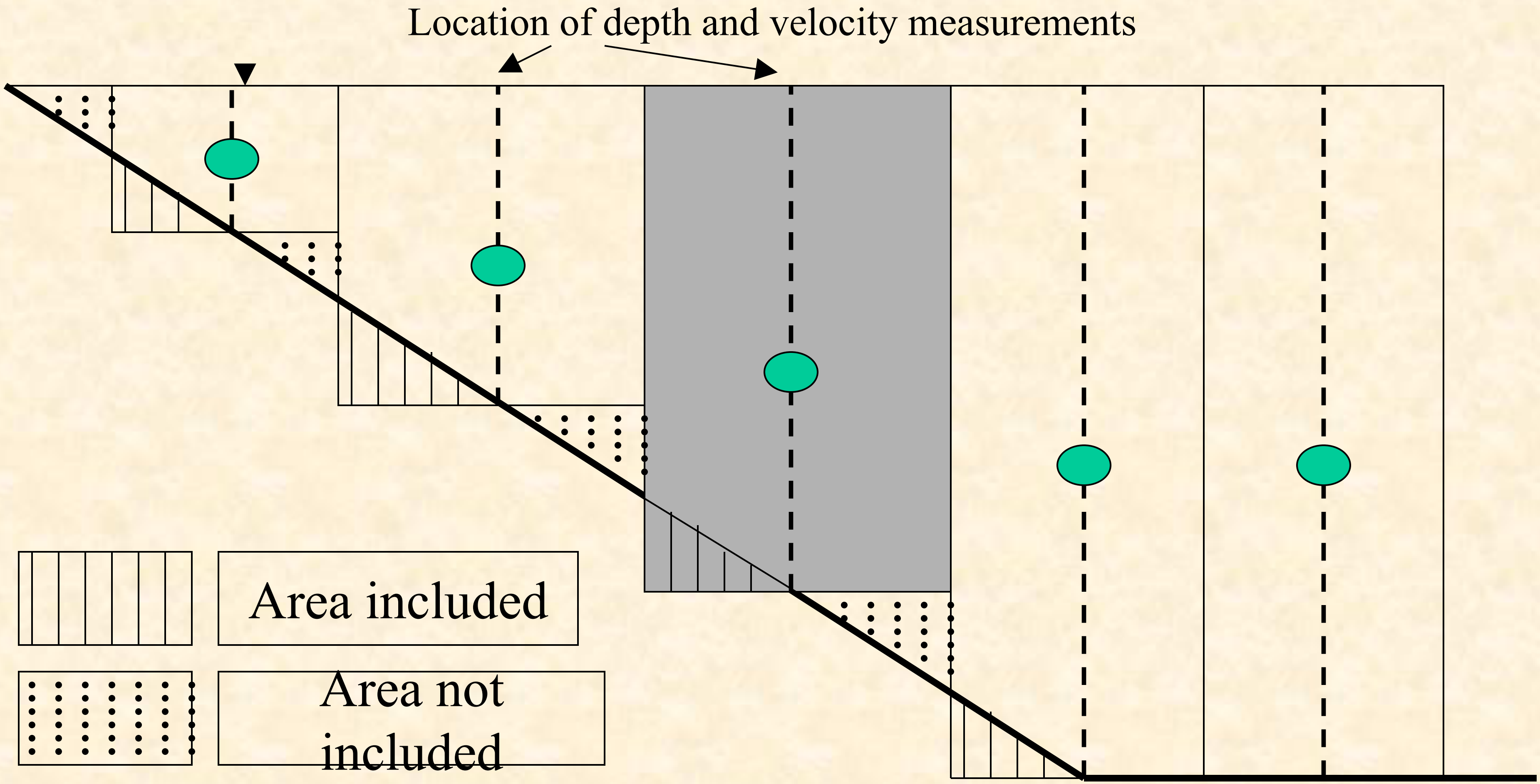
Measurement represents mid-section of a polygon

★ Velocity measured 0.6d from water surface (0.4d from bottom)

Record **x** value (tape value), **y** value (water depth at measurement site, and **velocity** at 0.6d (you will have 3 values recorded at each spot)

Photo from Black Hills State University

Mid-point method of calculating discharge (Q)



Key Assumption: Overestimation (area included) = Under estimation (area not included), therefore cross-section area is simply the sum of all the sections (rectangles), which is much easier than taking the integral! **However, the hypotenuse of each over-under estimation triangle can be used to calculate the wetted perimeter.**

How many subsections?

- Subsections should be at least 0.3 feet or ~0.1 m wide
- Each subsection should have 10% or less of total discharge (i.e., if flow is deep and fast measurements should be closer together and if flow is shallow and slow they can be farther apart)
- Number of subsections should be doable in a reasonable amount of time!

Equation for computing subsection discharge - q_i

Equation for computing q in each subsection

X = distance of each velocity point along tape

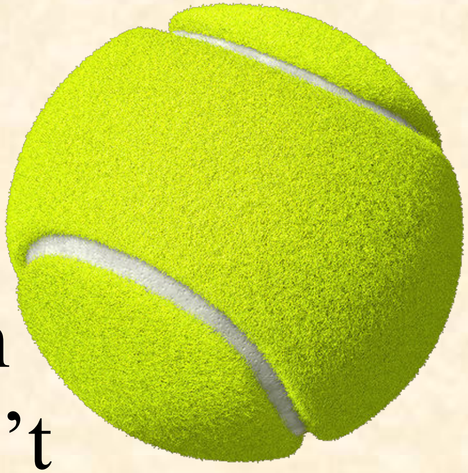
Y = depth of flow where velocity is measured

V = velocity

$$q_i = y_i \times v_i \times \left(\frac{x_i - x_{i-1}}{2} + \frac{x_{i+1} - x_i}{2} \right)$$

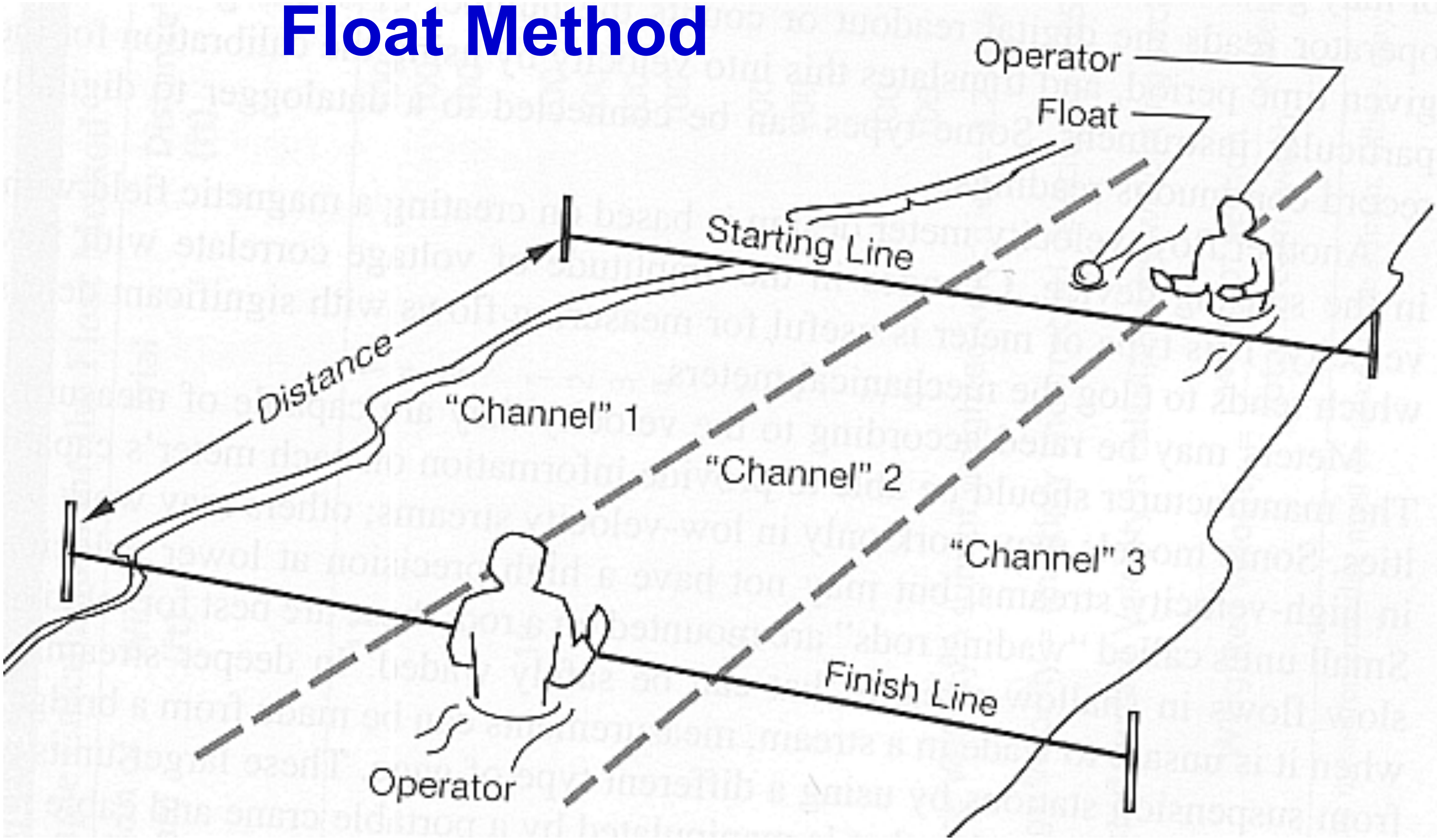
$$Q = \text{total discharge} = \text{sum of } q_i = \sum_{i=1}^{n} q_i$$

Float method of discharge measurement



- Gives reasonable estimates when no equipment is available
- Use something that floats that you can retrieve or is biodegradable if you can't retrieve it
  - E.g. oranges, dried orange peels, tennis balls, leaves, twigs
  - You can float yourself as a last resort

Float Method



surface velocity = distance /time

avg. subsurface velocity ~ (0.8*surface velocity)

Float method of velocity measurement

Three people are needed to run the float test. One should be positioned upstream and the other downstream a known distance apart, one in the middle to record data.

The upstream person releases the float and starts the clock and the downstream person catches the float and signals to stop the clock. The recorder writes down the time of travel of the float.

Velocity is the distance traveled divided by the time it takes to travel that distance. Velocity = distance/time

You should conduct at least 3 float tests and take an average velocity. This gives you surface velocity which is <u>NOT the same as average subsurface velocity</u>

With an estimate of cross-sectional area, discharge can be computed as Q = VA where V is average *subsurface* velocity (need to use correction factor)

Channel Substrate

- Substrate size (particles that line the channel) is an important component

  of habitat
- Substrate size is important for fish habitat and macroinvertebrate habitat
- Changes in land use/land cover can change substrate size distributions

Substrate categories

1. Sand, silt, clay. <0.25" or <0.8 cm (*smaller than pea size*)
2. Gravel. 0.25" -1" or >0.8-2.5 cm (*pea to golf-ball size*)
3. Large Gravel. >1" - 3" or >2.5-7.5 cm (*golf-ball to baseball size*)
4. Small Cobble. [>3"-6" or >7.5-15 cm (*baseball to cantaloupe size*)
5. Large Cobble. >6"-12" or >15-30 cm (*cantaloupe to basketball size*)
6. Small Boulders. >12"-40" or >30cm-1.0 m (*basketball to car-tire size*)
7. Large Boulders. >40" or >1.0 m (*greater than car-tire size*)
8. Bedrock

Substrate expectations

- Pools usually have finer substrates
  - Velocity in pools is slower and finer particles settle out
- Riffles usually have coarser substrates
  - Velocity in riffles is faster and finer particles are swept downstream

Aquatic Invertebrates

- Stream invertebrates are frequently used as bioindicators
- Benthic index of biotic integrity (B-IBI, developed by Jim Karr from SAFS) uses numbers and species of aquatic invertebrates to assess stream condition

Examples of organisms used as bioindicators

Large mouth bass

Muskellunge

Midge

Caddis fly

Stonefly

Mayfly

Riffle beetle

Photos from www.epa.gov/bioindicators/html/photos_fish.html and www.epa.gov/bioindicators/html/photos_invertebrates.html

What will we do in the field on Tuesday and Wednesday (depends on weather)?

- Go to a small stream at St. Edwards State Park (weather permitting):
  - Discuss low flow measurement issues
  - Assess light, sediment, water, organic and nutrient inputs
  - Look for aquatic insects

- Go to a larger stream (Juanita Creek) and take velocity cross-sections in order to compute total flow volume (discharge): using two different methods **!!Please read the procedures before lab!!**
- Evaluate substrate, look for aquatic insects

- Everyone needs to be dressed appropriately for the weather and for standing in water (we have some hip waders)

- **We will leave the C-10 parking lot at 12:30 sharp!**

If you drive separately- meet at Saint Edward State Park

Juanita Creek Beach Park:

9703 NE Juanita Dr, Kirkland, WA 98034

What will we do in the field later today?

- Go to the Mashel River
  - Assess light, sediment, water, organic and nutrient inputs
  - Look for aquatic insects
  - Take velocity cross-sections in order to compute total flow volume (discharge): using two different methods **!!Please read the procedures before lab!!**
  - Evaluate substrate
- Everyone needs to be dressed appropriately for the weather and for standing in water (we have some hip waders)