Water From a Global Perspective

Water covers ~70% of the earth’s surface
97.1% of that is in the oceans
2.24% frozen in ice caps/glaciers
0.61% is groundwater

So less than 0.05% of global water is surface freshwater

40% of which is in the Great Lakes and Lake Baikal

a tiny fraction of all freshwater is in rivers and streams

So why do (or should) we care about streams?
Stream Ecology? What’s that?

Ecology = the study of how organisms are related to their environment and to other organisms.
Stream Ecology? What’s that?

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Stream Biota

Big Fish

Small Fish

Invertebrates

Algae
5 Factors Influencing Stream Communities

- Light
- Temperature
- Flow
- Dissolved Oxygen
- pH
Where streams come from

1. Direct Input
2. Overland Flow
3. Shallow Sub-Surface Flow
4. Groundwater Flow
Flow Terminology

**Velocity:** simply the speed of water as it travels from point A to point B (distance/time)

**Discharge:** the amount of water that passes a given point over time (volume/time)

**Power:** the ability to do work (e.g., transport sediment, move boulders, etc.)
- Power typically increases with increasing velocity and/or discharge

**Hydrographs:** graphs used to examine changes in discharge over time
Hydrograph of a Storm Event

- **Discharge**
- **Time (days)**

- **Storm**
- **Rising Limb**
- **Peak**
- **Recession Limb**
- **(Base Flow)**
Habitats in Stream Systems

- Pools
- Riffles
- Waterfalls
- Glides/Runs
- Rapids/Cascades
Why aren’t streams all straight?

1. Valleys and floodplains are not smooth, level, or evenly sloped.

2. Soils, sediments, and deposits in floodplains are highly variable.
   - i.e. resistance is not consistent

3. Streams will always take the path of least resistance, not necessarily the most direct
Dynamics of The Meander

Erosion

Deposition

Deposition

Erosion
The Meander

Meanders:
1. Control flow rates
2. Provide habitat
3. Are natural and dynamic
Flowing water can be classified into 2 types:

**Laminar Flow**: Smooth flow that is like parallel sheets moving together.

![Laminar Flow Diagram](image)

**Turbulent Flow**: Chaotic flow that is rough and unorganized. (most common)

![Turbulent Flow Diagram](image)
Organisms and Flow

To deal with drag and lifting forces of turbulent flow, organisms may:

Adapt “streamlined” body forms to create more laminar-like flows

Adapt body forms or life styles that use the low velocity layer near the bottom.
Sunlight is the ultimate source of energy for all stream communities.

- However, this energy enters stream food webs via 2 major pathways:

**Autochthonous Production** (within the stream)

**Allochthonous Production** (from outside the stream)
Energy Pathways in Streams

Autochthonous Production (algae and aquatic plants)

Allochthonous Production (input from terrestrial plants)
Factors influencing light for in-stream production

**Stream-side vegetation**
(but used for allochthonous production and regulates temperatures)

**Time of day**

**Water depth**

**Season & climate**

**Water clarity**

**Surface roughness**
**Turbidity & Water Clarity**

**Turbidity** is generally a measure of the suspended particles in water (living and non-living).

**Water Clarity** is used to describe turbidity + the presence of dissolved compounds (i.e. color)

Water Clarity influences:
- The ability of sunlight to reach autochthonous producers
- The effectiveness of visual predators
- Temperature
Water Clarity is influenced by:

- Erosion
- Flows
- Litter-fall
- Underlying geology
- Suspended algae
- Biotic community
Temperature

Temperature is important because it regulates:
- rate of chemical reactions
- amount of gases and solutes dissolved in water
- metabolic rates of stream biota
- and more...

Stream temperature is influenced by:

**Sunlight**
- Riparian vegetation
- Groundwater inputs
- Width and depth
- Upstream factors
- Water clarity
Daily Patterns of Stream Temperature

- Open Site; Without Spring Inputs
- Shaded or Spring Influenced Site

Water Temperature (°C)

Time (h)
Range in Daily Temperature Going Downstream

Maximum Daily Temperature Range (°C)

Stream Size (order)

(Headwaters) (Mississippi)

From Vannote & Sweeney (1980)
Temperature range and organisms

**Stenotherms** (often called “cold water species”) exist in a narrow range of temperatures.
- e.g., Salmon and trout

**Eurytherms** (often called “warm water species”) may exist in a wide range of temperatures.
- e.g., Bass and suckers
Dissolved Oxygen

Dissolved oxygen in a stream is largely a function of:

**Air exchange at the water surface**
- Roughness INCREASES oxygen exchange

**Biological activity**
- Daytime photosynthesis INCREASES oxygen
- Nighttime respiration from all organisms, DECREASES oxygen

**Water temperature**
- The colder the water the more oxygen can be dissolved
Dissolved Oxygen Saturation

% Saturation compares the amount of oxygen that is dissolved vs the maximum amount that could be dissolved at a given temperature and pressure

**100%** means the water is well-aerated

**<100%** means more oxygen is being used than added

**Supersaturation (>100%)** occurs when production of oxygen in the water exceeds the rate of loss from the water.
Daily Patterns of Dissolved Oxygen

- **Open Site**
- **Shaded Site**

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<th>Time (h)</th>
<th>D.O. Saturation (%)</th>
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</thead>
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<td>70</td>
</tr>
<tr>
<td>6:00</td>
<td>80</td>
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<tr>
<td>12:00</td>
<td>100</td>
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<tr>
<td>18:00</td>
<td>110</td>
</tr>
<tr>
<td>24:00</td>
<td>120</td>
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</table>
pH

Measure a liquid’s acidity or alkalinity depending on the amount of Hydrogen Ions ($H^+$).

Water naturally exists in a balance:

$H_2O$ (water) $\leftrightarrow$ $H^+$ (Hydrogen ions) $\leftrightarrow$ $OH^-$ (Hydroxide ions)

(mostly this) $\leftrightarrow$ (some of these)
- **Acids** have high concentrations of H$^+$

- **Bases** have low concentrations of H$^+$

The pH scale goes from 0 to 14, where 7 represents pure neutral water.
Adding acids (rain, pollution, etc.) increases the amount of $H^+$, decreasing pH.

- Streams naturally exist between pH 6-8
- At 6 and below, things get rough...

What does pH affect?
- rate of chemical reactions
- amount of materials dissolved in water
- amount of nutrients available to algae
- general health/performance of organisms
5 Factors Influencing Stream Communities

- Light
- Temperature
- Flow
- pH
- Dissolved Oxygen
Some Big Picture Take-Home Messages
Streams are closely tied to surrounding riparian landscape

- Shade/microclimate
- Bank stability
- Filters runoff from landscape
- Flood/flow control
- Provides energy sources to aquatic biota
- Aquatic habitat (undercut banks, root wads)
- Wood inputs
- Habitat for semi-aquatic species
Streams Operate in 4 Dimensions

- Lateral
- Longitudinal
- Vertical

...and TIME
Streams are dynamic!

Stream ecologists and managers must consider how streams change:
- in **SPACE**
- in **TIME**
Streams are dynamic!

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- in **SPACE**
- in **TIME**
“Be The Fish”