Day 2. Palmer Ecosystem Structure and its controls

**Structure**
- focal habitat types
- Diversity of habitats
- channel configuration
- focal species
- functional group
- species diversity

**Function**
- food web interactions
- nutrient processing/uptake
- production (primary or secondary)
- decomposition
- detoxification

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**Invertebrate Metrics**

**Taxa Richness Metrics**
- Total taxa
- Ephemeroptera taxa
- Plecoptera taxa
- Trichoptera taxa
- EPT taxa
- Long-lived taxa

**taxa Composition Metrics**
- % Ephemeroptera taxa
- % Trichoptera taxa
- % Diptera and Non-Insect taxa

**Tolerants and Intolerants**
- Intolerant taxa richness
- % Tolerant taxa

**Feeding and Other Habits**
- % Predators
- Clinger Taxa

**Population Attributes**
- Dominance (3 taxa)
Amphipoda (scuds) - fast with strong swimming legs

Gerridae (water striders) don’t need the surface frozen to skate around on it

Corixidae (water boatman) hind legs modified for swimming, front legs for feeding

Trichoptera (caddisfly) - walking legs and anal hooks. Fast water predators

Plecoptera (stonefly) - with strong walking legs

Planaria (flatworm) - slimes about, also, flattened to prevent washing away

Corixidae (water boatman) - hind legs fast with strong swimming legs

Odonata (dragonfly) - gets around by having the squirts

Notonectidae (backswimmer) - a true bug that swims on its back with oar-like legs

Leptoceridae (caddisfly) - make and carry stone cases that give protection and ballast. Long hind legs used for swimming and walking

Ecological structure affected by the interaction of flow and substrates
Velocity, Diffusion, Re-aeration & metabolism

Position and movement

Habitat utilization, predation, resource acquisition

Diffusion, Re-aeration & metabolism

Catastrophic Disturbance (mortality, drift)

Hydrogeomorphic Effects
For conformers current velocity can act as a substitute for O₂ concentration in terms of regulating respiration rates; For regulators reduced velocity requires more work and therefore energy.

Example: At level of physiology: O₂ concentration-velocity tradeoffs

Example: At community level: caddis fly resource capture
Flow influences at multiple scales

flow habitat preferences, body morphologies, and motilities

The Reynolds number (Re) is used to determine whether laminar or turbulent flow occurs:

\[ Re = \frac{VR}{\nu} \]

Where:  
\( V \) = velocity of flow  
\( R \) = hydraulic radius or depth  
\( \nu \) = fluid viscosity
This blackfly larvae is adapted to exploit the velocity profile near the substrate.

**FIGURE 6.6** (a) The typical filigree sense of a blackfly larva (*Simulium ornatum*) samples. The larval body extends downstream at progressively greater deflection from vertical with increasing current velocity, and is oriented W–E. The filigree sense is visible to the larva's left by following the line of the current trace used. The position of the gilled cephalic fan is upper and lower, rather than side by side. The boundary layer (depth where 0% of maximum flow) begins at roughly the height of the upper fan. (b) Details of cephalic fan: (i) head of a normal larva seen from behind, with cephalic fans fully open; (ii) Simulium flavescens with uniform range of orientation; (iii) *Simulium* with long and short microvilli. (From Caudill, 1998; SEM photomicrographs courtesy of D.A. Craig.)
**Diversity: empirical observations & theories of mechanisms**

**Observations**
1. Diversity increases with area
   (Island Biogeography >> dispersal & extinction; heterogeneity)
2. Diversity increases over time (stability hypothesis)
3. Tropics often extremely diverse
4. Diversity increases at intermediate levels of natural disturbance
   (floods; predation; etc.)

**Possible Mechanisms**
- Diversity increases with habitat **heterogeneity**
- Diversity linked to distance to **source populations**
- Diversity linked to population size because of **extinction risk**
- Diversity is highest at intermediate levels of **natural disturbance**
- Given 1. and 2. are equal, diversity increases with **productivity** (energy base)

**Habitat heterogeneity & restoration**

![Graph showing biological response over time since restoration](image)

Geomorphic Heterogeneity = \( d_{84} / d_{60} \)
Benthic Primary Production and Respiration
biofilm colonized tile assay
light/dark bottle incubation
measured at 4, 8, 15 & 25 d

Gross productivity (mg O₂ m⁻² hr⁻¹)

LH riffles
HH riffles
Reference riffles

trt < 0.05
day < 0.01
trt * day = 0.50

Intermediate Disturbance Hypothesis

Distance to source: SPATIAL ECOLOGY and Restoration

Local populations ↔ metapopulations
Salamanders – esp. headwater species
  Riparian vegetation
  Macrophytes
  Wetland marsh plants

Core - satellite populations

Must maintain populations in core areas

As N decreases, random variation in vital rates
  Increases extinction risk

As N decreases, loss of genetic variation reduces extinction risk
Must pay attention to spatial arrangement of restoration sites

- patch size
- distance to nearest intact patch
- patch connectivity
- perimeter/area ratios

Restoration lag can be overcome by adjacent vs. random placement of restoration site


Maryland example: importance of spatial context

- 1st order stream
- 74% High Density Res
- 14% Bedrock
- 52% “Run” Habitat
Watershed context: restoring "dead" tributaries & paths of colonization
So.. how can sites be modified to enhance diversity?

- Spatial heterogeneity of resources and ecosystem functionality
- Productivity (abundant & diverse food base: autochothonous or allochthonous)
- Disturbance regimes
- Introduce/plant large populations
- Place close to source of colonists
Finally, the ultimate goal: restoration for resilience

Guiding principles
1. Restore/manage processes that support services (functions)
2. Identify processes that can not be replaced – some require protection
3. Identify greatest threat to each service & thresholds
4. Always have insurance: functional diversity
5. Set up a savings account: storage effect, bet-hedging, seed banks
6. Spatial arrangement matters
7. Restore keystone players and habitats