Hydrologic Connectivity as a Template for Understanding Human-Physical-Ecological Coupling

Todd A. Crowl
Utah State University
&
Luquillo LTER

LTER Mini-symposium, Feb. 2008
Drivers and Responses

Social Framework
Water Systems Are Coupled Human and Natural Systems

**Natural systems**
- Hydrology
- Biogeochemistry
- Geomorphology

**Human systems**
- Water resources infrastructure
- Water demands & discharges
- Demands & actions on water
- Infrastructure interactions
- Policies and facilities

**Engineered system**
- Engineered treatment works

**Hydrologic / Geomorphologic interactions**
- Landscape & climate changes

**Hydrologic / Biogeochemical interactions**
- Water demands & discharges
- Policies and facilities
Water Systems Are Coupled Human and Natural Systems

**Natural systems**

- Geomorphology
- Hydrology
- Biogeochemistry

**Human systems**

- Water resources infrastructure
- Engineered treatment works
- Policies and facilities
- Infrastructure interactions
- Demands & actions on water
- Water demands & discharges
- Landscape & climate changes

**Ecological interactions**

- Hydrologic / Biogeochemical interactions
- Hydrologic / Geomorphologic interactions
**Hydrologic connectivity** - water mediated transport of matter, energy and organisms within or between elements of the hydrologic cycle… including diffuse anthropogenic pathways.
**Hydrologic connectivity** - water mediated transport of matter, energy and organisms within or between elements of the hydrologic cycle… **including diffuse anthropogenic pathways**
Hydrologic Connectivity at the Luquillo LTER

• Network fragmentation and biodiversity-ecosystem function
• Connections with the social fabric
• Urbanization and diffuse regional effects with local implications
Collaborators

Alan Covich & Cathy Pringle - Univ. of Georgia
Bill McDowell - Univ. New Hampshire
Fred Scatena - Univ. Pennsylvania
Jean Lodge - International Institute of Tropical Forestry
John Loomis - Colorado State University
Armando Gonzalez-Caban - USDA Forest Service
Luis Santiago - Univ. Puerto Rico

Juan Felipe Blanco Libreres - LTER post-doc

Effie Greathouse, Katie Hein, Tamara Heartsill-Scalley - LTER phd students

Kevin Landom, Summer Kartchner, Coralys Torres, Vanessa Welch, Alejandro Berbenos, Sara Redd & Valerie Schroepfer - LTER REU students
DIADROMOUS SPP
Shrimp processing results in significant increases in DOC and Nitrogen availability; low diversity results in increased export.
Xiphocaris (shredders)

CPOM

FPOM

CPOM

FPOM

Xiphocaris (shredders)

Atya (collectors)

litterfall

export

consumption

consumption

shredder-dependent processing

shredder-independent processing

export
High diversity - complex processing

Chains:

Efficient transformation and utilization of carbon particles

Cycle of N, P and DOC

Retention of nutrients and energy for maximum *in situ* production
Natural experiment:
Large-scale declines above dams

Greathouse et al. 2006a, Ecological Applications
Greathouse et al. 2006b, Oecologia
High-gradient sites

Selected benthic resources

- Chlorophyll $a$
  - Dammed ($D$) vs. Undammed ($U$)
  - $\pm 1$ SE

- CBOM
  - Dammed ($D$) vs. Undammed ($U$)

- FBOM
  - Dammed ($D$) vs. Undammed ($U$)

- FBIM
  - Dammed ($D$) vs. Undammed ($U$)

$D =$ dammed, $U =$ undammed

Greathouse et al. 2006a, Ecological Applications
Greathouse et al. 2006b, Oecologia
High-gradient sites

Selected benthic resources

- Chlorophyll $a$
- CBOM
- FBOM
- FBIM

$\pm 1$ SE  - Pools  - Riffles

D = dammed, U = undammed

Greathouse et al. 2006a, Ecological Applications
Greathouse et al. 2006b, Oecologia
Results
Above large dam

Toa Vaca

Arecibo

Before Adding Shrimp
day 0

After Adding Shrimp
day 9

day 9

day 7

Greathouse et al. 2006b, Oecologia
Lugares de Entrevista en los Ríos Espíritu Santo y Mameyes en Río Grande. Puerto Rico.
Water drinking, biota (fish & shrimp), recreation (swimming & picnics), and aesthetics (sight seeing) are the main values of San Juan and Locals.

- **San Juan (High Value):**
  - Water drinking
  - Biota (fish & shrimp)
  - Recreation (swimming & picnics)

- **Locals (Low Value):**
  - Water drinking
  - Biota (fish & shrimp)
  - Aesthetics (sight seeing)
- Water drinking
- Biota (fish & shrimp)
- Recreation (swimming & picnics)
- Aesthetics (sight seeing)

Value:
- High
- Med
- Low

San Juan
Locals
Mainland
water drinking
biota (fish & shrimp)
recreation (swimming & picnics)
aesthetics (sight seeing)
Water drinking
Biota (fish & shrimp)
Recreation (swimming & picnics)
Aesthetics (sight seeing)

San Juan Locals

Value
High
Med
Low

San Juan

Locals
water drinking
biota (fish & shrimp)
recreation (swimming & picnics)
aesthetics (sight seeing)

San Juan
Locals

value

high
med
low
San Juan
Locals

water drinking
biota (fish & shrimp)
recreation (swimming & picnics)
aesthetics (sight seeing)

value
high
med
low
water drinking, biota (fish & shrimp), recreation (swimming & picnics), aesthetics (sightseeing)

value

+ waterfalls
+ pool area
+ pool depth
- sediments
- discharge
Drinking water

Recreation (swimming & picnics)

Aesthetics (sight seeing)

Biota (fish & shrimp)

Low

Med

High

San Juan

Locals

+ waterfalls
+ pool area
+ pool depth
- sediments
- discharge
+ parking space
- distance from roads

Scatena et al. in review
San Juan (and other urbanizations) Effects?
Heat Island Effect

Change in albedo, runoff & evapotranspiration
Heat Island Effect

Change in albedo, runoff & evapotranspiration
Puerto Rican 100 Year Annual Departure from Mean Rainfall 10 stations

- Orographic effects of urbanizations

Heartsill-Scalley et al. 2007
Network Structure Reflects Rainfall

- High Rainfall Network (100 cell threshold)
- Low Rainfall Network (1000 cell threshold)
Stream ecosystems are largely driven by autochthonous inputs of carbon (leaves and wood)
Allochthonous Input sources

**Tributary inputs**

**Over-bank inputs**

**Aerial inputs**
Allochthonous Input sources

- Tributary inputs
- Over-bank inputs
- Aerial inputs

Crowl et al. 2006
Mat forming White Rot Fungus
Mat forming White Rot Fungus

Tributaries supply 90% of leaf input
And of much higher quality

Faster processing and increased energy flow
Thanks for the $$$
NSF: LTER, Biocomplexity, DIG, REU
EPA
USDA Forest Service
International Institute of Tropical Forestry
Ecosystem function or service

Connectivity

The graph shows the relationship between ecosystem function or service and connectivity, indicating an increase in ecosystem function or service as connectivity increases.
Ecosystem function or service vs. Connectivity

- Within watershed
- Among watersheds