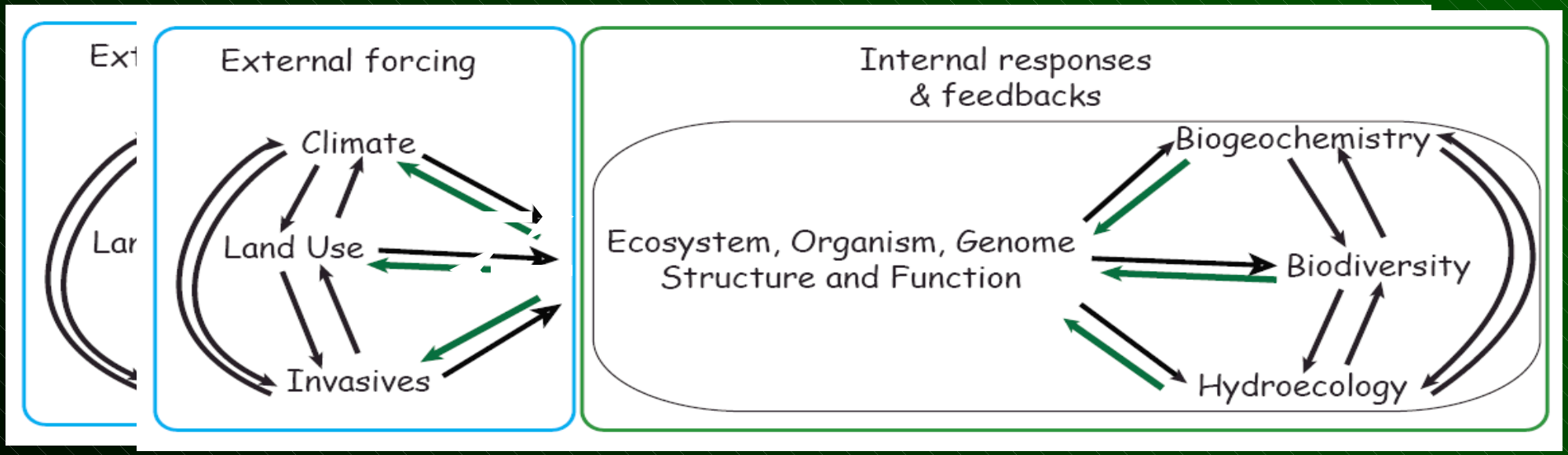
Hydrologic Connectivity as a Template for Understanding Human-Physical-Ecological Coupling

Todd A. Crowl
Utah State University
&
Luquillo LTER

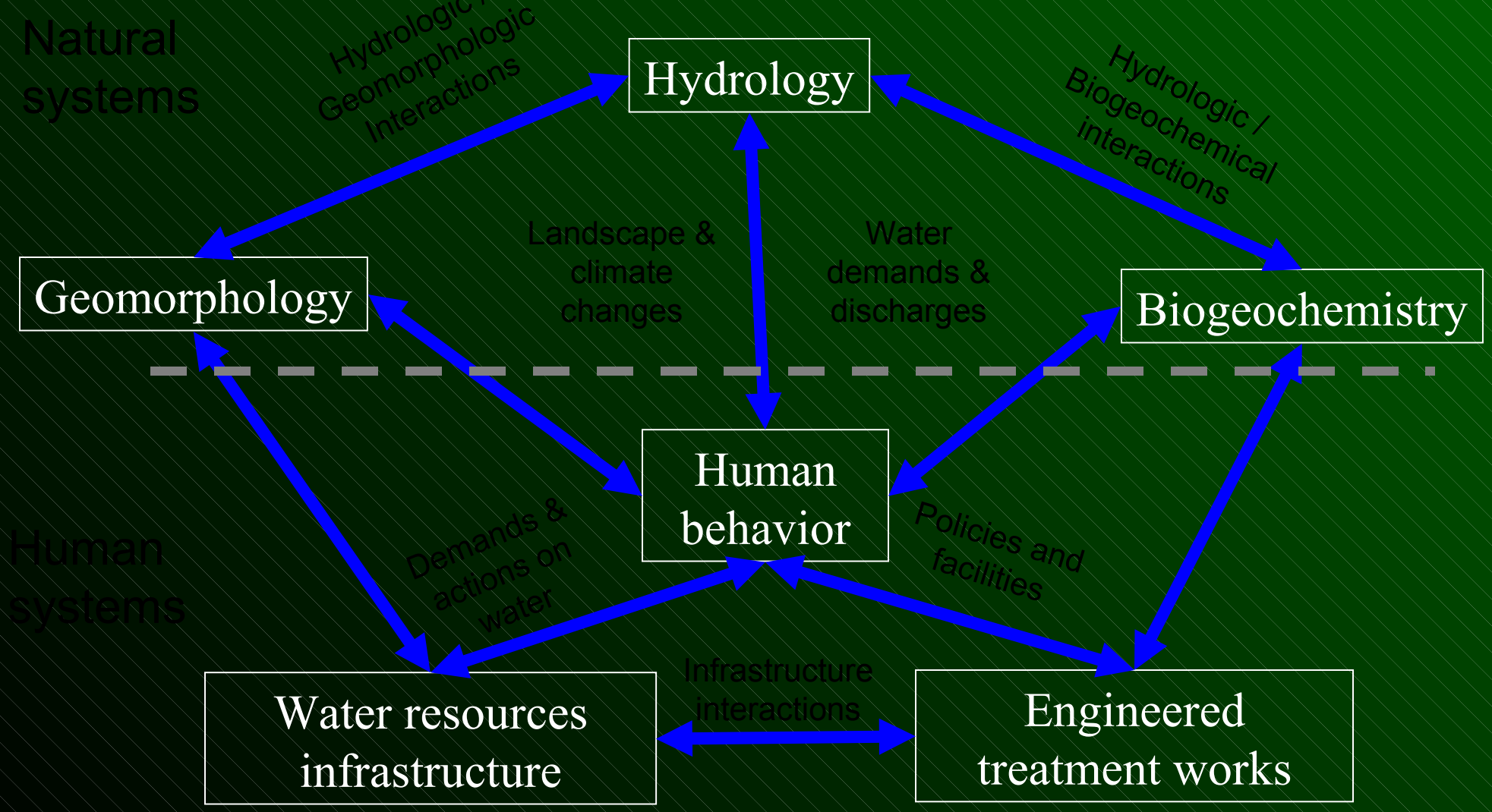
LTER Mini-symposium, Feb. 2008

Drivers and Responses

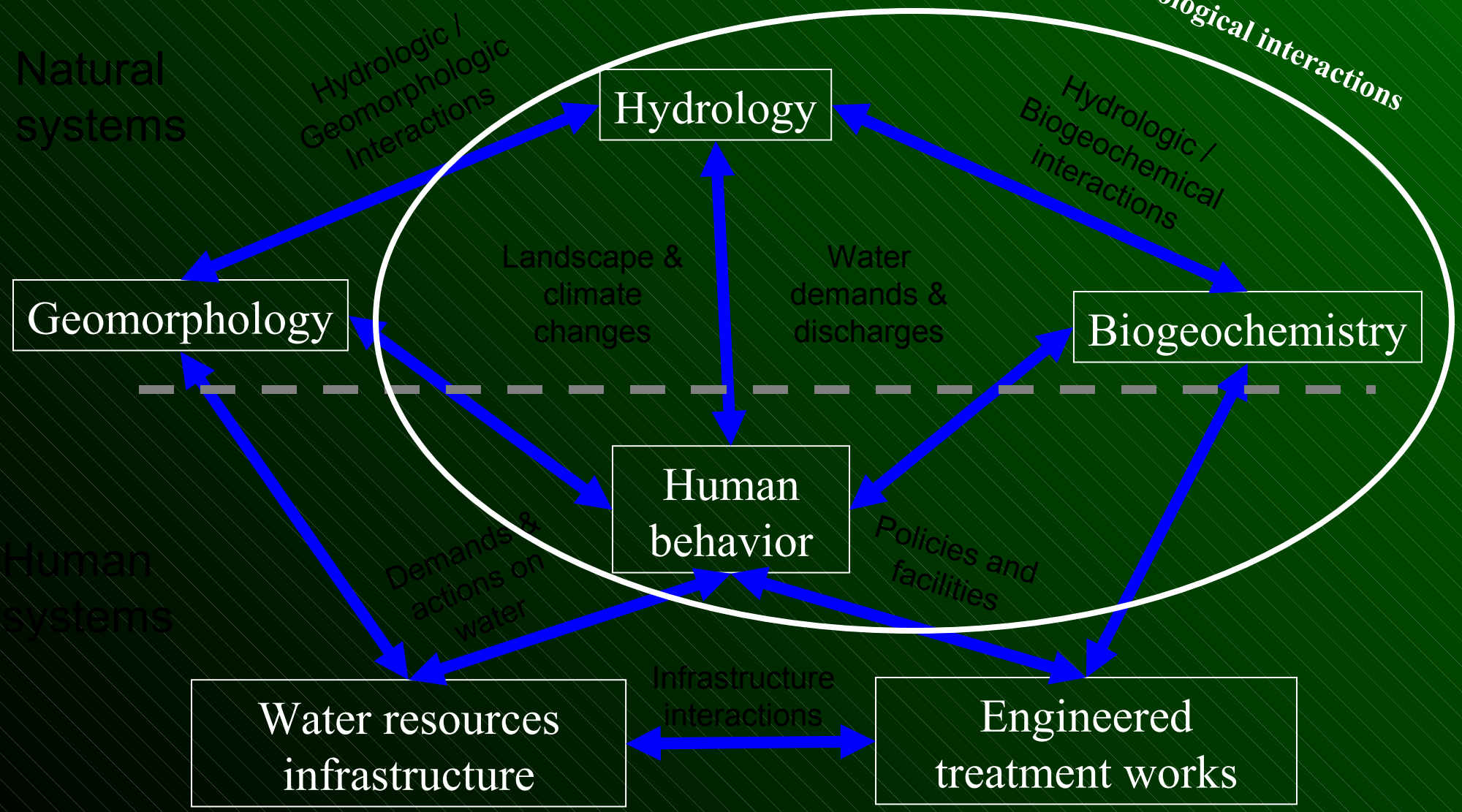


Social Framework

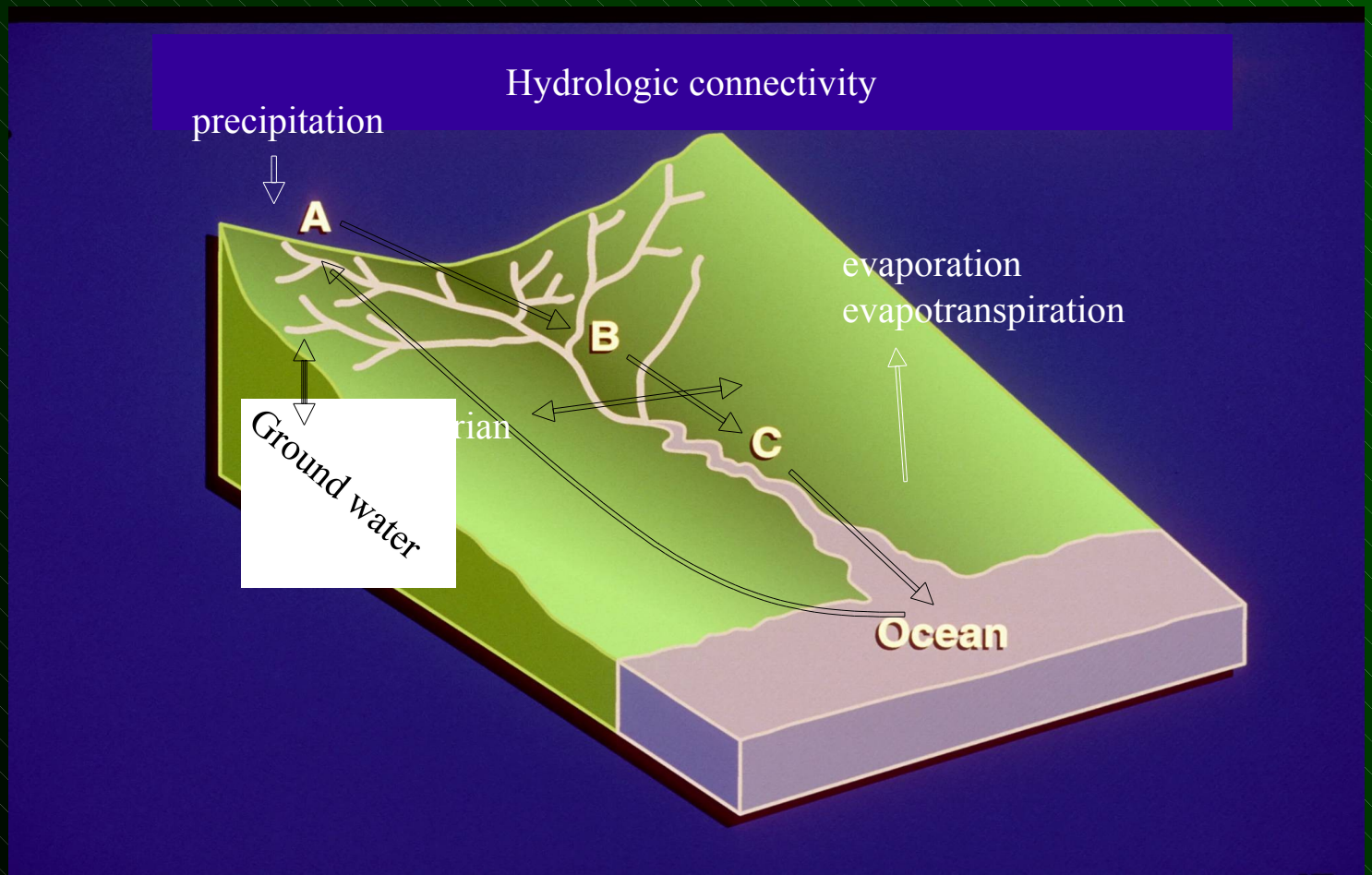
Water Systems Are Coupled Human and Natural Systems



Water Systems Are Coupled Human and Natural Systems



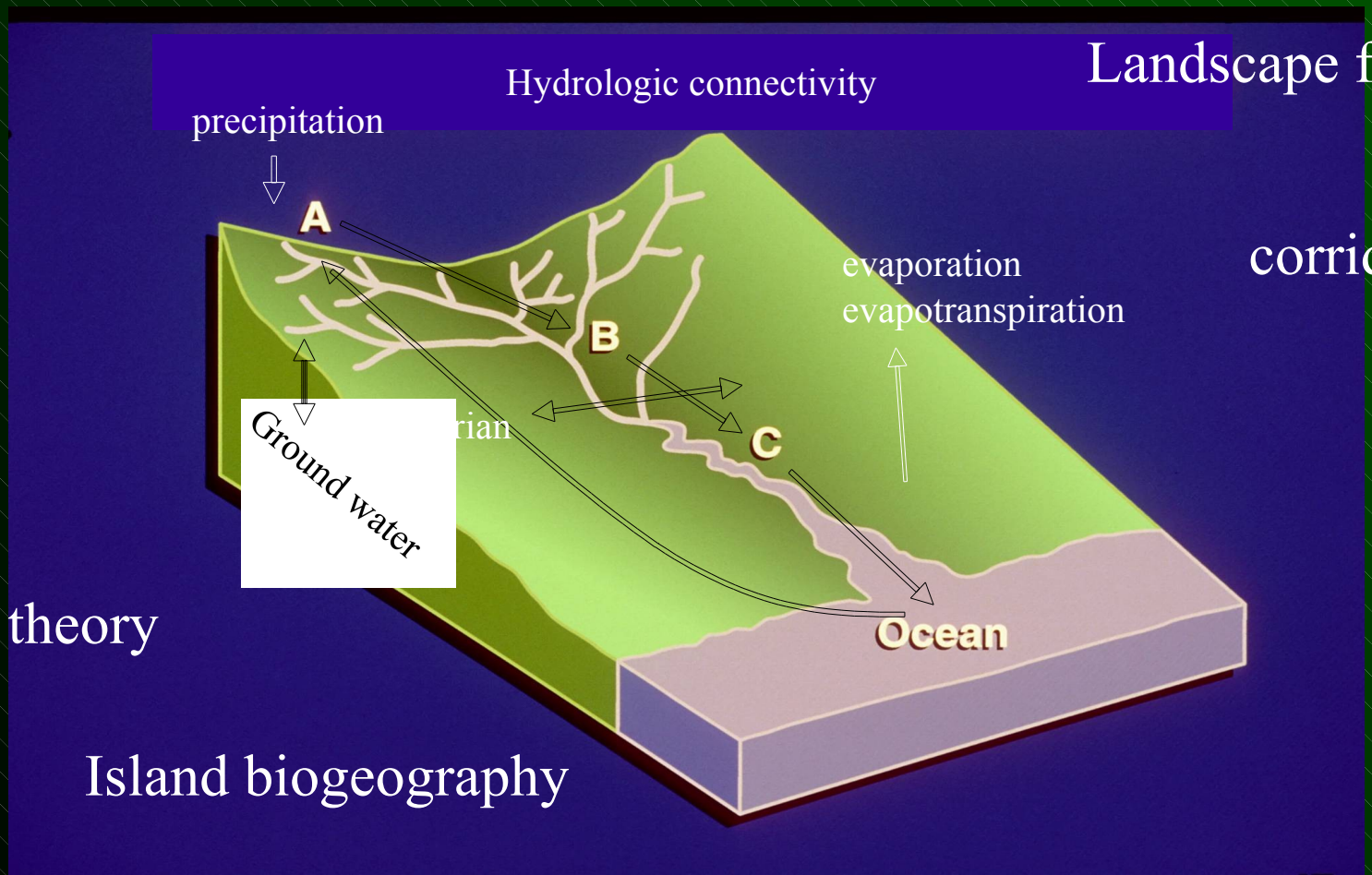
Hydrologic connectivity **-**
water mediated transport of matter, energy and organisms within or between elements of the hydrologic cycle…
including diffuse anthropogenic pathways



Hydrologic connectivity **-**
water mediated transport of matter, energy and organisms within or between elements of the hydrologic cycle…
including diffuse anthropogenic pathways

Metapopulation dynamics

Landscape fragmentation



corridors

Network theory

Island biogeography

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

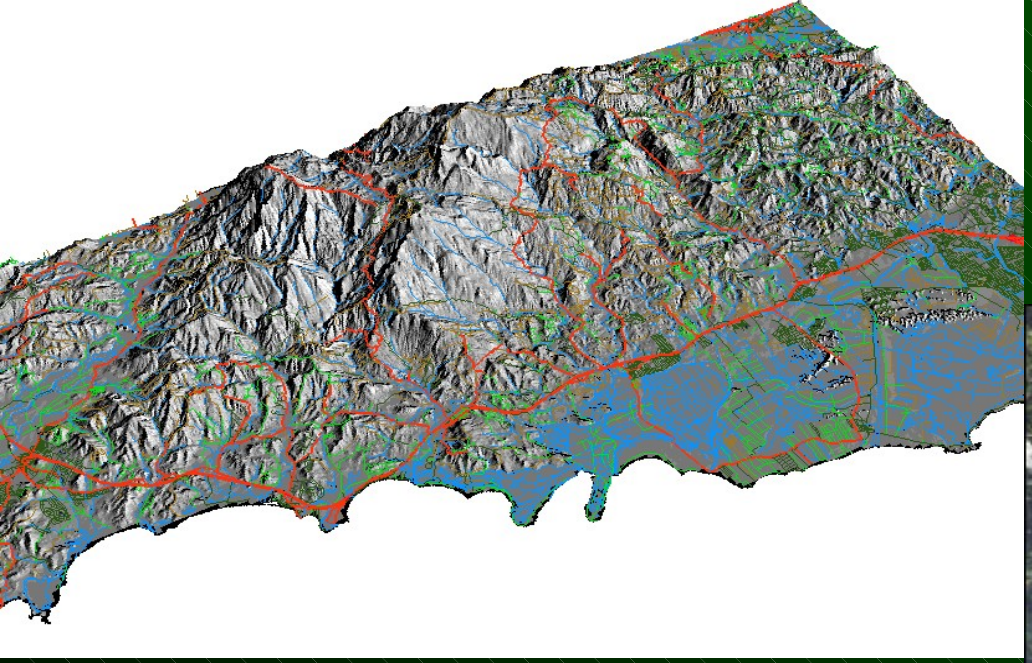
Alan Covich & Cathy Pringle - Univ. of Georgia
Bill McDowell - Univ. New Hampshire
Fred Scatena - Univ. Pennsylvania
Jean Lodge - International Institute of Tropical Forestry
John Loomis - Colorado State University
Armando Gonzalez-Caban - USDA Forest Service
Luis Santiago - Univ. Puerto Rico

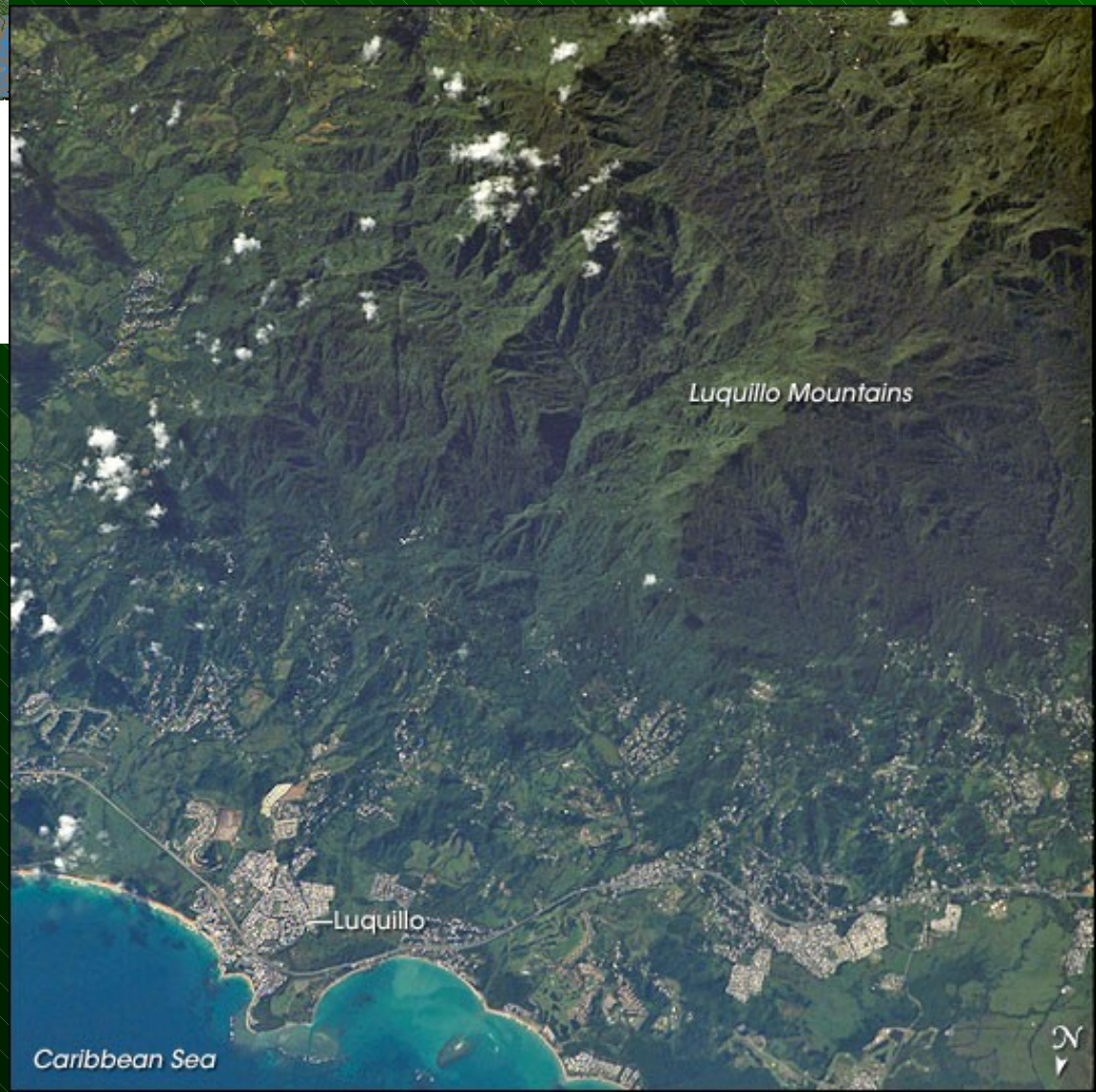
Juan Felipe Blanco Libreres - LTER post-doc

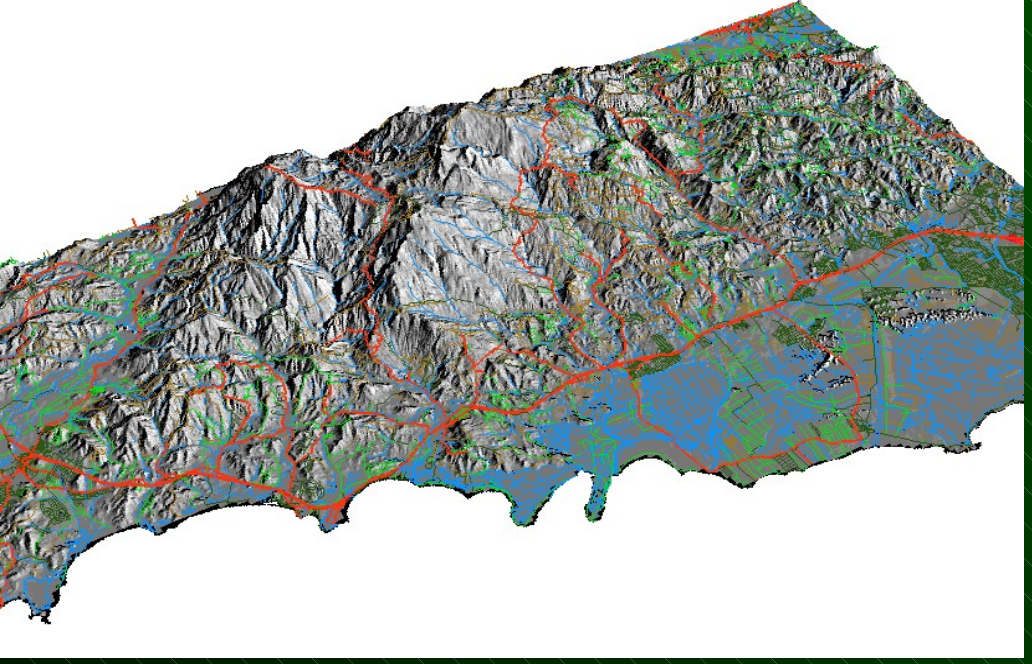
Effie Greathouse, Katie Hein, Tamara Heartsill-Scalley - LTER phd students

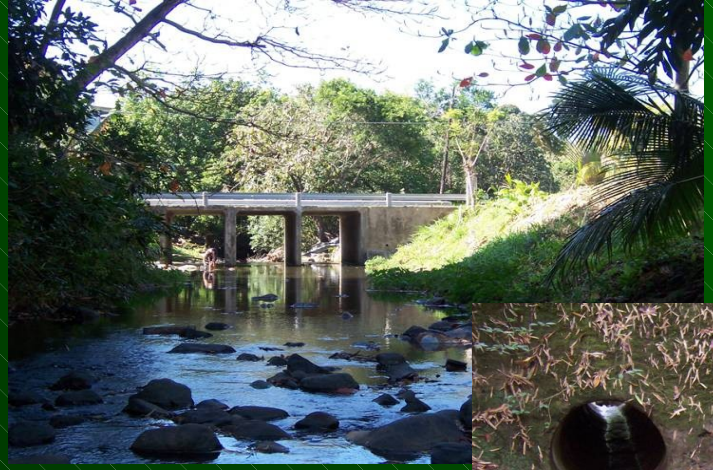
Kevin Landom, Summer Kartchner, Coralys Torres, Vanessa Welch, Alejandro Berbenos, Sara Redd & Valerie Schroepfer - LTER REU students


U.S.A.
GULF OF MEXICO
MIAMI
BAHAMAS
ATLANTIC OCEAN
CUBA
DOMINICAN REPUBLIC
CAYMAN ISLANDS
HAITI
PUERTO RICO
VIRGIN IS.
N
JAMAICA
CARIBBEAN SEA
LESSER ANTILLES
CARIBBEAN
Aruba
NETHER ANTILLES
SOUTH AMERICA
2001©DRpure.com



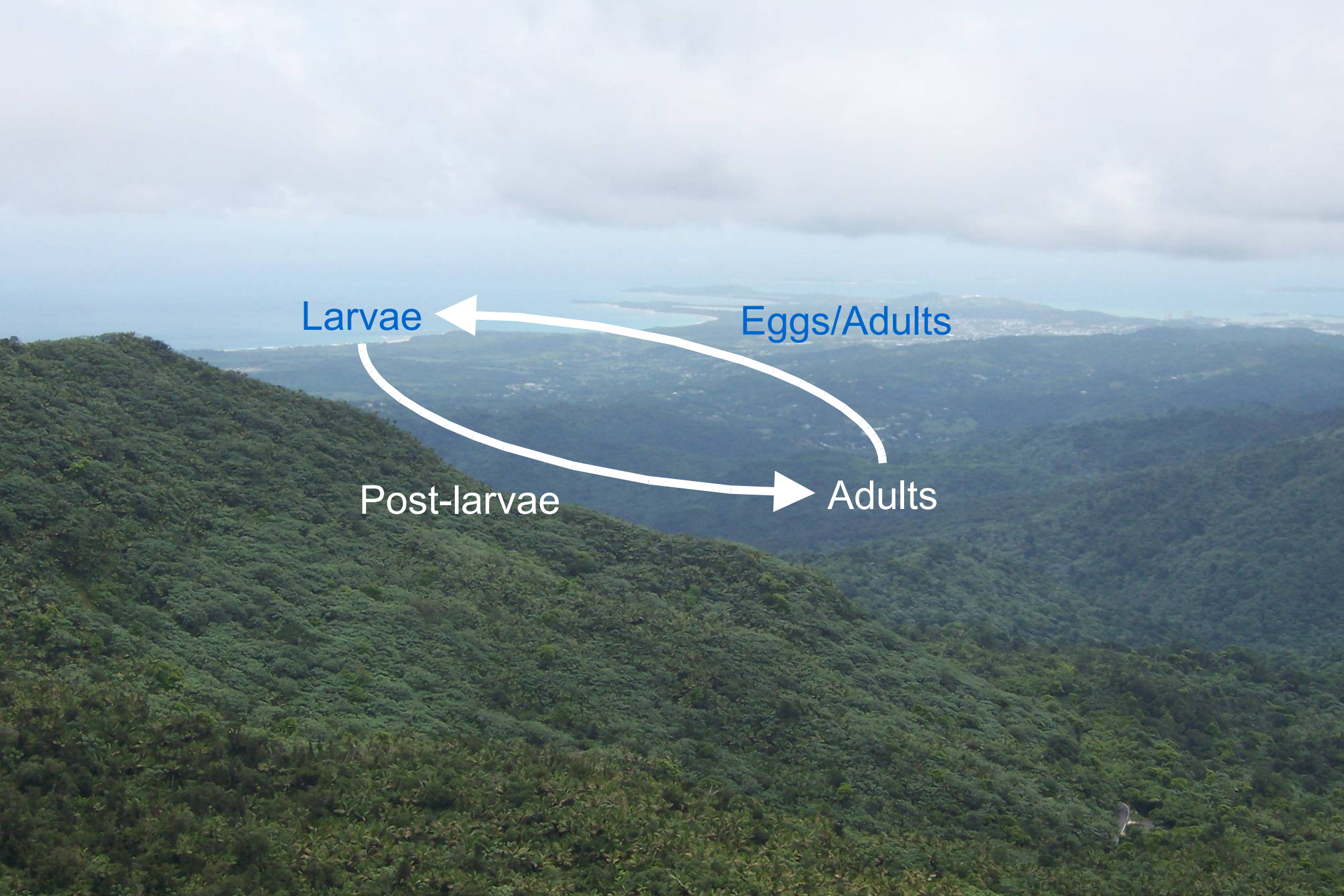

Luquillo Mountains
Luquillo
Caribbean Sea
N






AAA
RAW WATER PIT
2
RAW WATER PIT
1

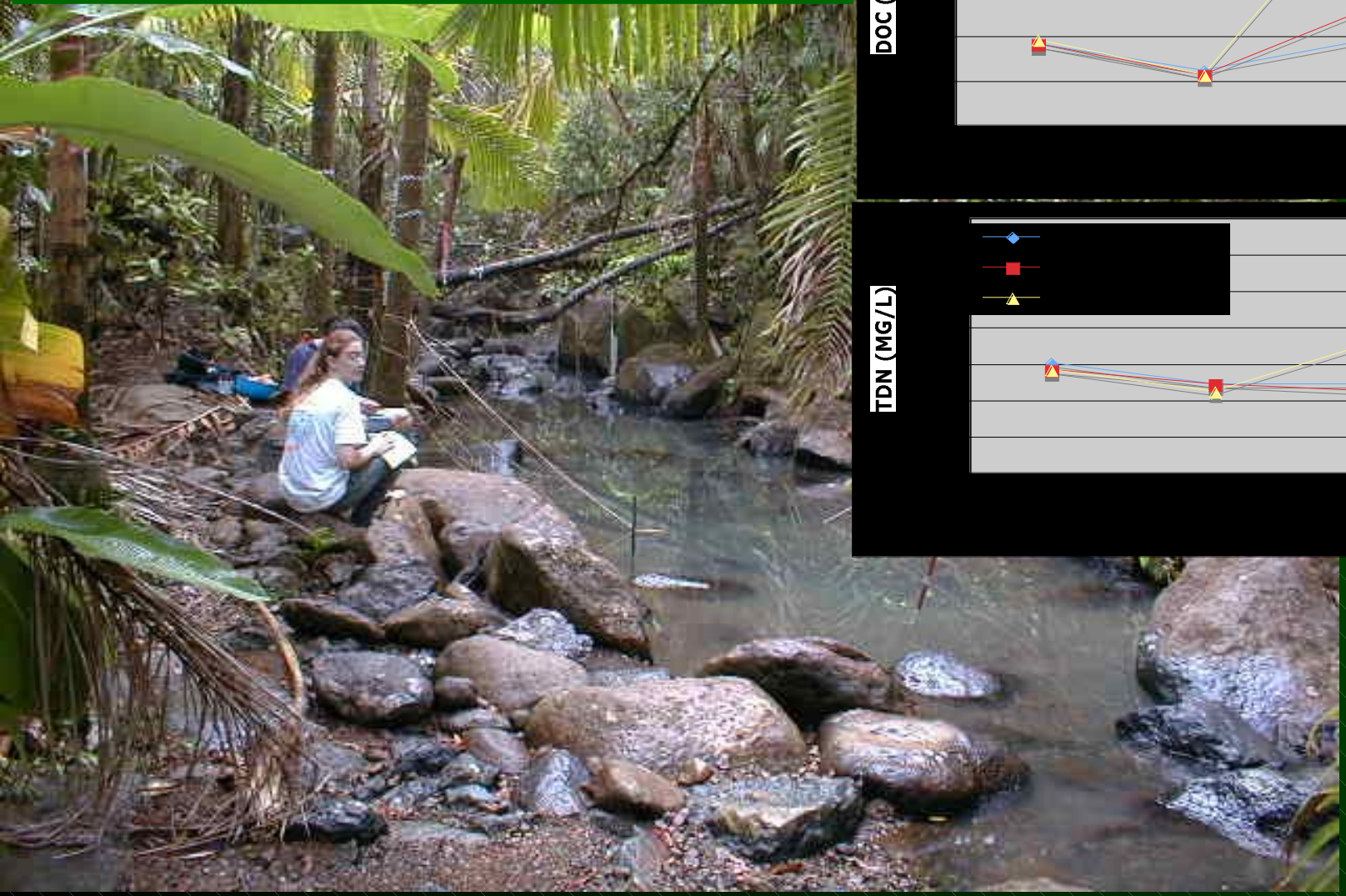

DIADROMOUS SPP

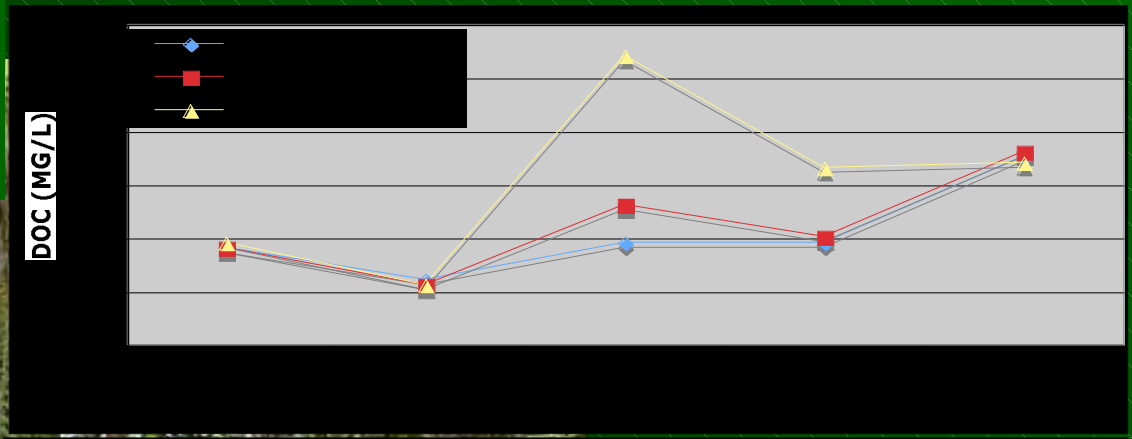

Larvae
Eggs/Adults
Post-larvae
Adults

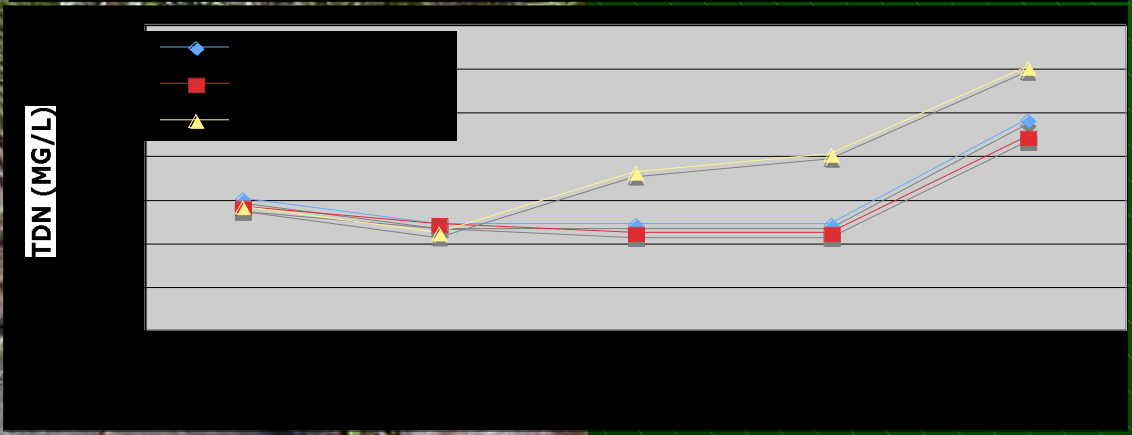

X


X

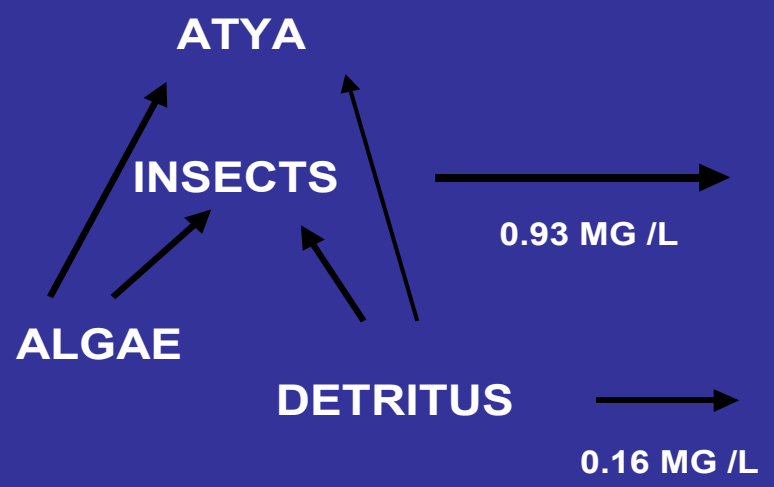
Shrimp processing results in significant increases
In DOC and Nitrogen availability; low diversity results in increased export

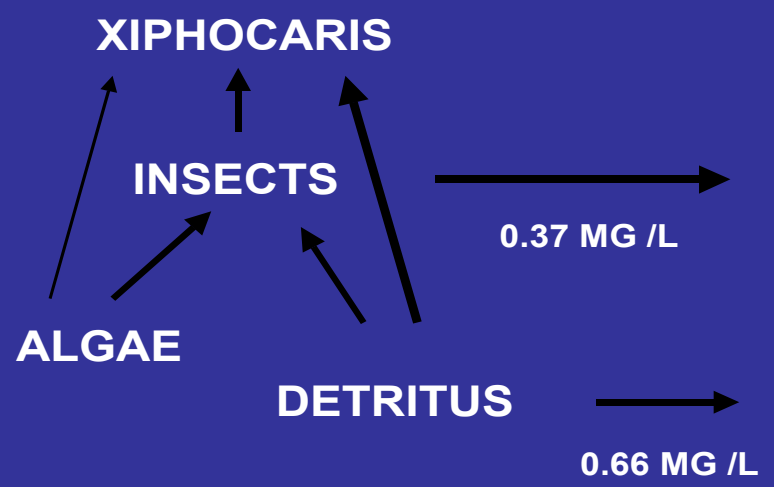


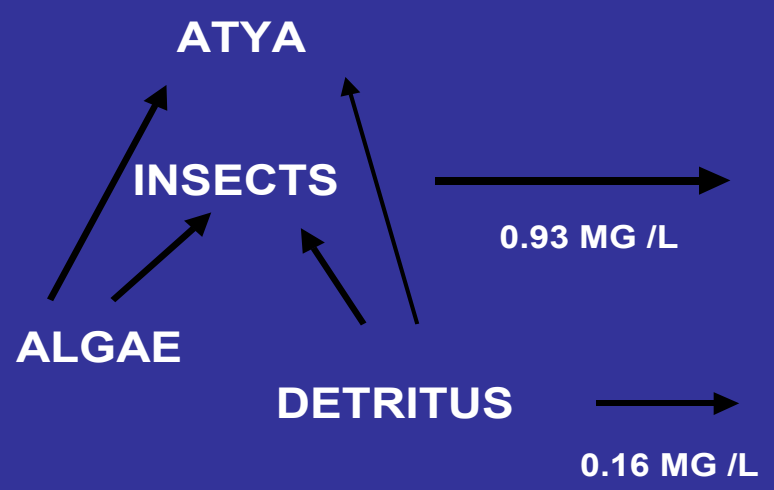


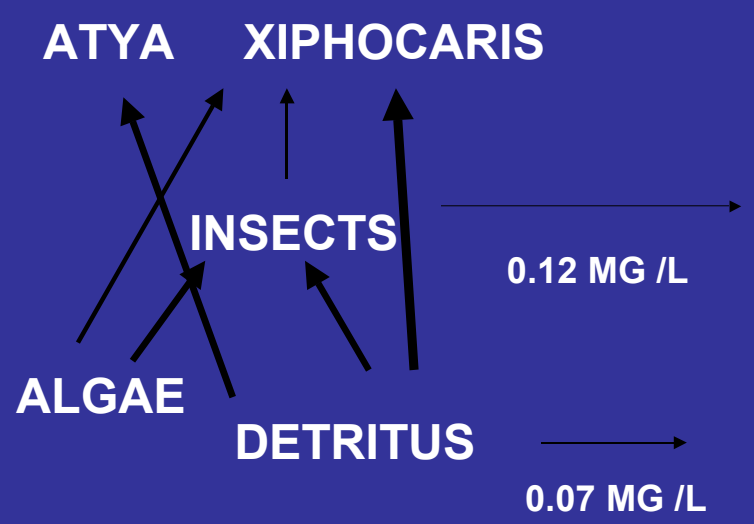


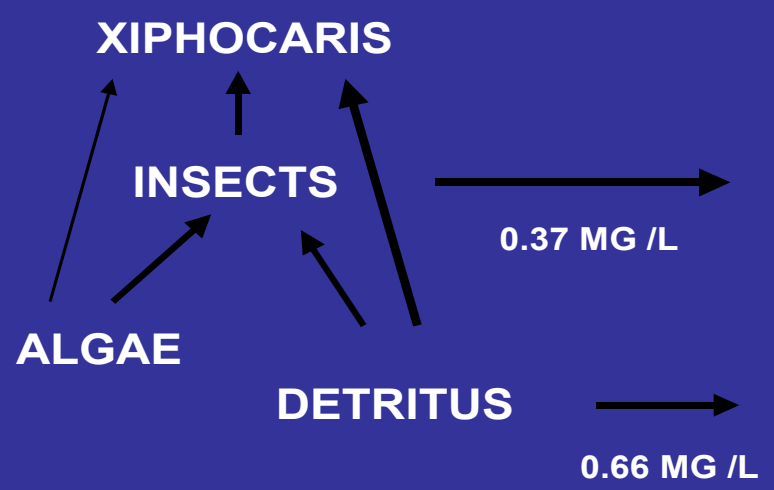
Crowl et al. Ecology 2001


ATYA
INSECTS
0.93 MG /L
ALGAE
DETRITUS
0.16 MG /L

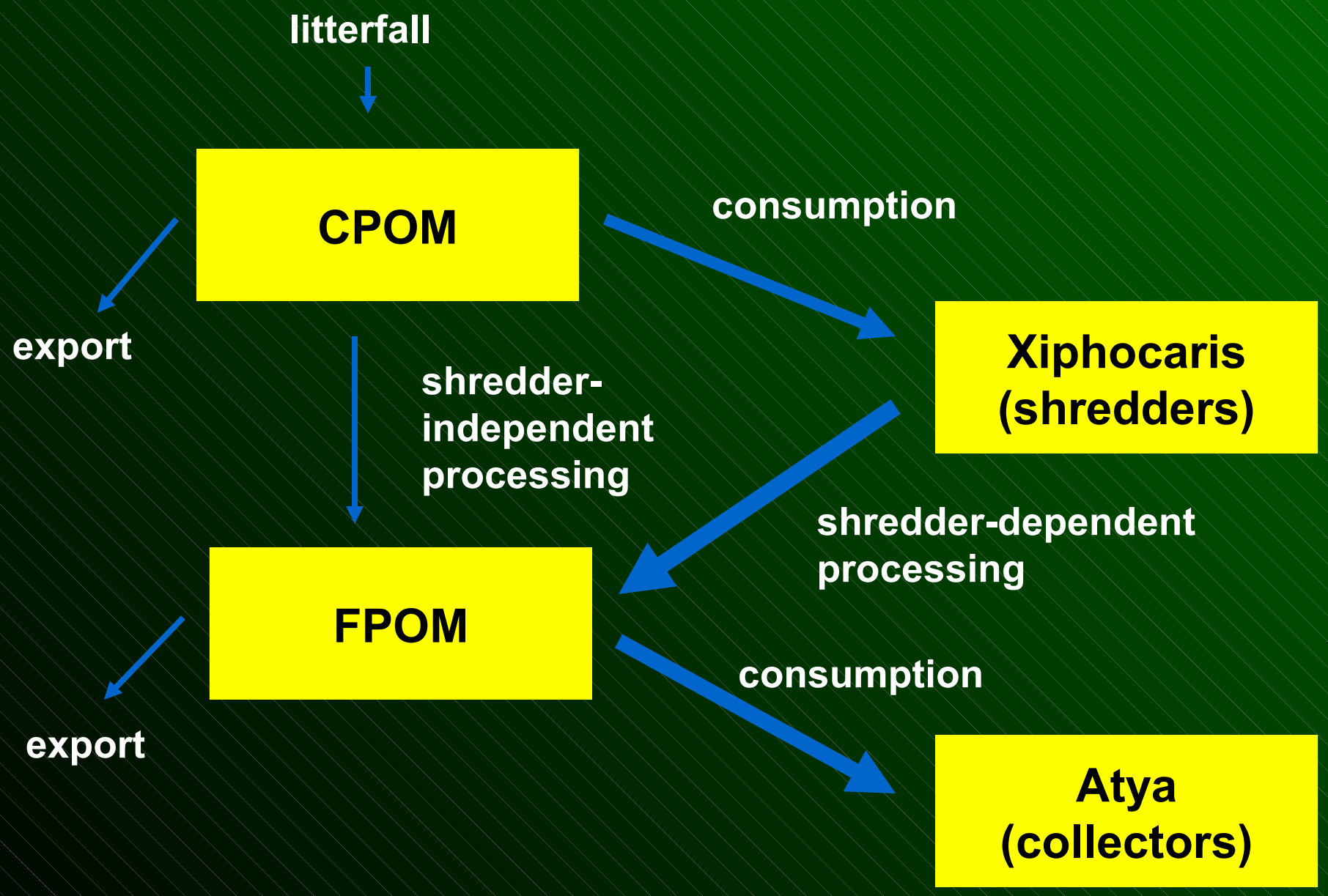

XIPHOCARIS
INSECTS
0.37 MG /L
ALGAE
DETRITUS
0.66 MG /L

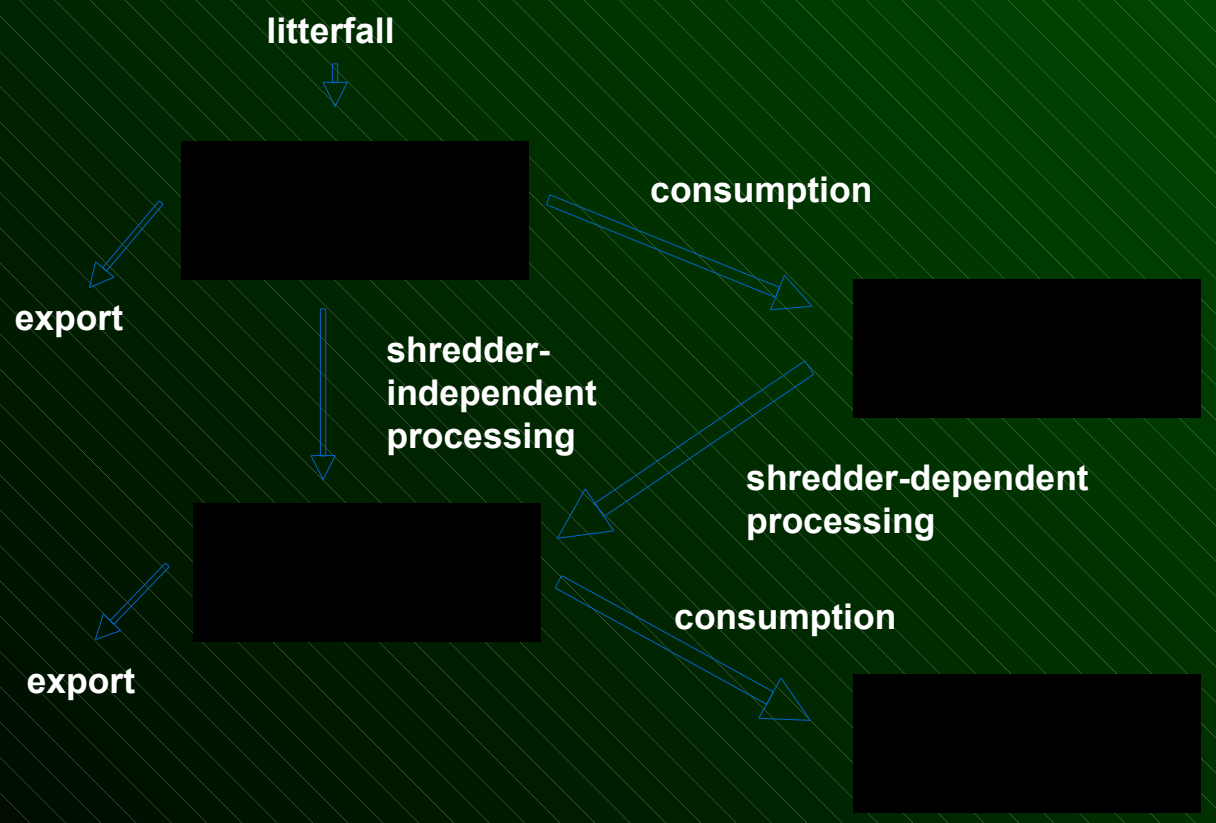






Crowl T.A. and A.P. Covich. 2007


litterfall
CPOM
consumption
export
Xiphocaris
(shredders)
shredder-
independent
processing
shredder-dependent
processing
FPOM
consumption
export
Atya
(collectors)



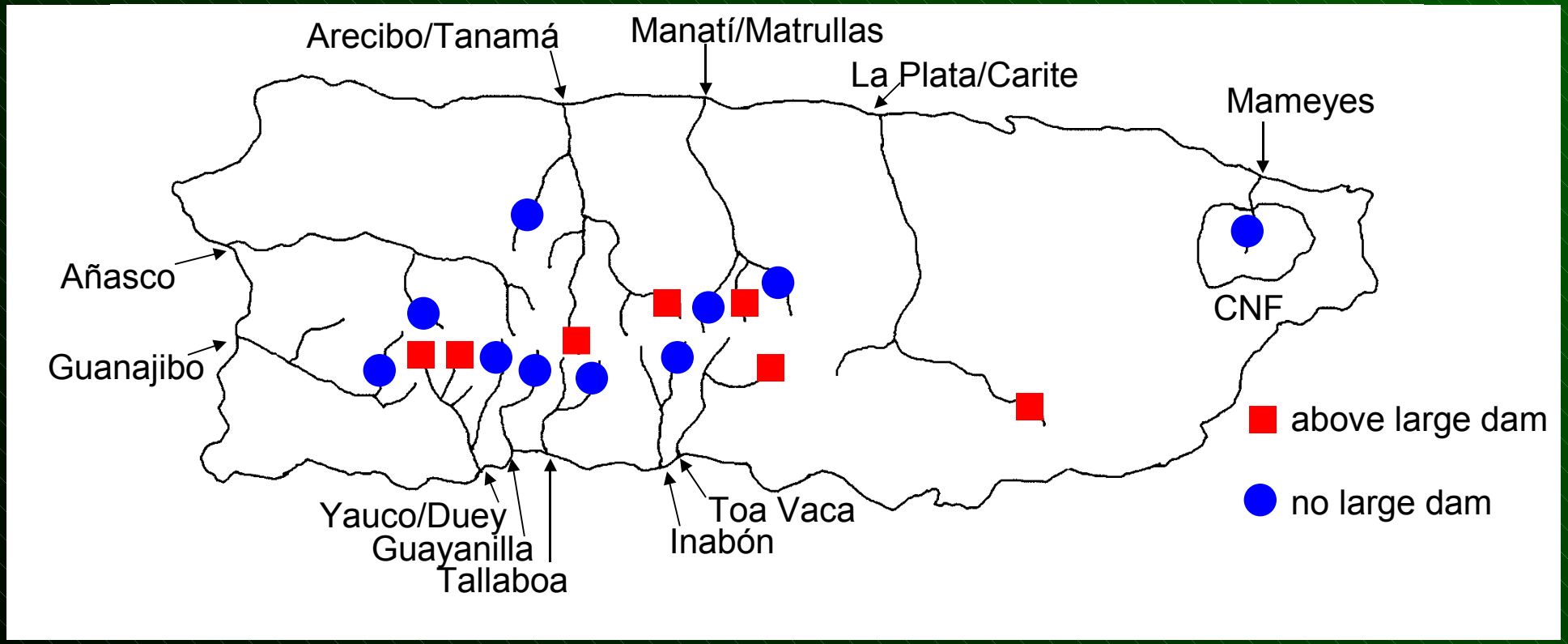
High diversity - complex processing Chains:

Efficient transformation and utilization of carbon particles

Cycle of N, P and DOC

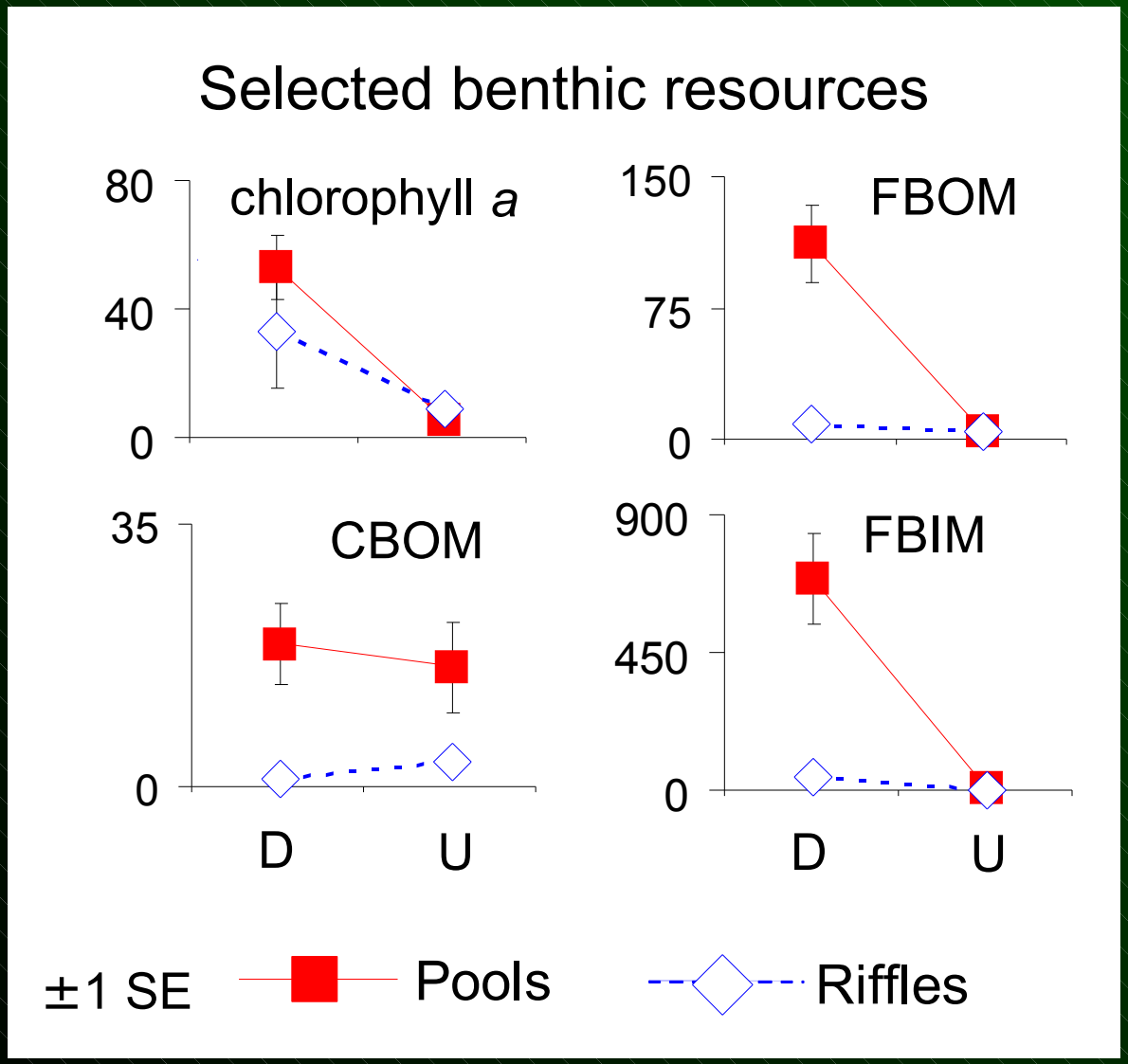
Retention of nutrients and energy for maximum *in situ* production

Natural experiment: Large-scale declines above dams



Greathouse et al. 2006a, Ecological Applications
Greathouse et al. 2006b, Oecologia

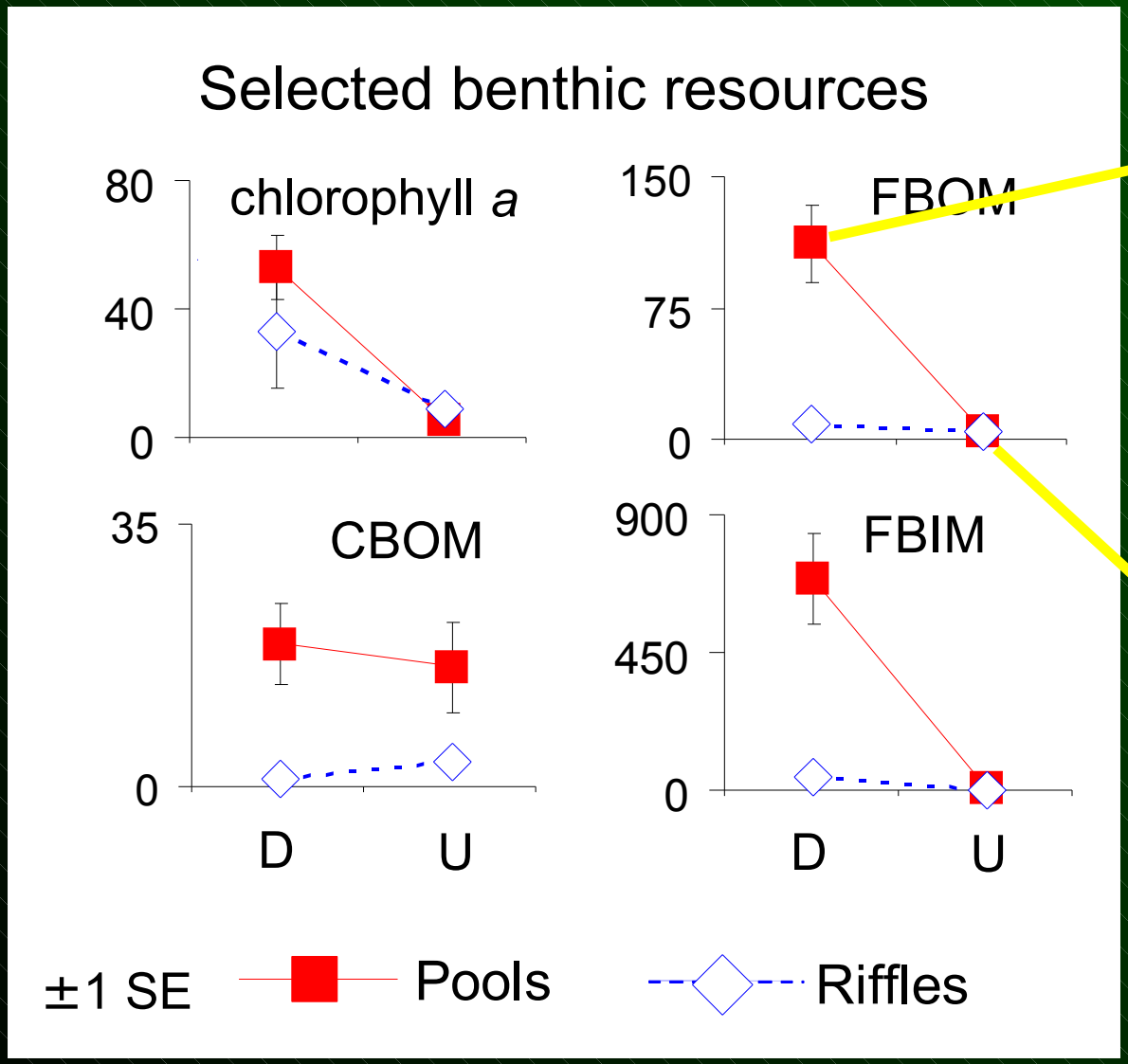
High-gradient sites



D = dammed, U = undammed

Greathouse et al. 2006a, Ecological Applications
Greathouse et al. 2006b, Oecologia

High-gradient sites



D = dammed, U = undammed

Greathouse et al. 2006a, Ecological Applications
Greathouse et al. 2006b, Oecologia

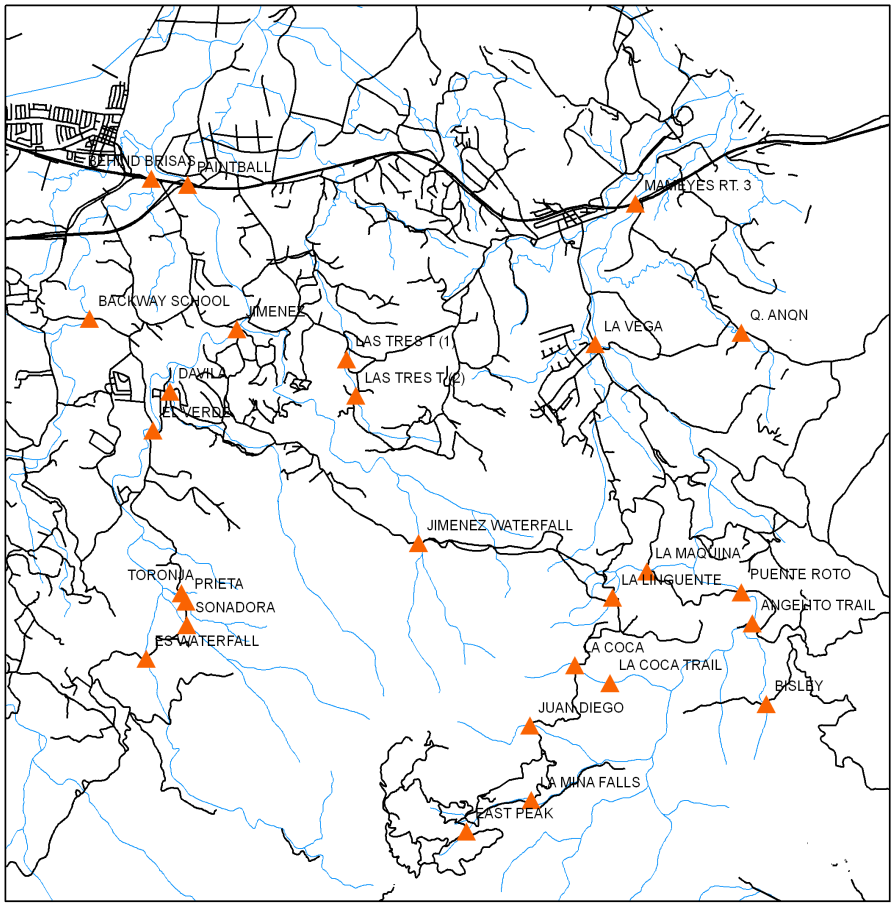
Results

Above large dam

	Before Adding Shrimp	After Adding Shrimp
Toa Vaca	day 0 	day 9 
Arecibo	day 0 	day 7 

Greathouse et al. 2006b, Oecologia

Lugares de Entrevista en los Ríos Espíritu Santo y Mameyes en Río Grande. Puerto Rico.

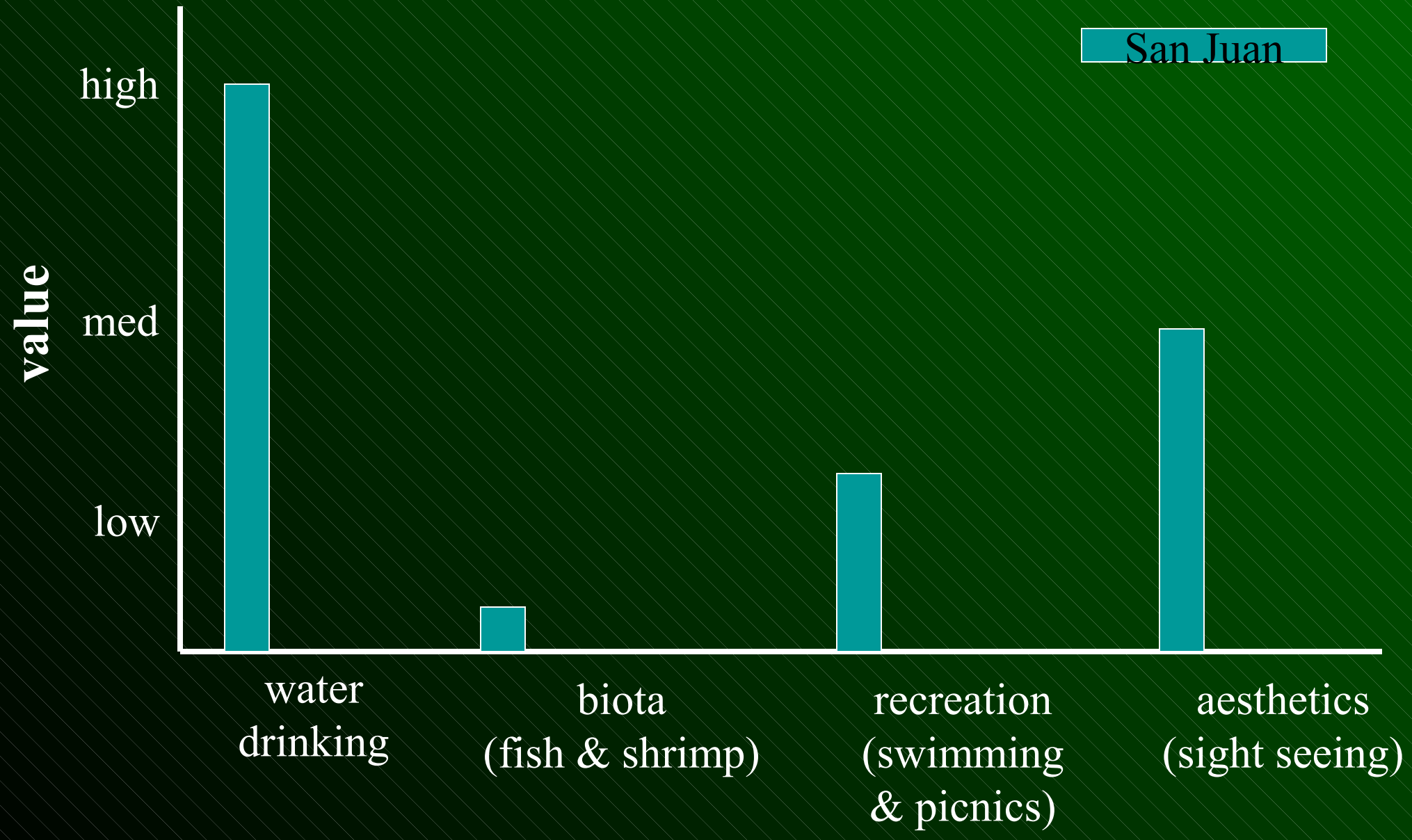


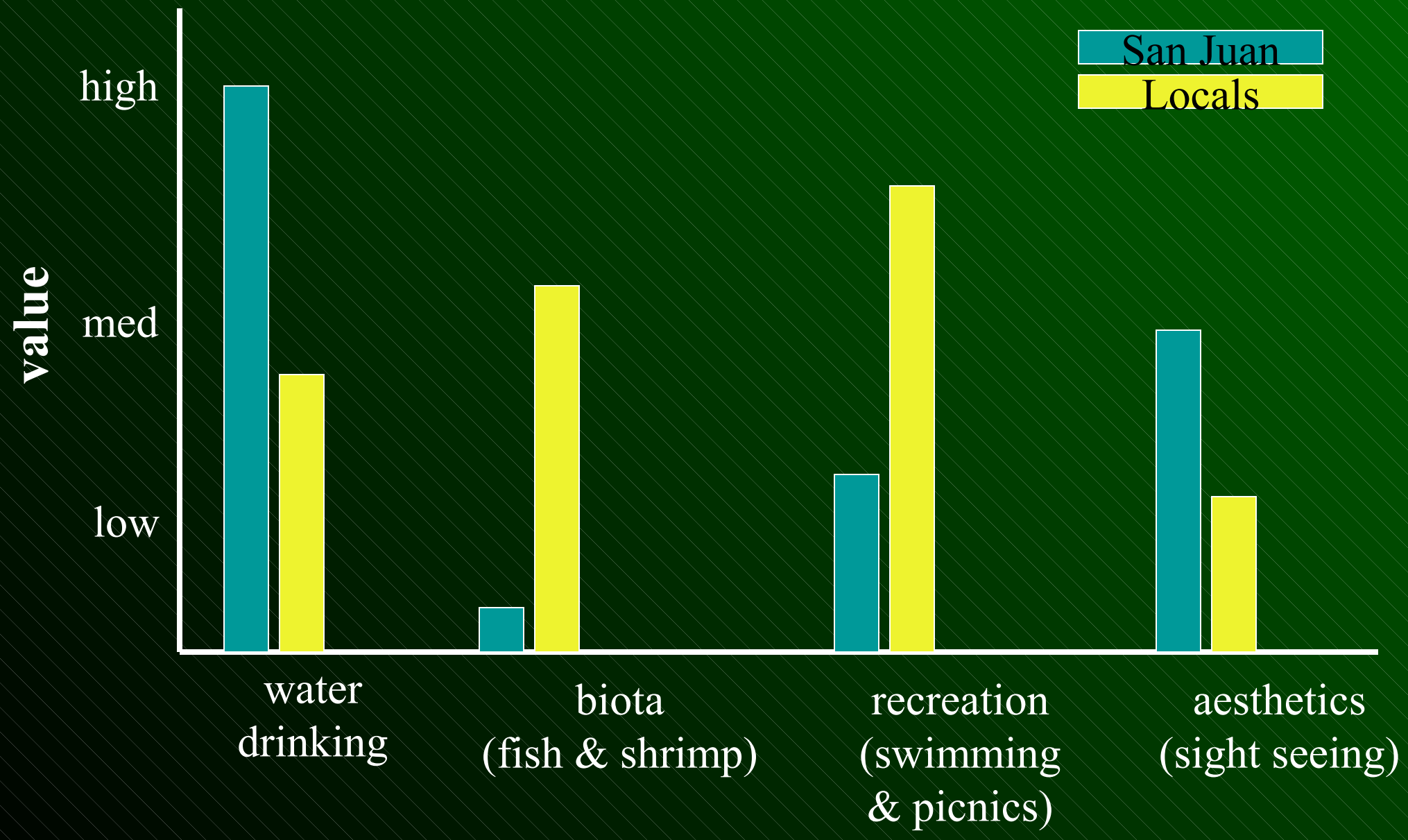
Leyenda

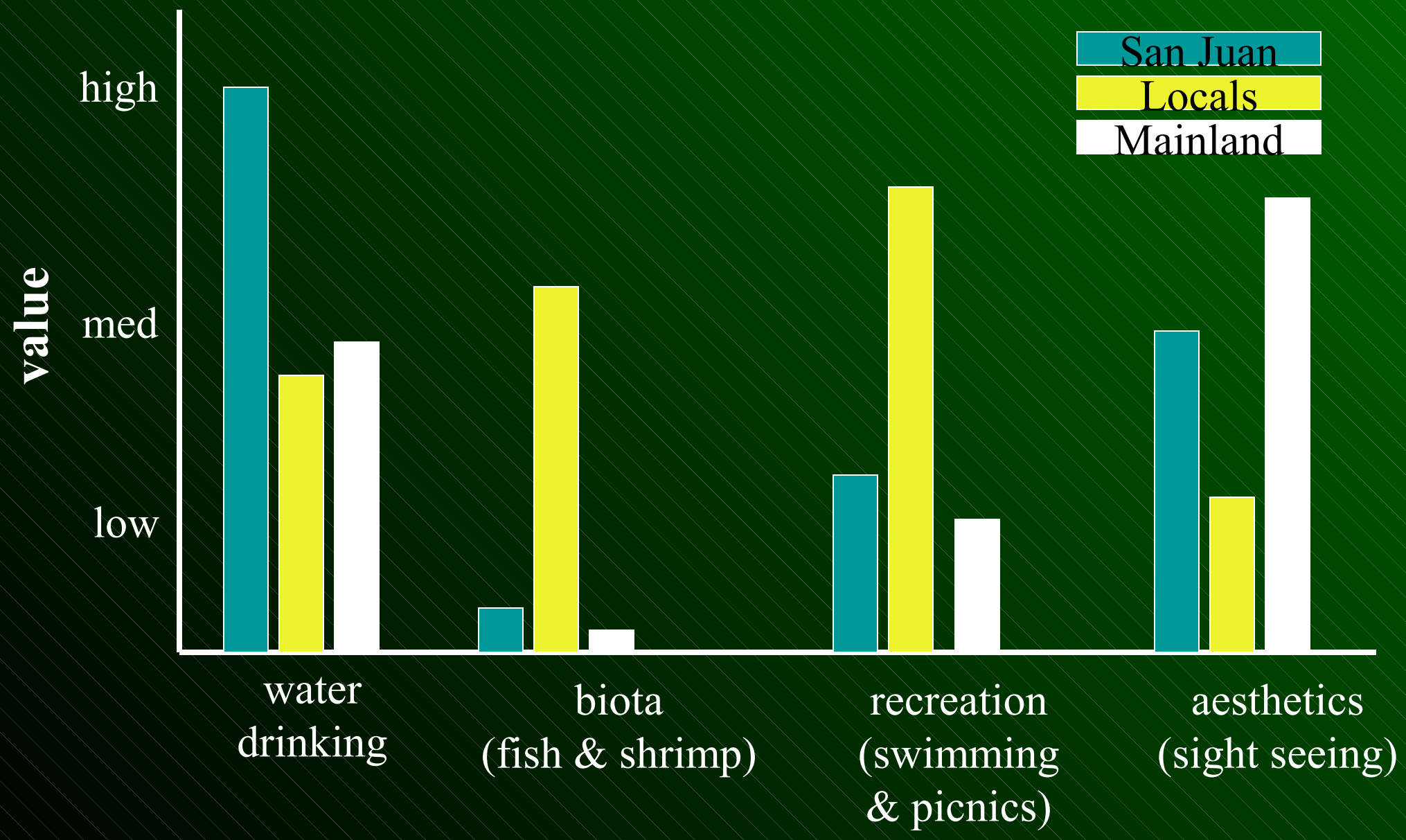
- study_sites_2005
- roads_stdy
- stdystrm

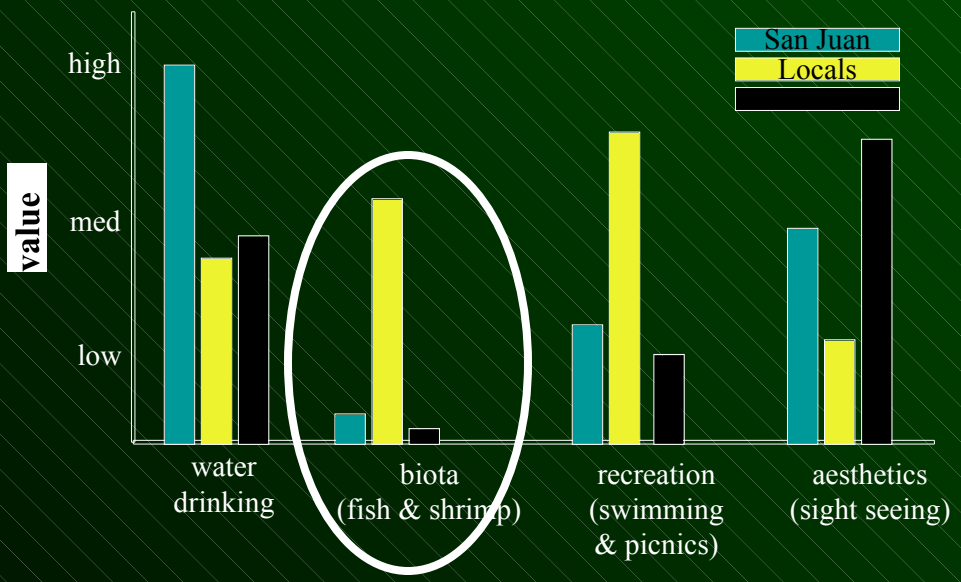
NOT TO SCALE

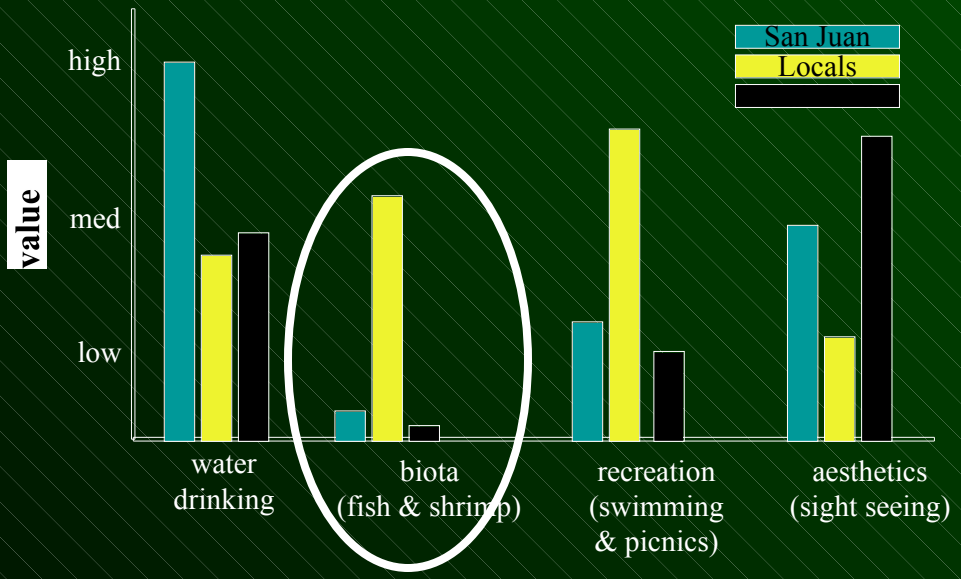
0 1,300 2,600 5,200 Meters

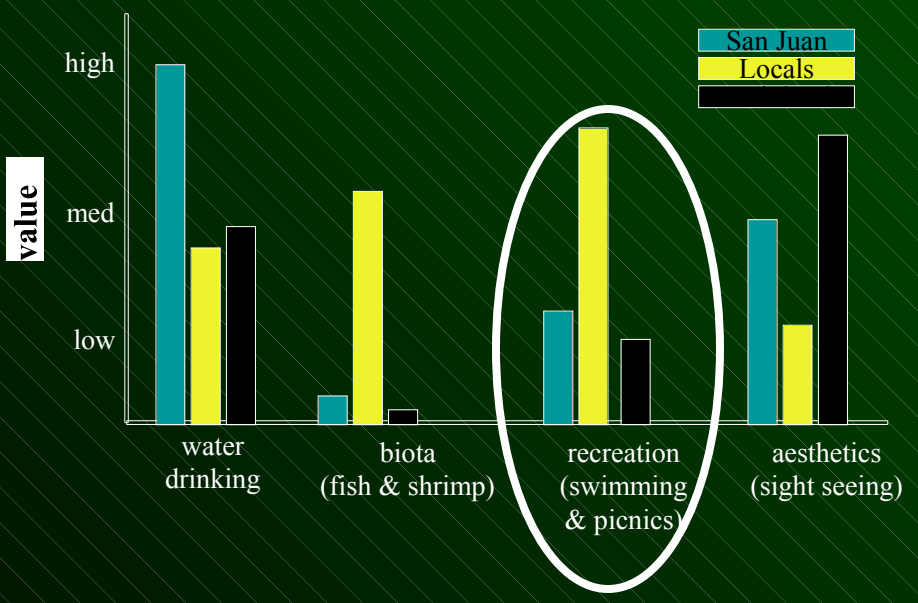

San Juan
value
high
med
low
water drinking
biota (fish & shrimp)
recreation (swimming & picnics)
aesthetics (sight seeing)

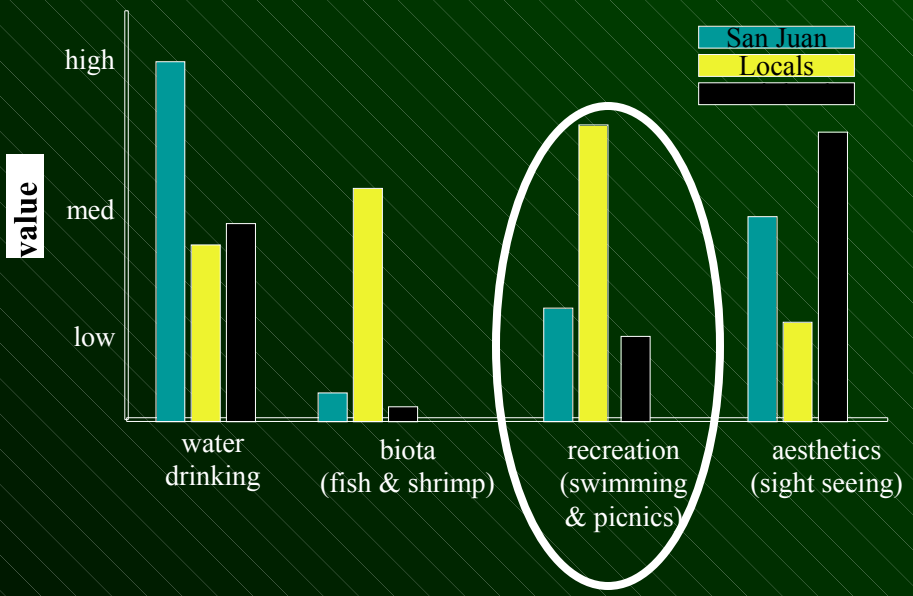

San Juan
Locals
value
high
med
low
water drinking
biota (fish & shrimp)
recreation (swimming & picnics)
aesthetics (sight seeing)


San Juan
Locals
Mainland
value
high
med
low
water drinking
biota (fish & shrimp)
recreation (swimming & picnics)
aesthetics (sight seeing)


San Juan
Locals
value
high
med
low
water drinking
biota (fish & shrimp)
recreation (swimming & picnics)
aesthetics (sight seeing)


San Juan
Locals
value
high
med
low
water drinking
biota (fish & shrimp)
recreation (swimming & picnics)
aesthetics (sight seeing)


San Juan
Locals
value
high
med
low
water drinking
biota (fish & shrimp)
recreation (swimming & picnics)
aesthetics (sight seeing)


San Juan
Locals
value
high
med
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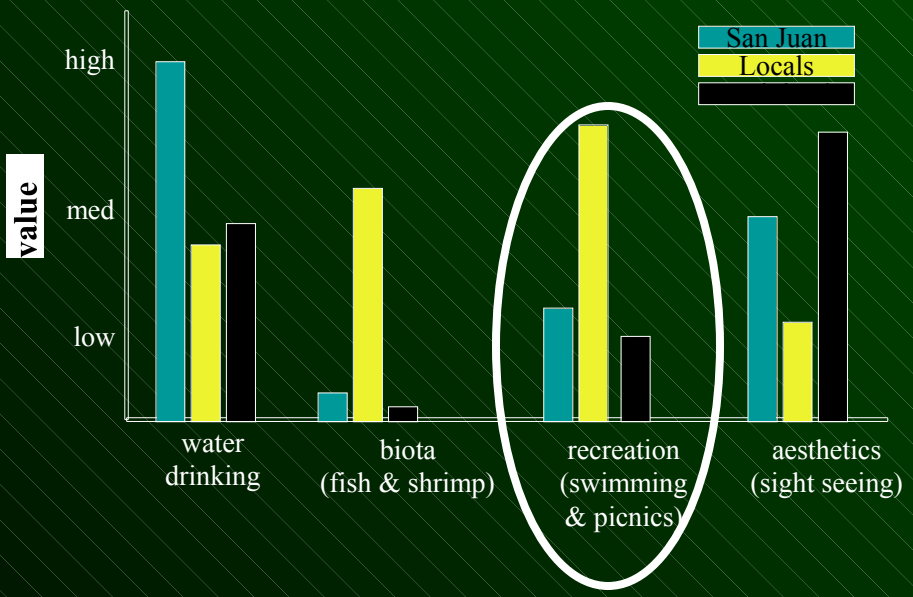
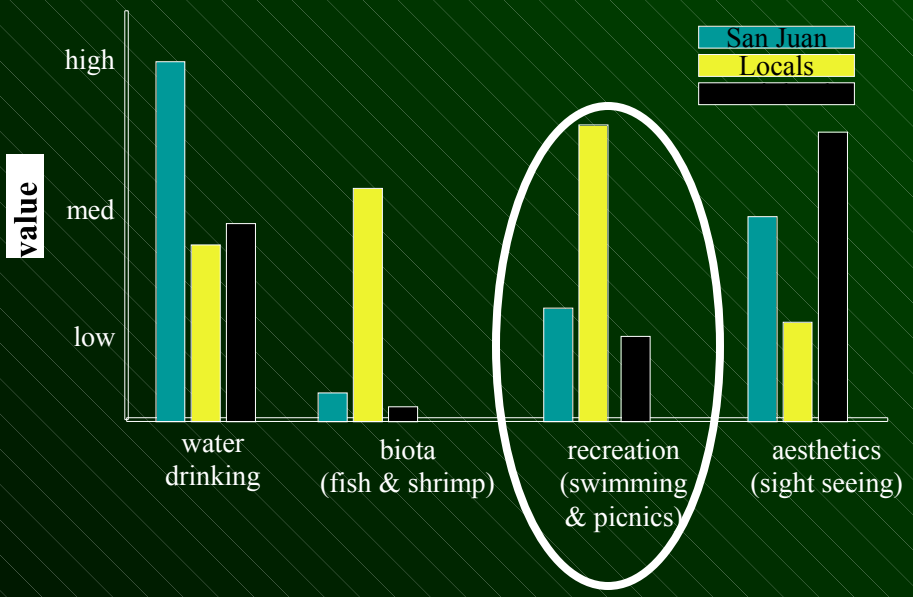


+ waterfalls
+ pool area
+ pool depth
- sediments
- discharge



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

+ parking space
- distance from roads

Scatena et al. in review

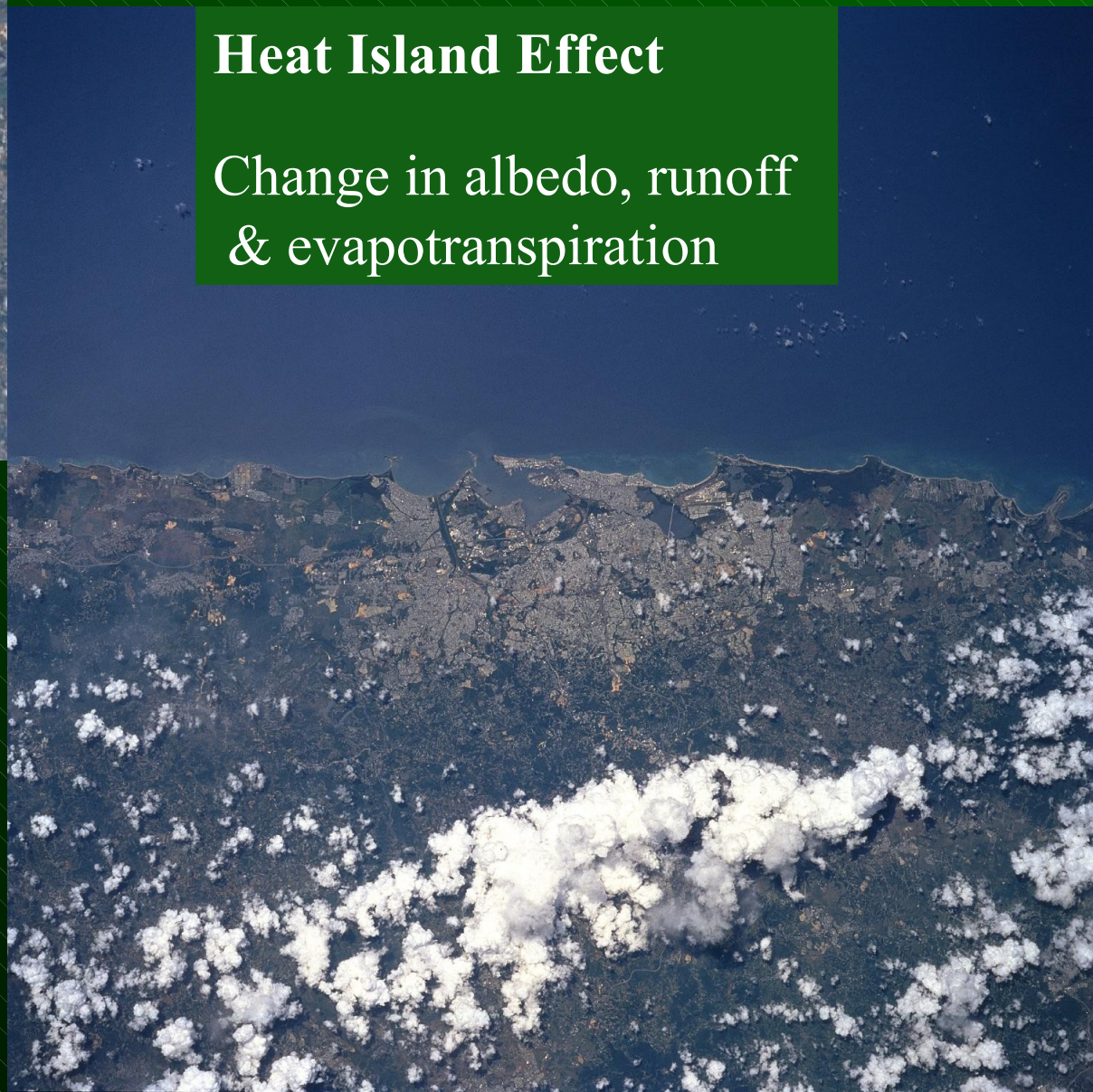
San Juan (and other urbanizations)
Effects?

Heat Island Effect

Change in albedo, runoff
& evapotranspiration

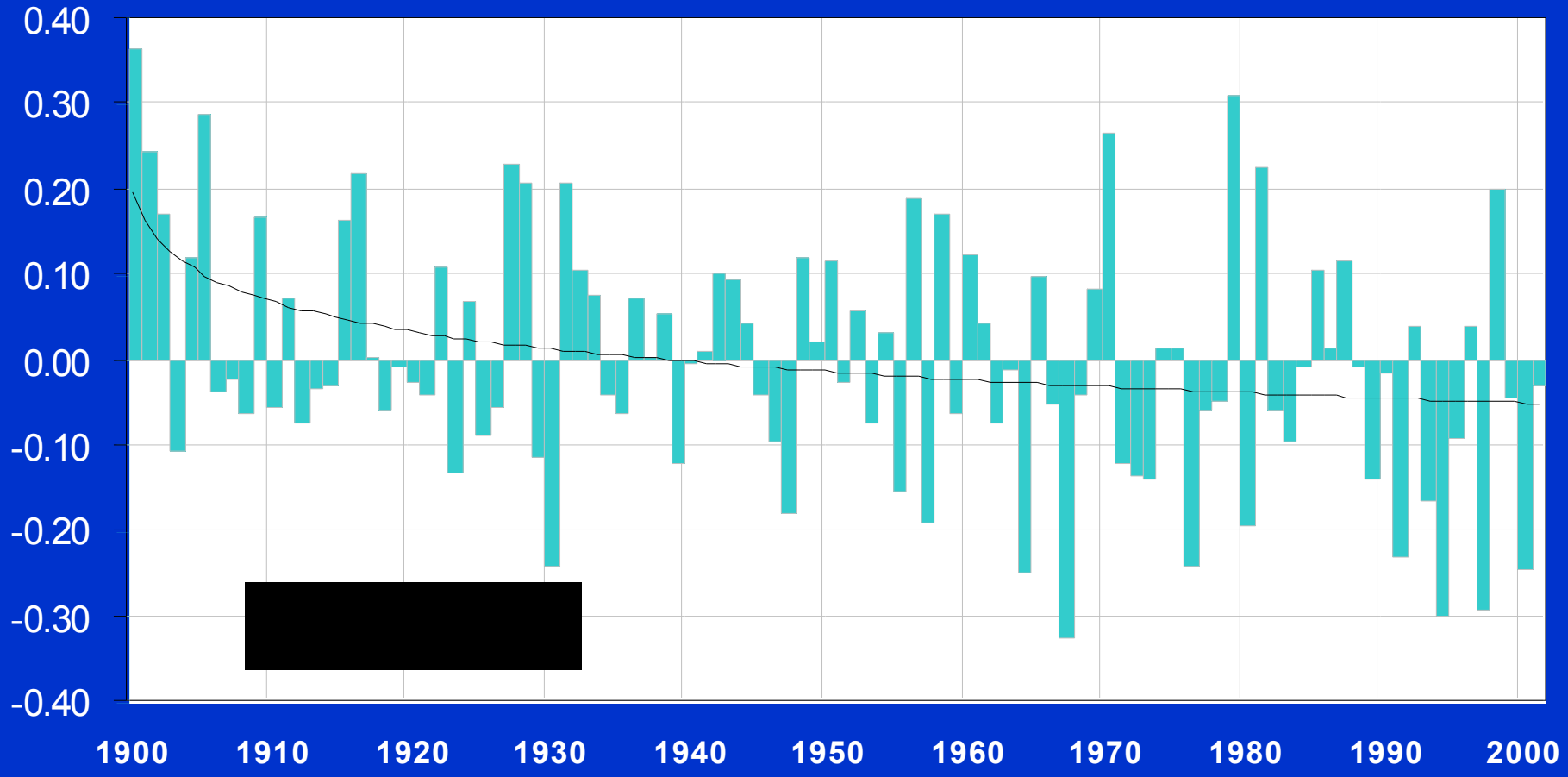
Heat Island Effect

Change in albedo, runoff & evapotranspiration



Puerto Rican 100 Year Annual Departure from Mean Rainfall 10 stations

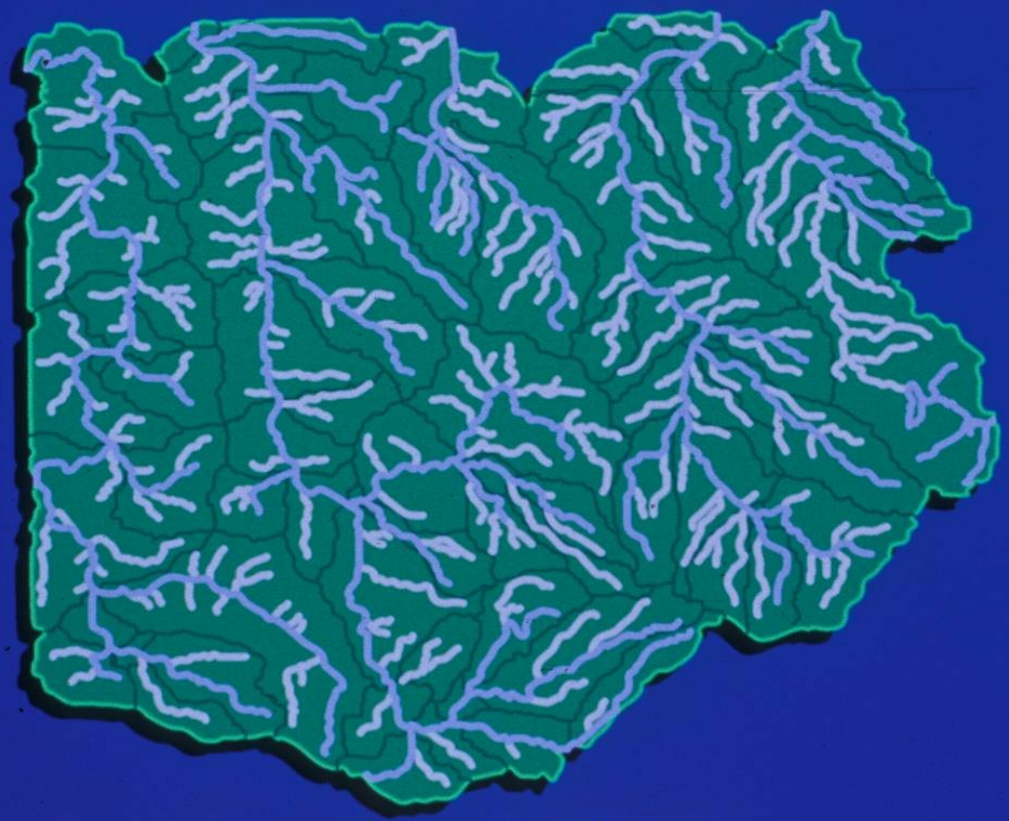
- Orographic effects of urbanizations



Heartsill-Scalley et al. 2007

Model Stream Flow: Luquillo Experimental Forest

High Rainfall Network (100 cell threshold)

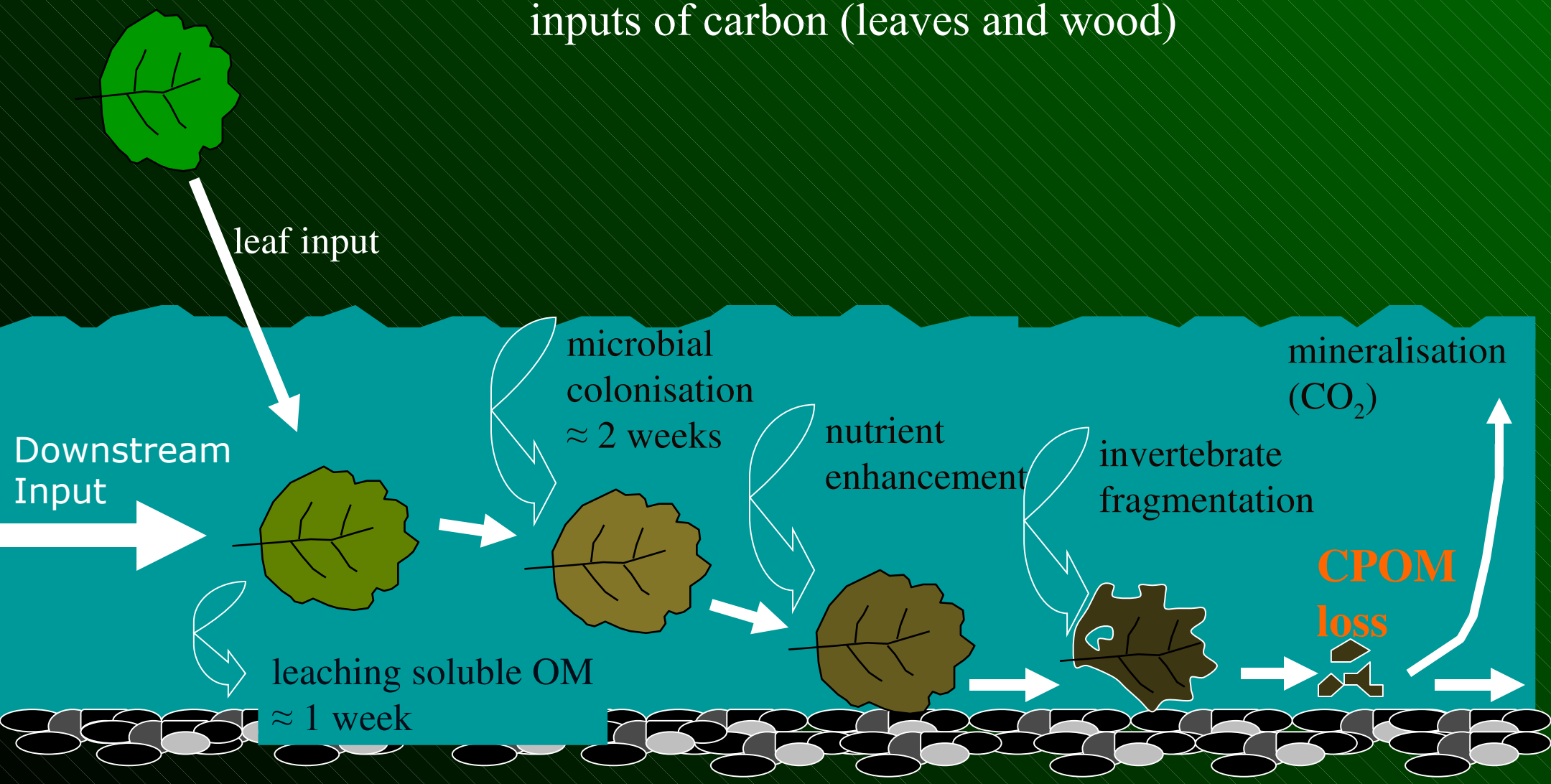


Low Rainfall Network (1000 cell threshold)

2 0 2 4 Kilometers

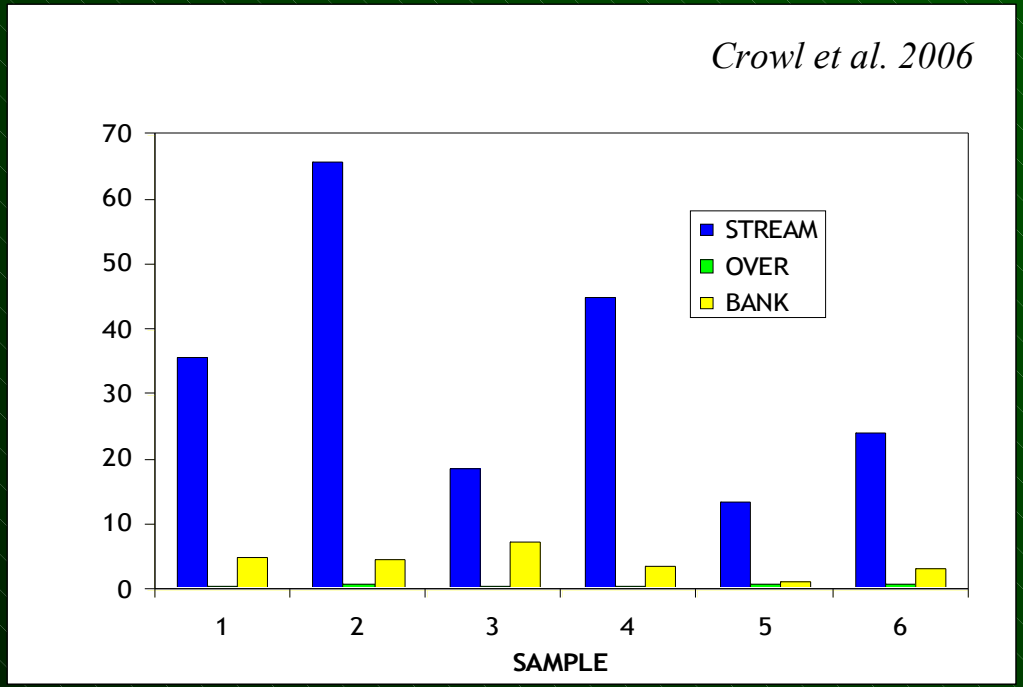
Network Structure Reflects Rainfall

Stream ecosystems are largely driven by autochthonous inputs of carbon (leaves and wood)



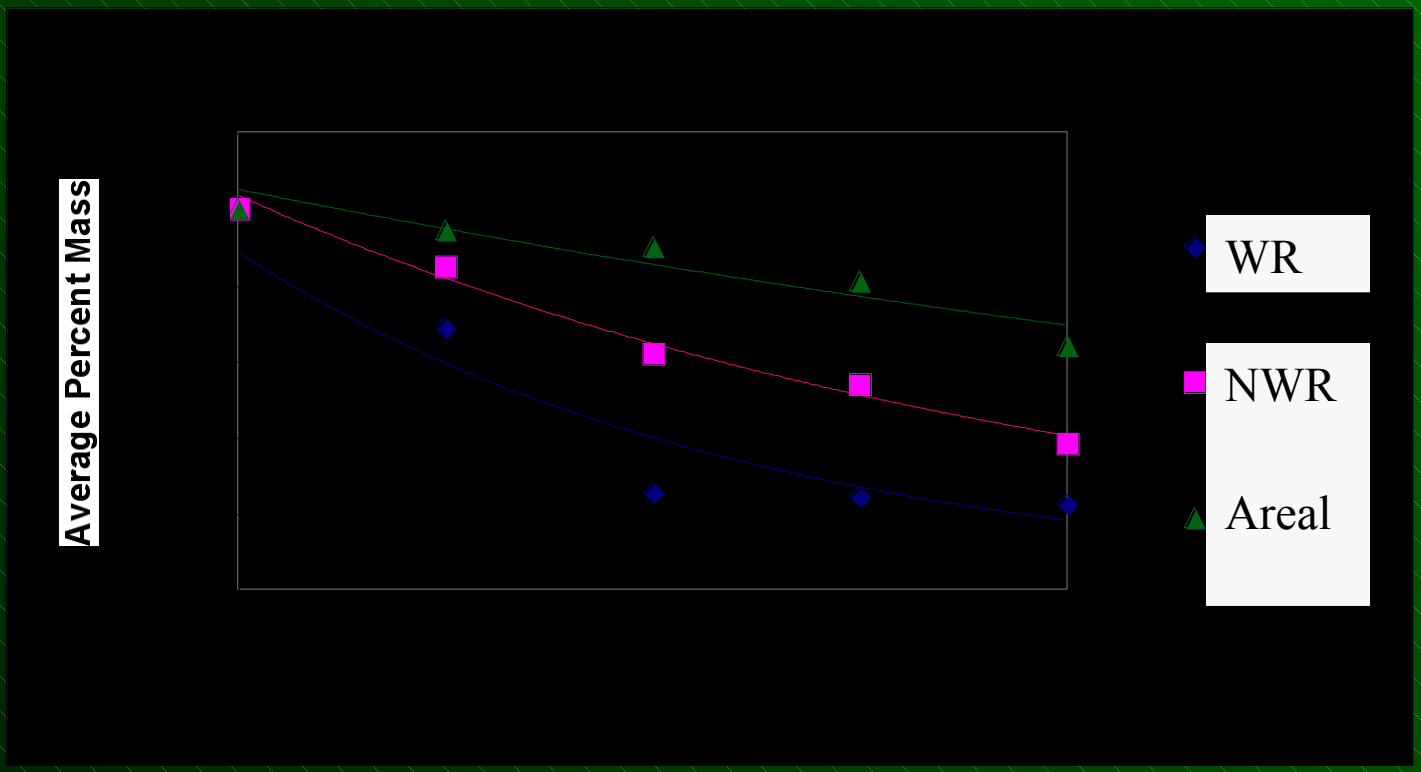
Allochthonous Input sources

Allochthonous Input sources



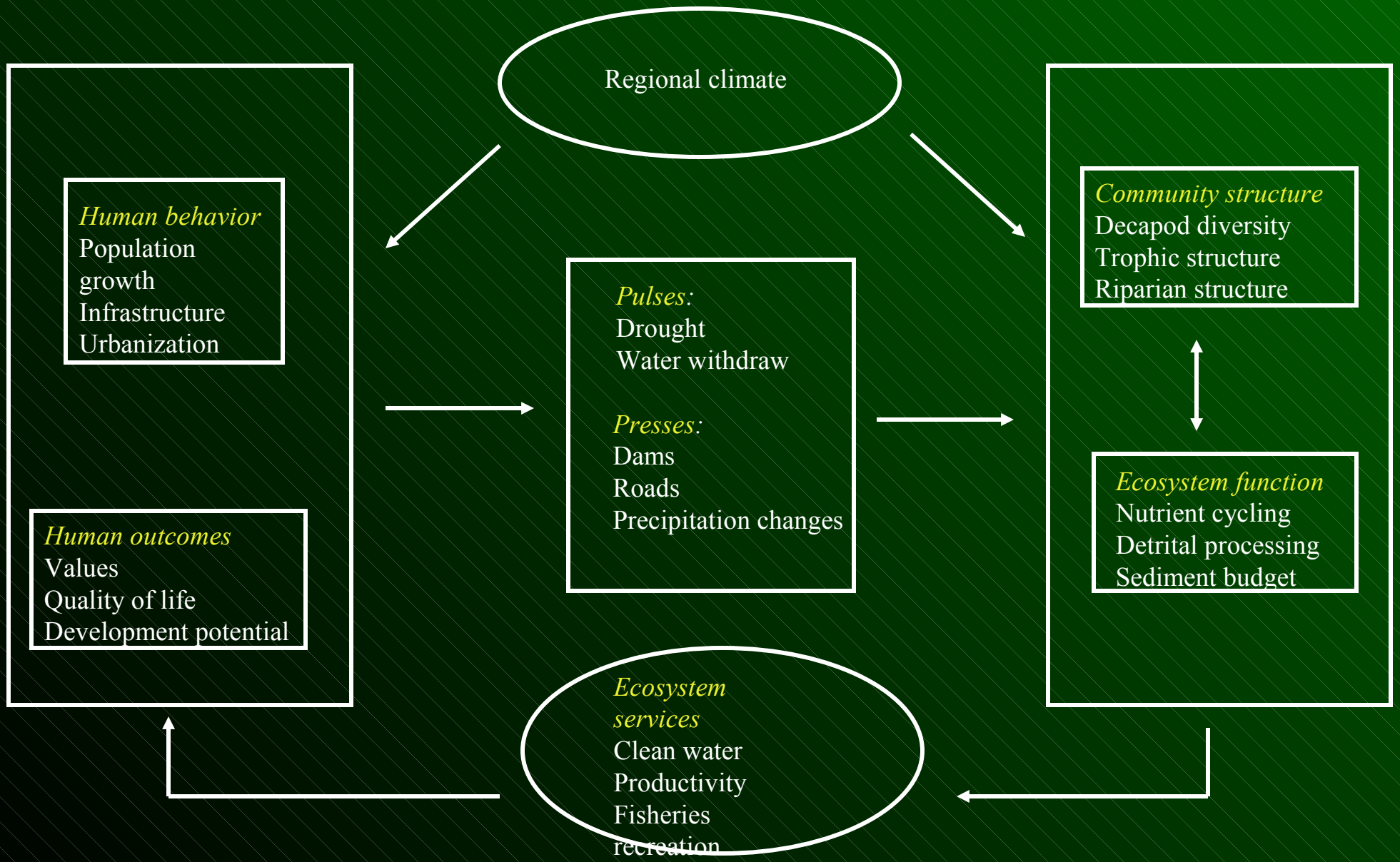
Mat forming White Rot Fungus

Mat forming White Rot Fungus

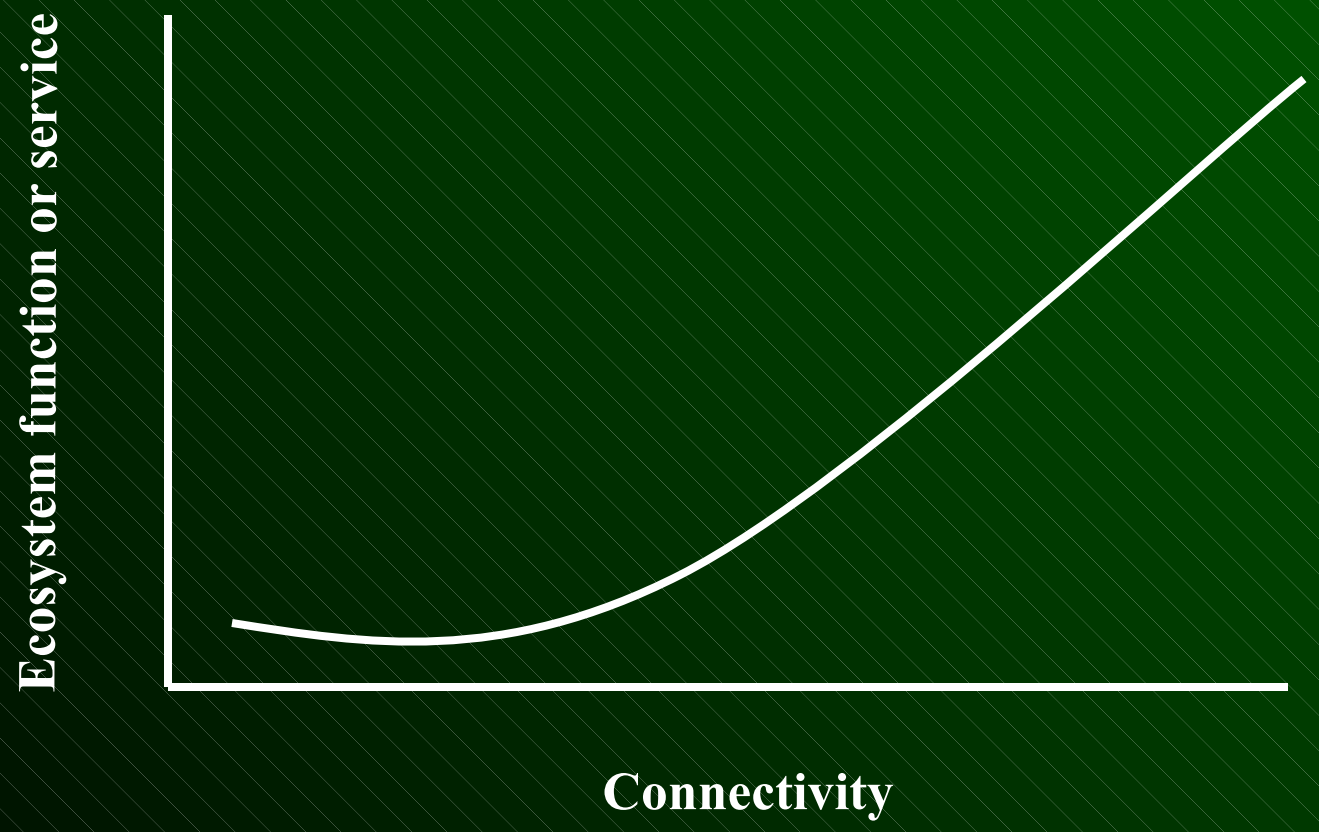


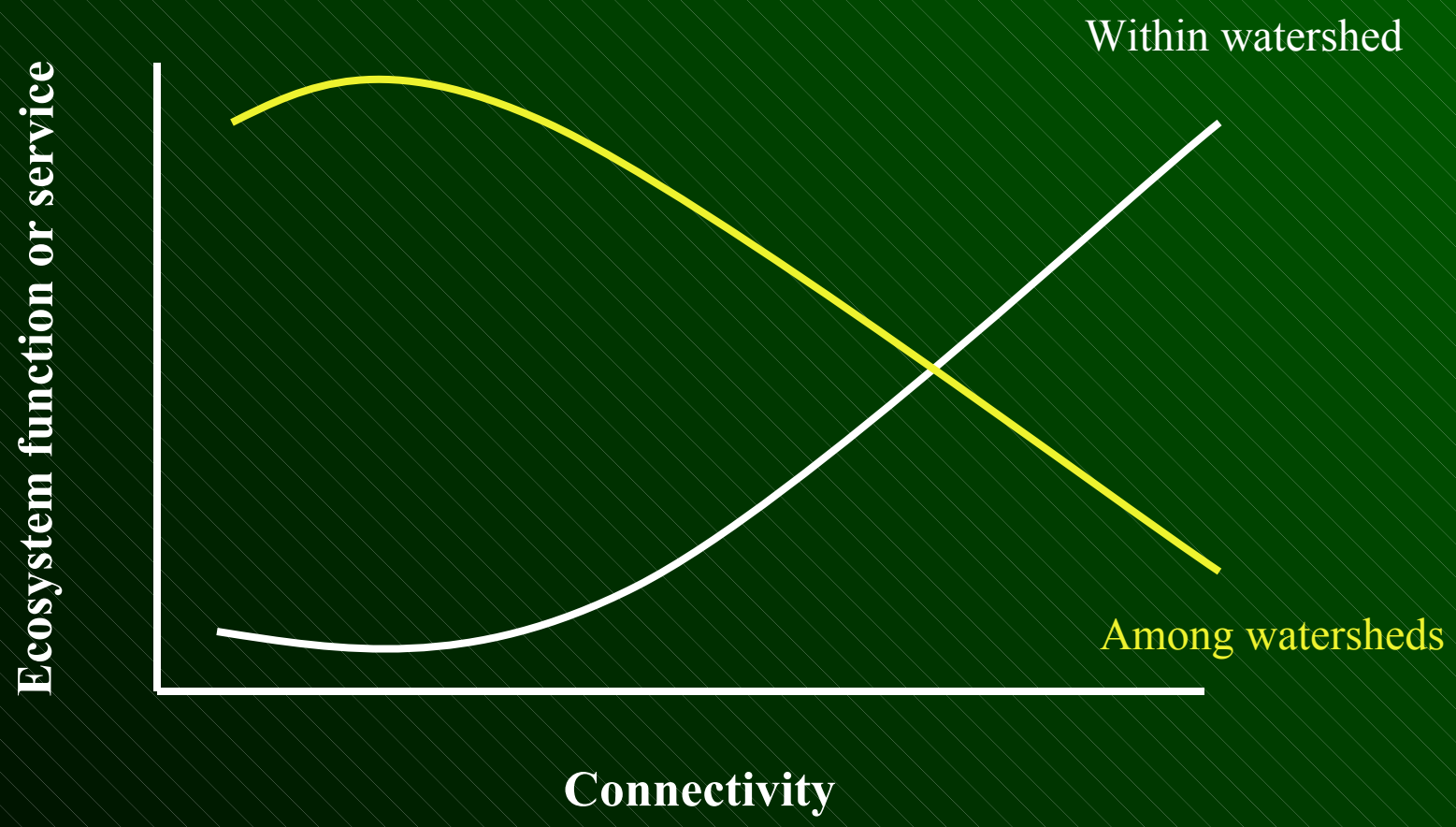
Tributaries supply 90% of leaf input
And of much higher quality

Faster processing and increased energy flow


Regional climate
Human behavior
Population
growth
Infrastructure
Urbanization
Human outcomes
Values
Quality of life
Development potential
Pulses:
Drought
Water withdraw
Presses:
Dams
Roads
Precipitation changes
Community structure
Decapod diversity
Trophic structure
Riparian structure
Ecosystem function
Nutrient cycling
Detrital processing
Sediment budget
Ecosystem
services
Clean water
Productivity
Fisheries
recreation

Thanks for the $$$
NSF: LTER, Biocomplexity, DIG, REU
EPA
USDA Forest Service
International Institute of Tropical Forestry


Ecosystem function or service
Connectivity


Within watershed
Among watersheds
Ecosystem function or service
Connectivity