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Long-term Impacts on Rio Grande Fish Foodweb Structure and Function

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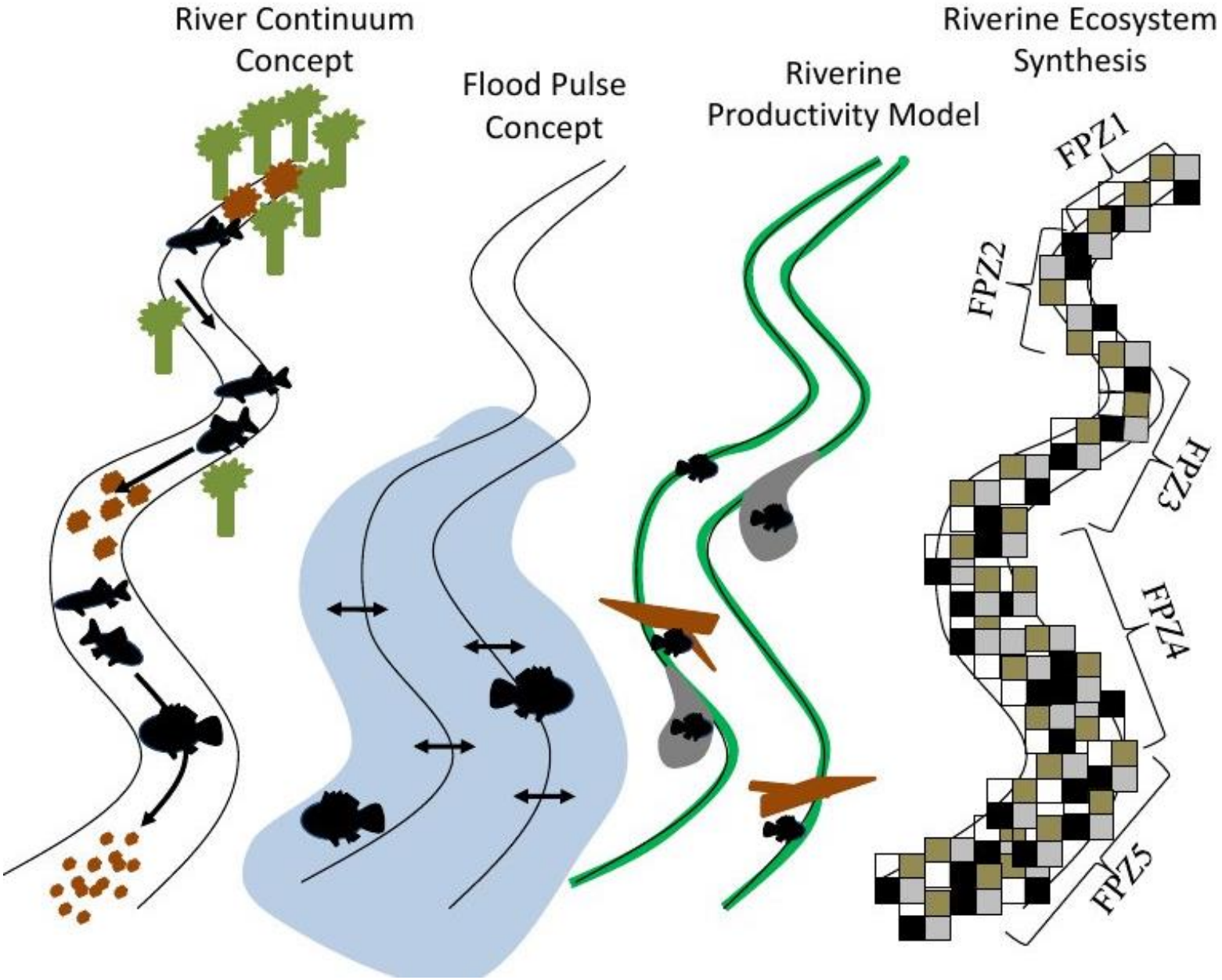
Long-term impacts on Rio Grande fish foodweb structure and function

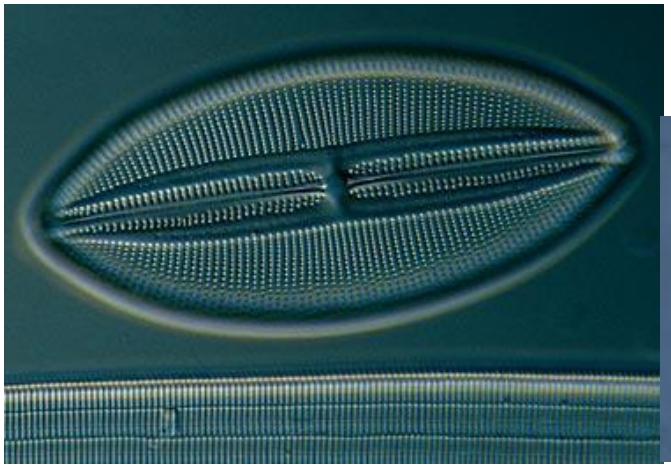
THE UNIVERSITY of NEW MEXICO

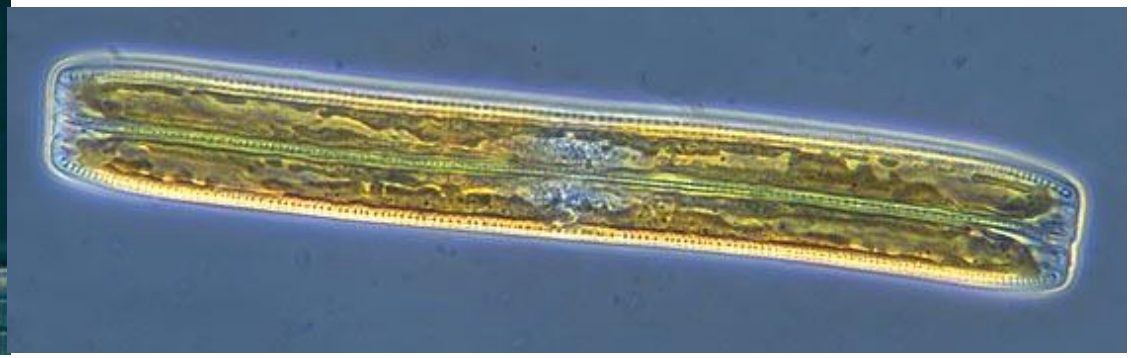
Museum of Southwestern Biology
Division of Fishes


River Continuum Concept
Flood Pulse Concept
Riverine Productivity Model
Riverine Ecosystem Synthesis
FPZ1
FPZ2
FPZ3
FPZ4
FPZ5

Instream Primary Producers

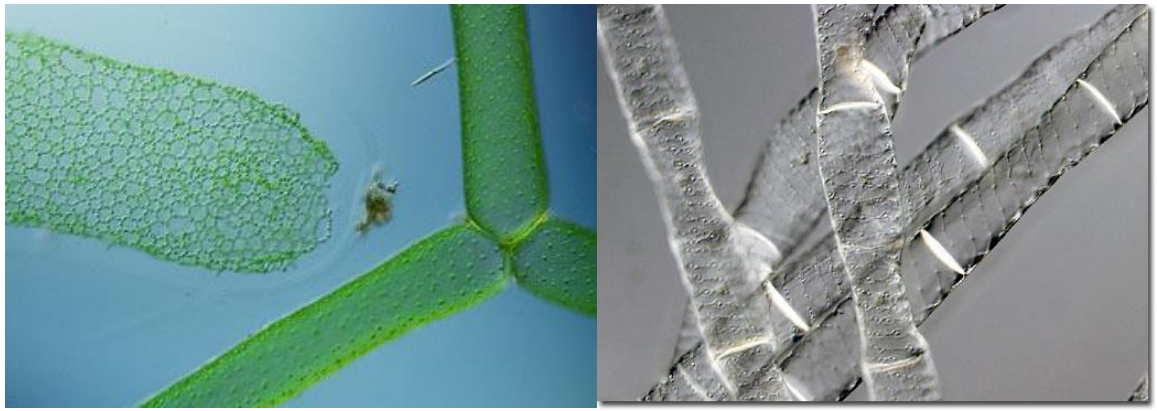
Diatoms





Cyanobacteria

Green Algae

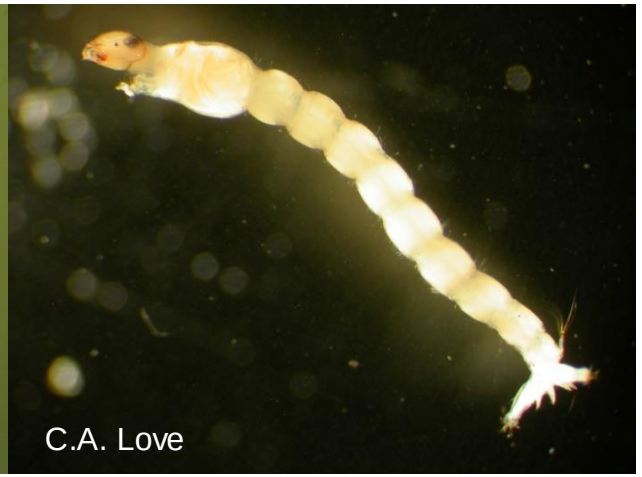


Riparian (Terrestrial) Producers

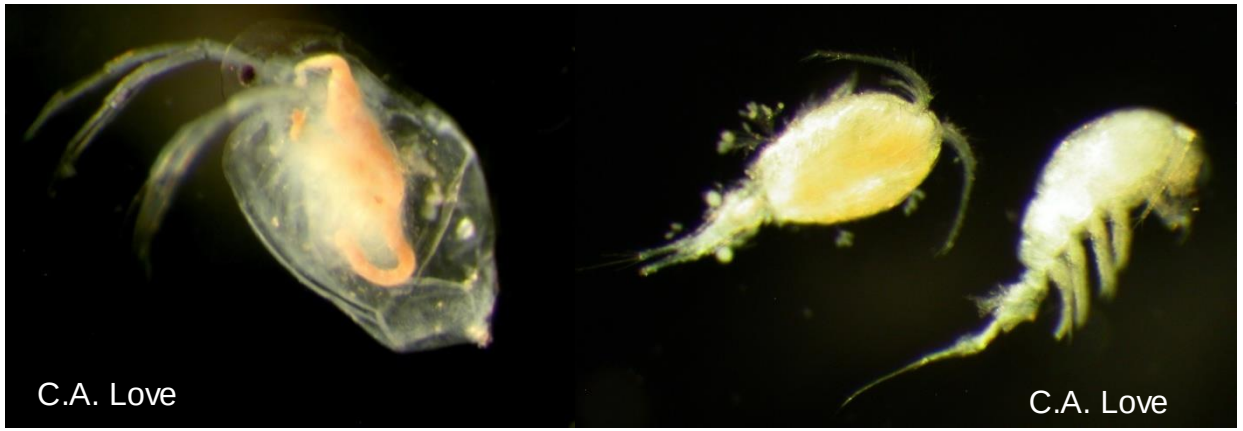
Common Rio Grande Invertebrates

Mayfly larva

Nematoda



Chironomid (midge) larva



Microcrustacea

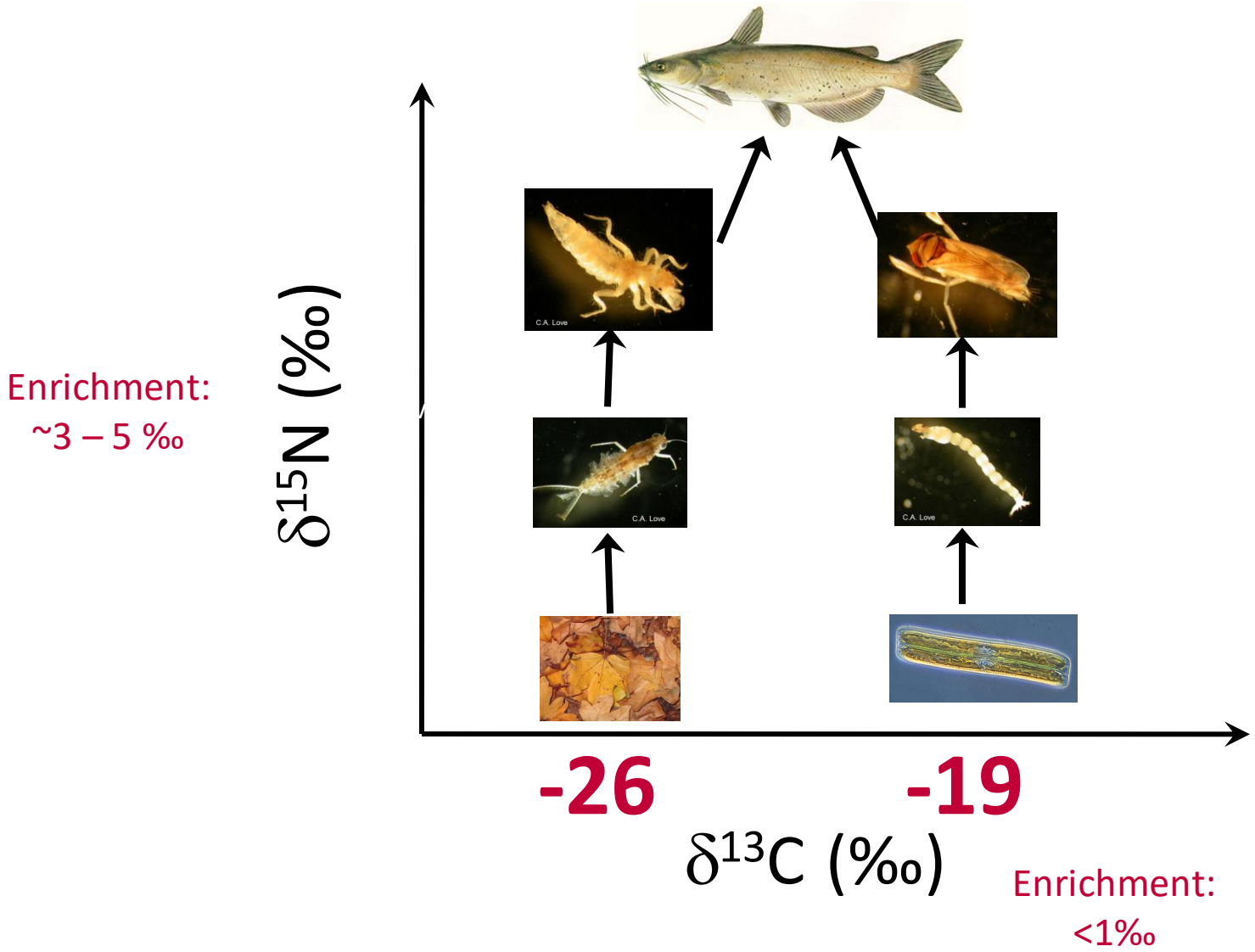
Rotifera

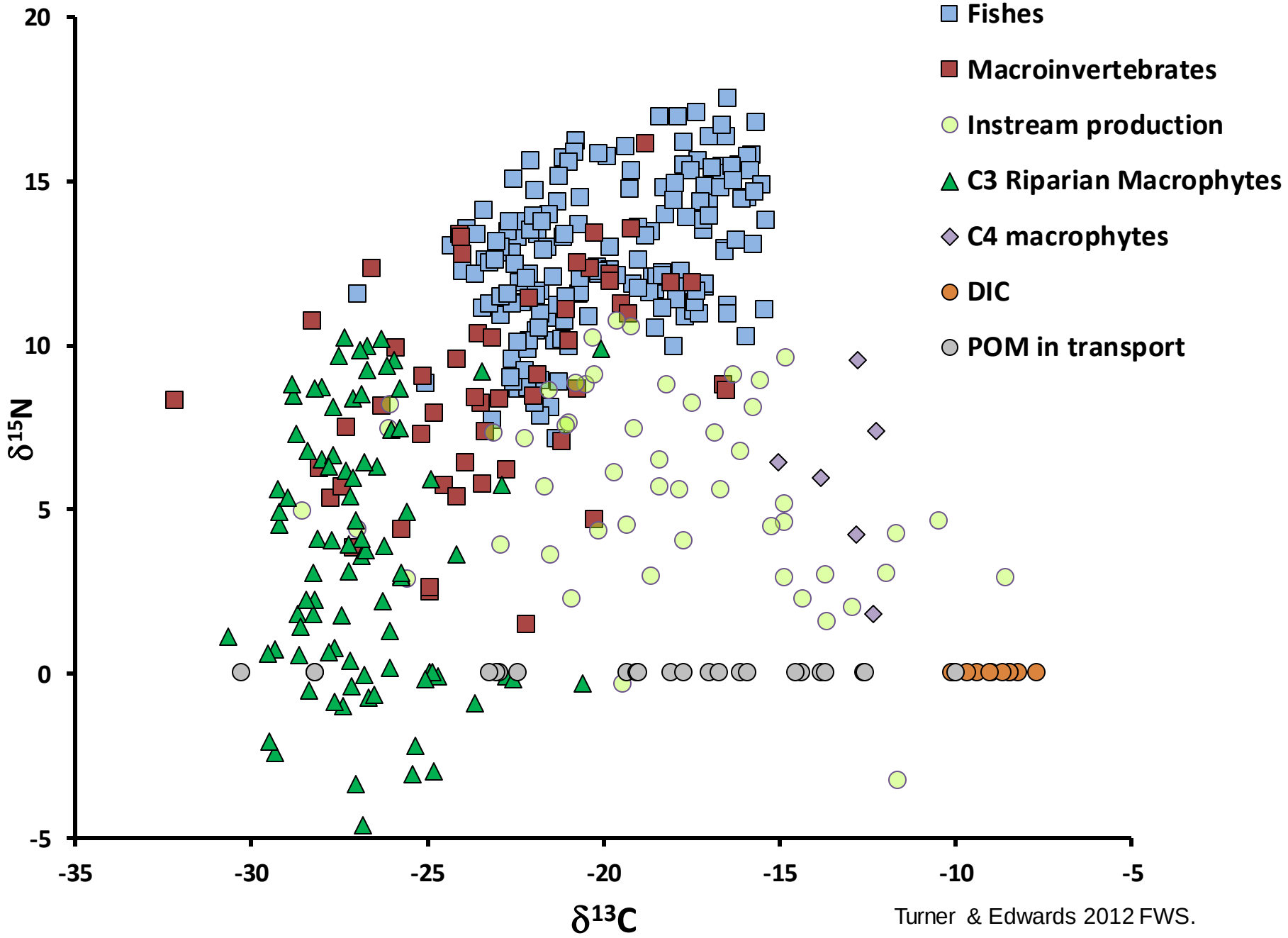
Predatory invertebrates

Corixidae
(water boatman)

Odonata
(dragonfly)

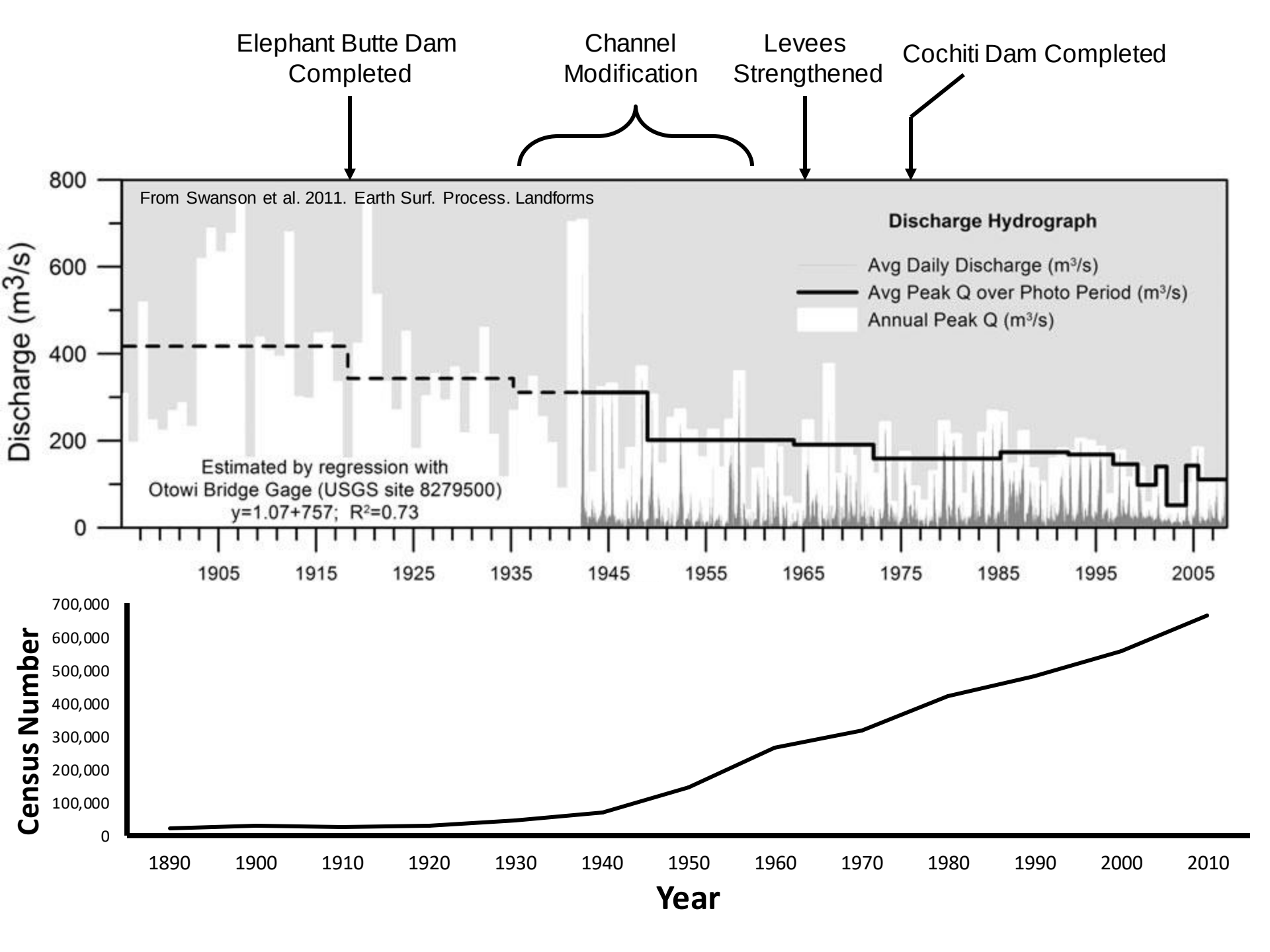
Food webs and stable isotopes





Turner & Edwards 2012 FWS.

Is there a difference?


Elephant Butte Dam Completed
Channel Modification
Levees Strengthened
Cochiti Dam Completed
From Swanson et al. 2011. Earth Surf. Process. Landforms
Discharge Hydrograph
Avg Daily Discharge (m³/s)
Avg Peak Q over Photo Period (m³/s)
Annual Peak Q (m³/s)
Estimated by regression with
Otowi Bridge Gage (USGS site 8279500)
y=1.07+757; R²=0.73
Discharge (m3/s)
800
600
400
200
0
1905
1915
1925
1935
1945
1955
1965
1975
1985
1995
2005
Census Number
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year

Cochiti Dam - 1975

Rio Grande at Albuquerque, New Mexico

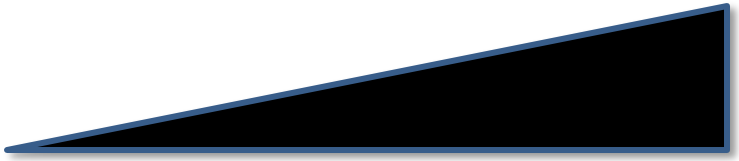
1949

1957

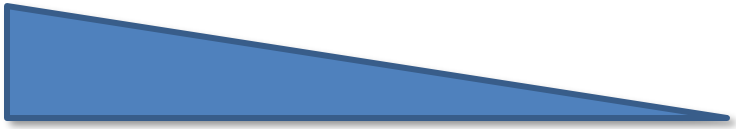
1996

Images courtesy of Mary Harner

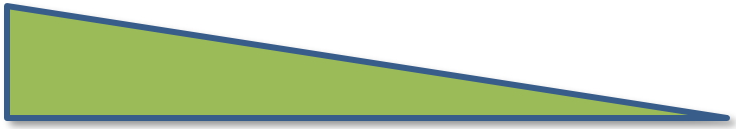
Predicted Effects of River Regulation



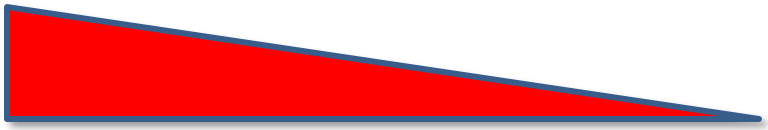
Channelization & Flow Regulation



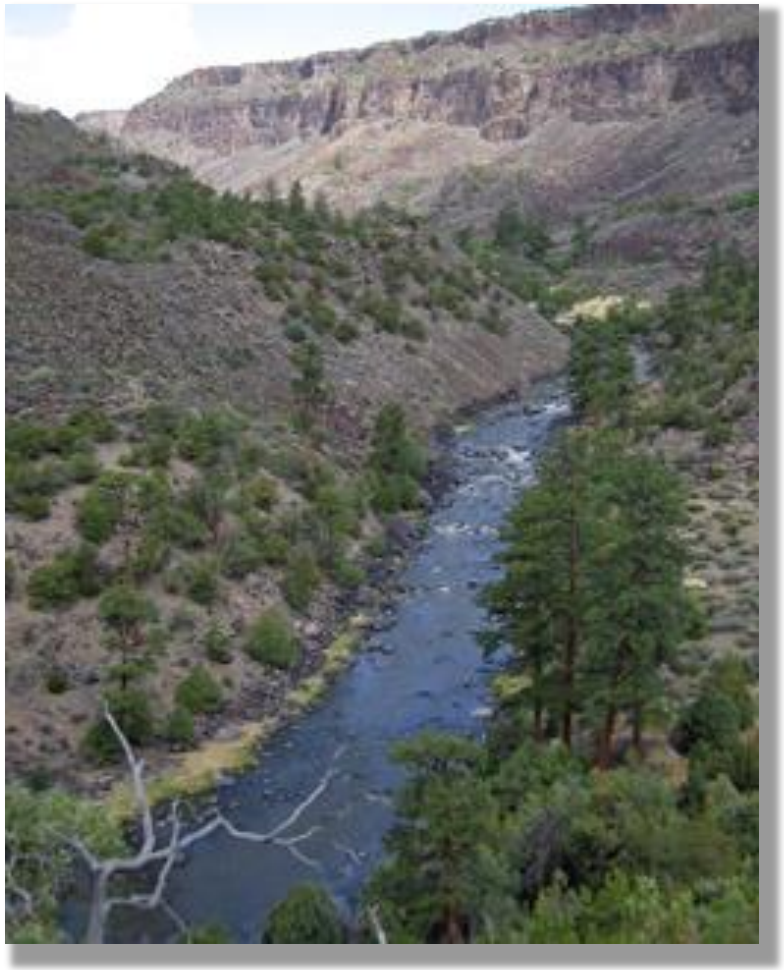
Ecosystem Size & Heterogeneity



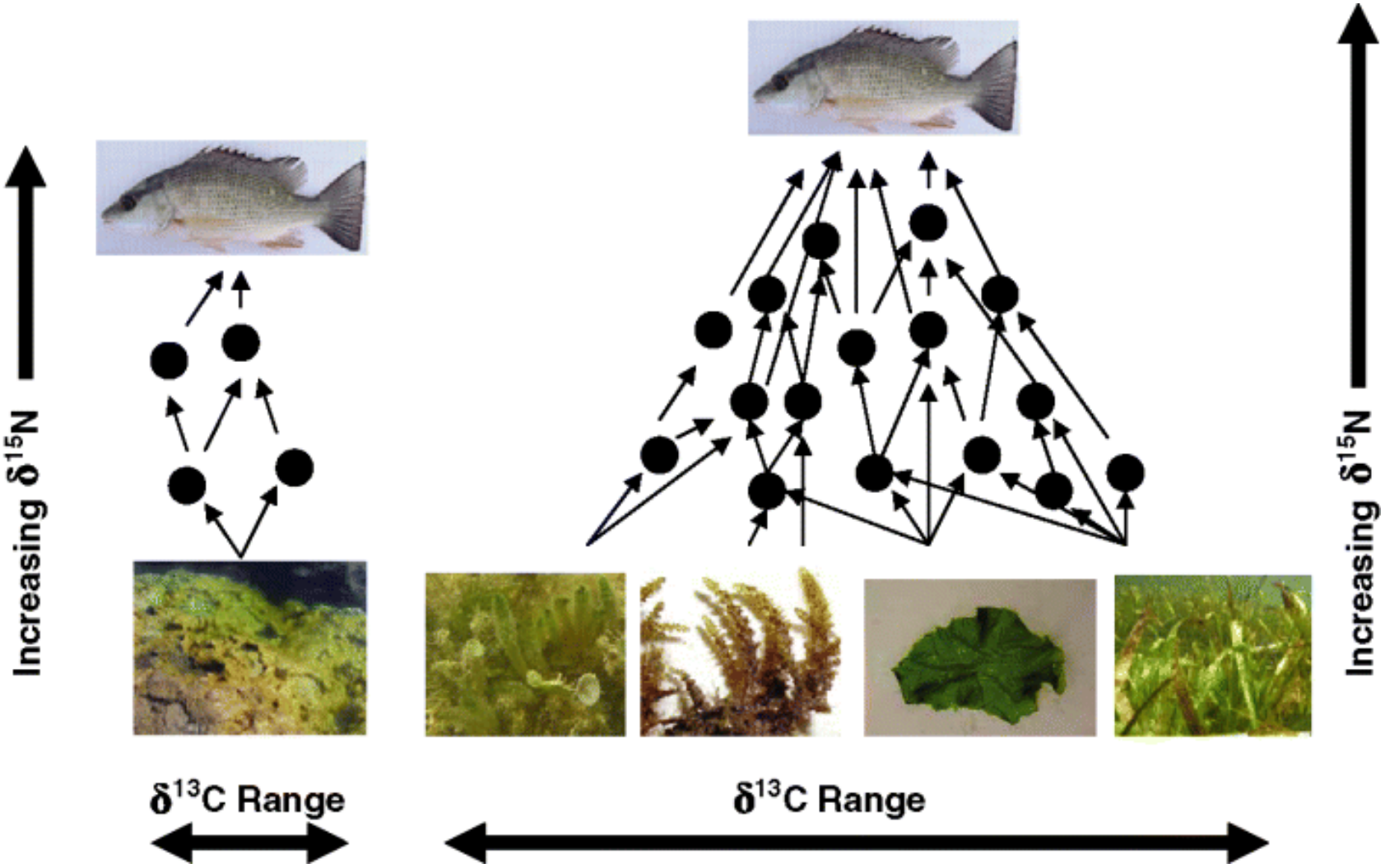
Productivity & Energy Inputs



Trophic Complexity & Food Chain Length



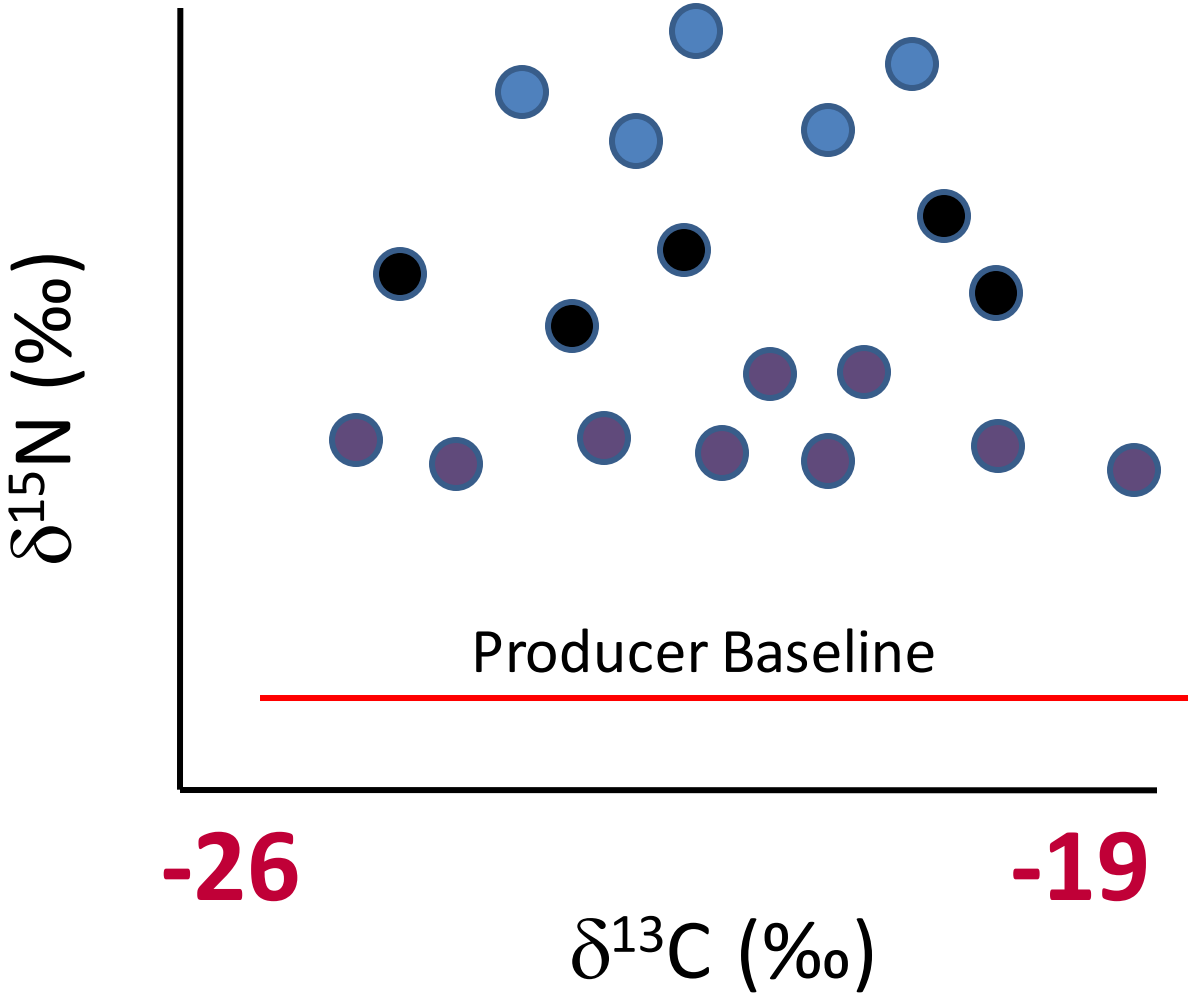
Niche width collapse in a resilient top predator following ecosystem fragmentation

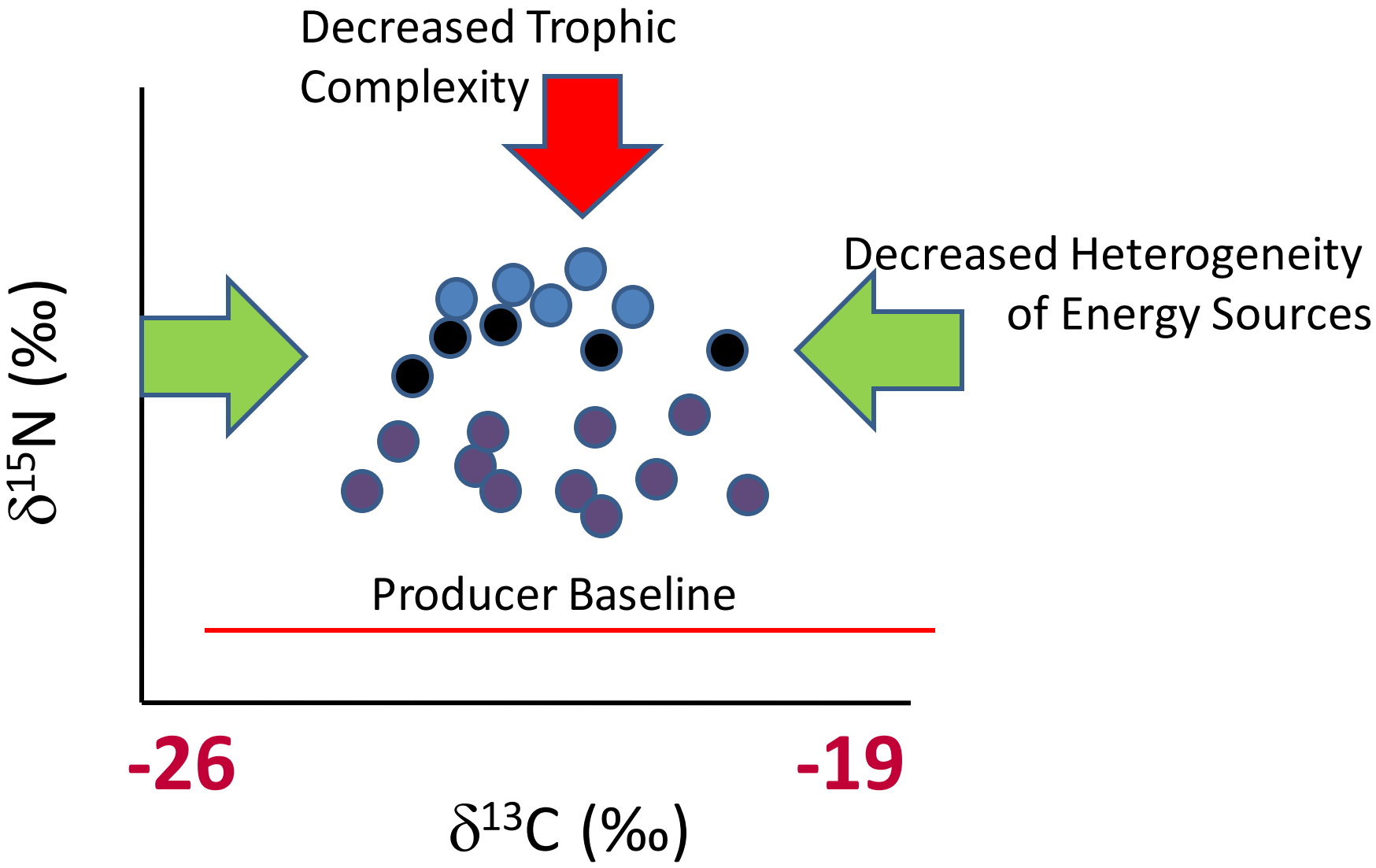


Ecology Letters
Volume 10, Issue 10, pages 937-944, 31 JUL 2007 DOI: 10.1111/j.1461-0248.2007.01087.x
http://onlinelibrary.wiley.com/doi/10.1111/j.1461-0248.2007.01087.x/full#f4

A Role for Natural History Collections

- Infrequently used to understand changes in ecosystem function
- Stable isotope studies of historical material permits testing for changes in ecosystem function
- Fishes are ‘integrators’ of aquatic food resources


δ15N (‰)
Producer Baseline
-26
-19
δ13C (‰)


Decreased Trophic Complexity
Decreased Heterogeneity of Energy Sources
Producer Baseline
δ15N (‰)
-26
-19
δ13C (‰)

Analytical Approach

- Develop test statistics to evaluate differences among samples in:
  - Centroid location (in bivariate space)
  - Dispersion (Layman metrics)
  - Direction and magnitude of response
- Develop null distributions based on resampling via residual permutation procedures (RPPs)

Turner et al. 2010. Ecology

Locality Map

Cochiti Dam

Angostura Diversion Dam

Albuquerque

Isleta Diversion Dam

Bernardo

San Acacia Diversion Dam

Socorro

San Marcial

Elephant Butte
Reservoir

Rio Grande Fishes Sampling Scheme (k_{max}= 10; n = 713)

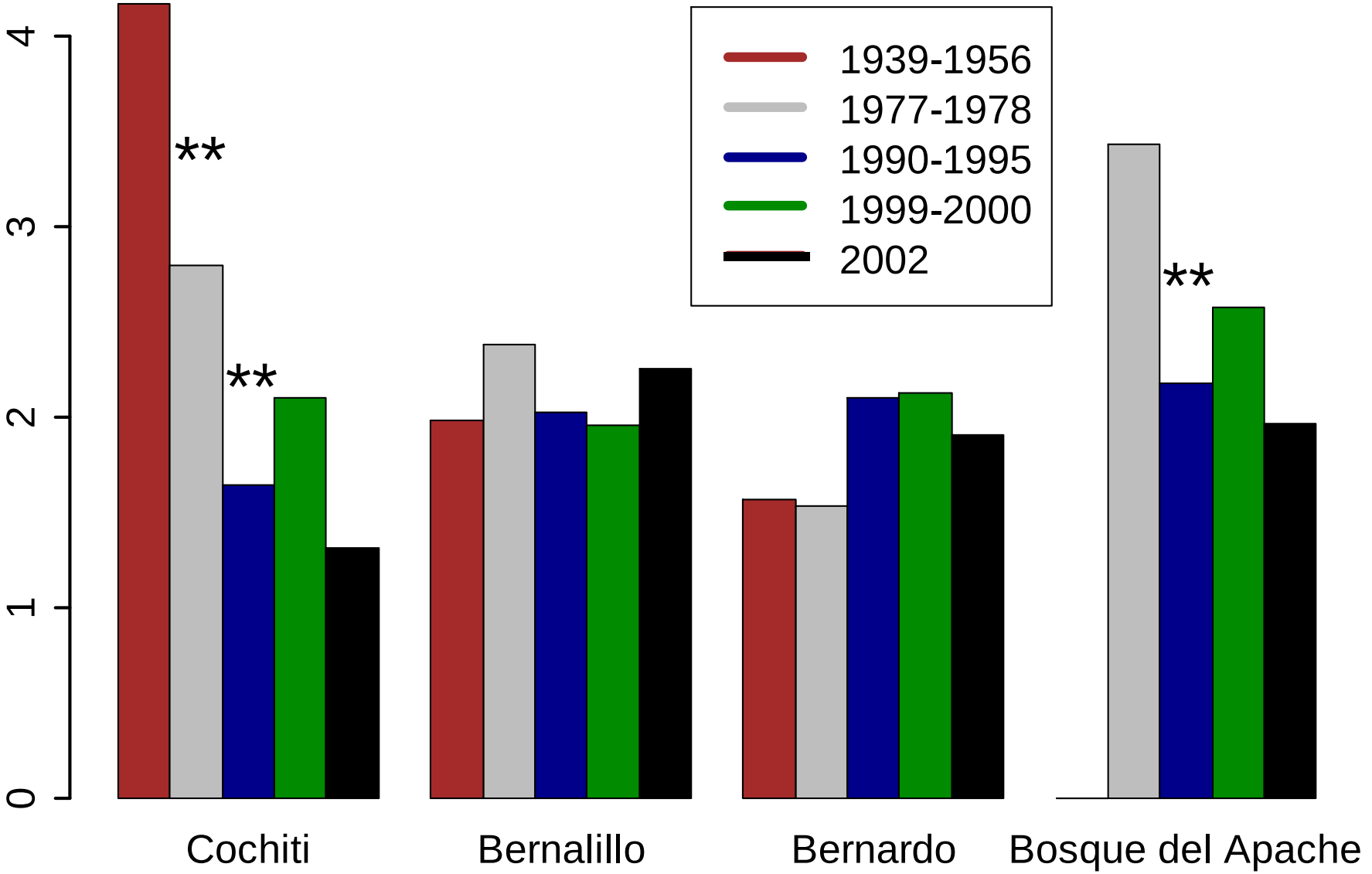
Past

Present

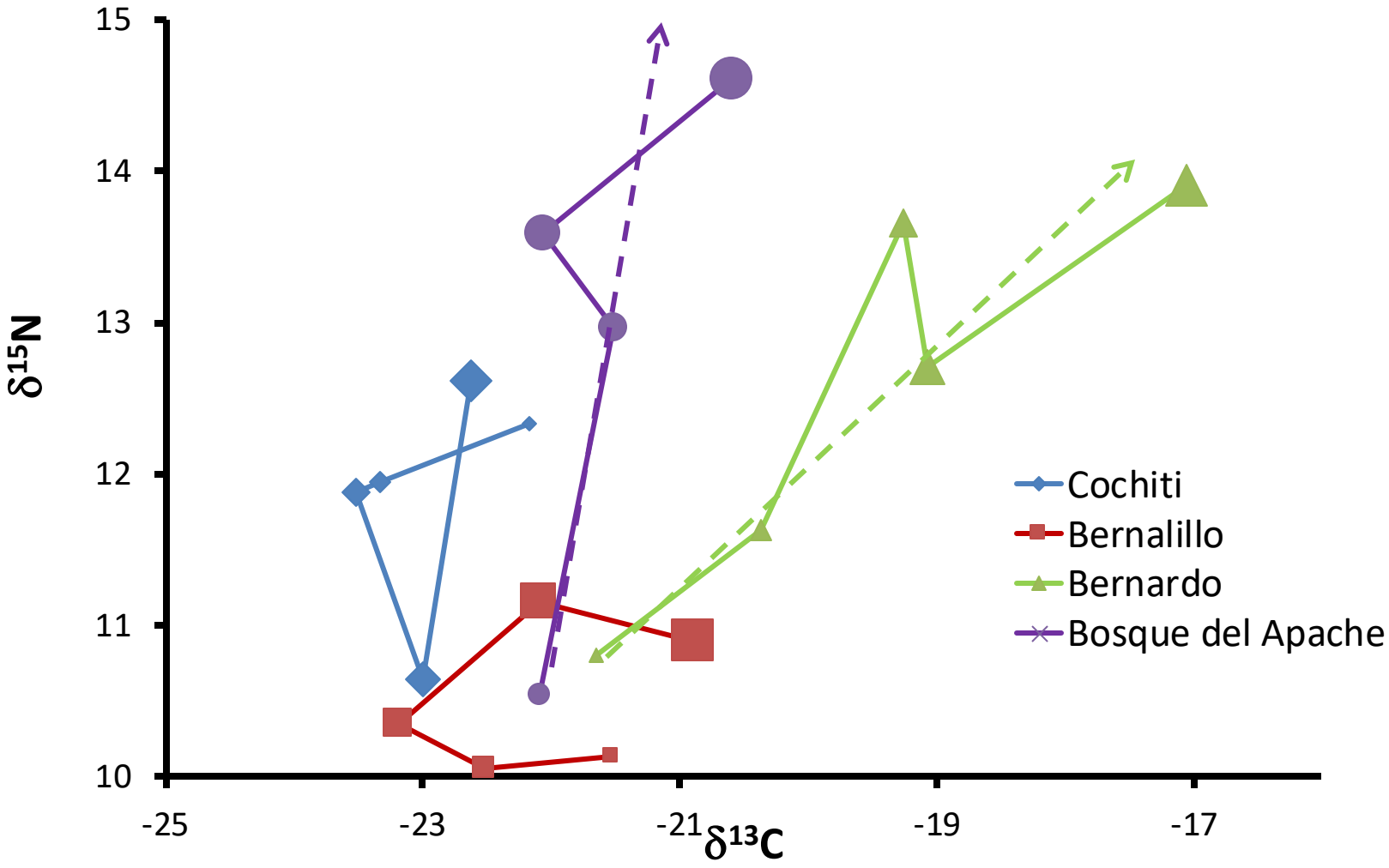
Time Frame	Cochiti		Bernalillo		Bernardo		Bosque	
	k	*n*	*k*	*n*	*k*	*n*	*k*	*n*
1930 -1950	7	31	7	26	6	27	---	---
1970s	8	37	9	38	8	36	8	39
early 1990s	8	36	10	48	9	45	9	45
late 1990s	7	28	7	33	8	40	8	35
2000s	4	36	7	52	9	59	6	22

upstream → **downstream**

‘Isotopic Niche’ Dispersion



Trajectories over time (late 1930s – 2000s)



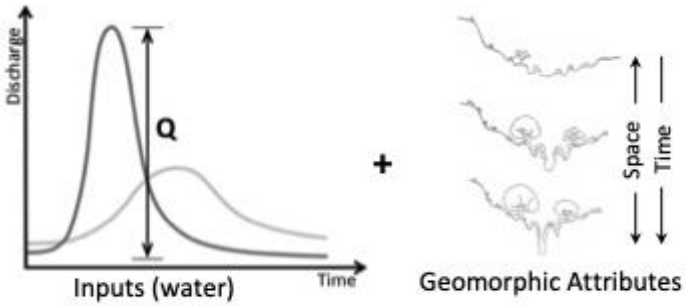
Size: Bernardo = Bosque > Cochiti = Bernalillo

Shape: Bernardo = Bosque ≠ Cochiti ≠ Bernalillo

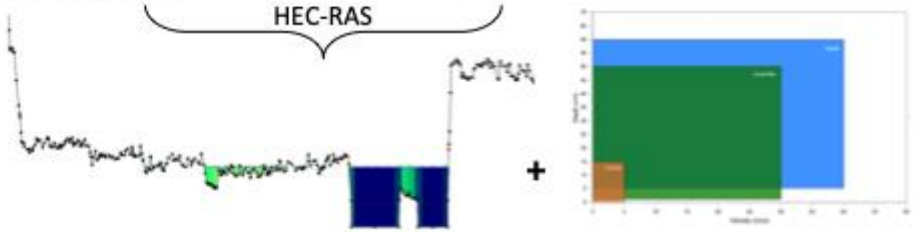
- **River regulation** strongly affects nutrient flow and fish community dynamics in the Rio Grande

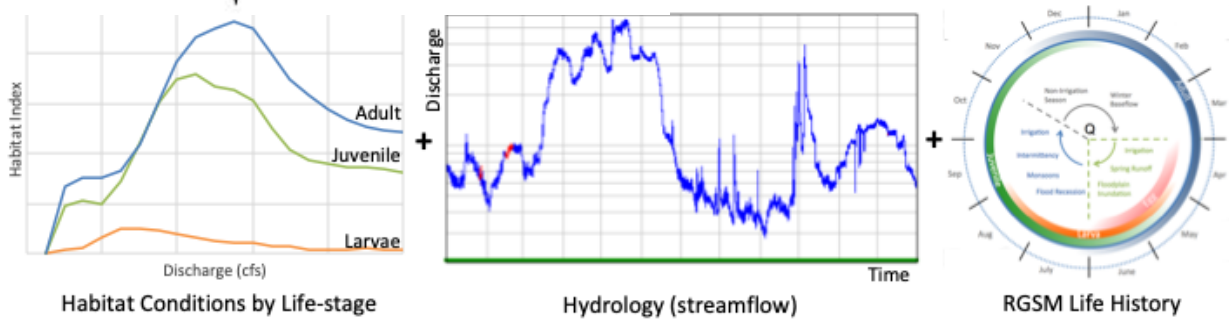
- Effects increase in severity over decadal time scales

- **Potential** for restoration ecology
  - Restoration of overbank spring floods given new channel morphology
  - Address point-source effects

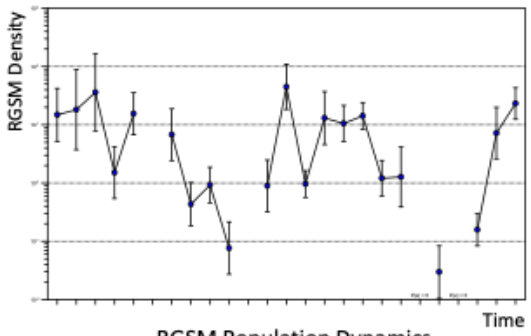


Characterize and Assess:
Geomorphic Attributes –
Habitat Conditions





Characterize and Assess:
Habitat Conditions –
Biotic Response (RGSM)



Acknowledgements

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- NSF DEB Ecology

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