Hypothesis testing of Everglades marsh community interactions using structural equation modeling

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Community Structure

- Biotic interactions in community structure
  - Easy to document
  - More difficult to determine causality
- Problems:
  - Omnivory
  - Multiple environmental gradients
  - Sampling problems

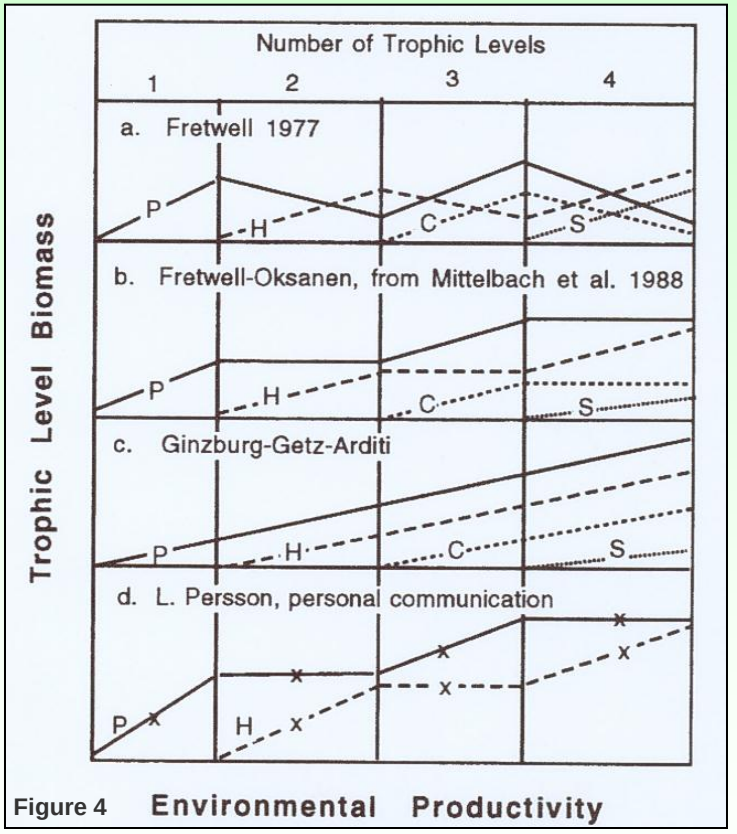
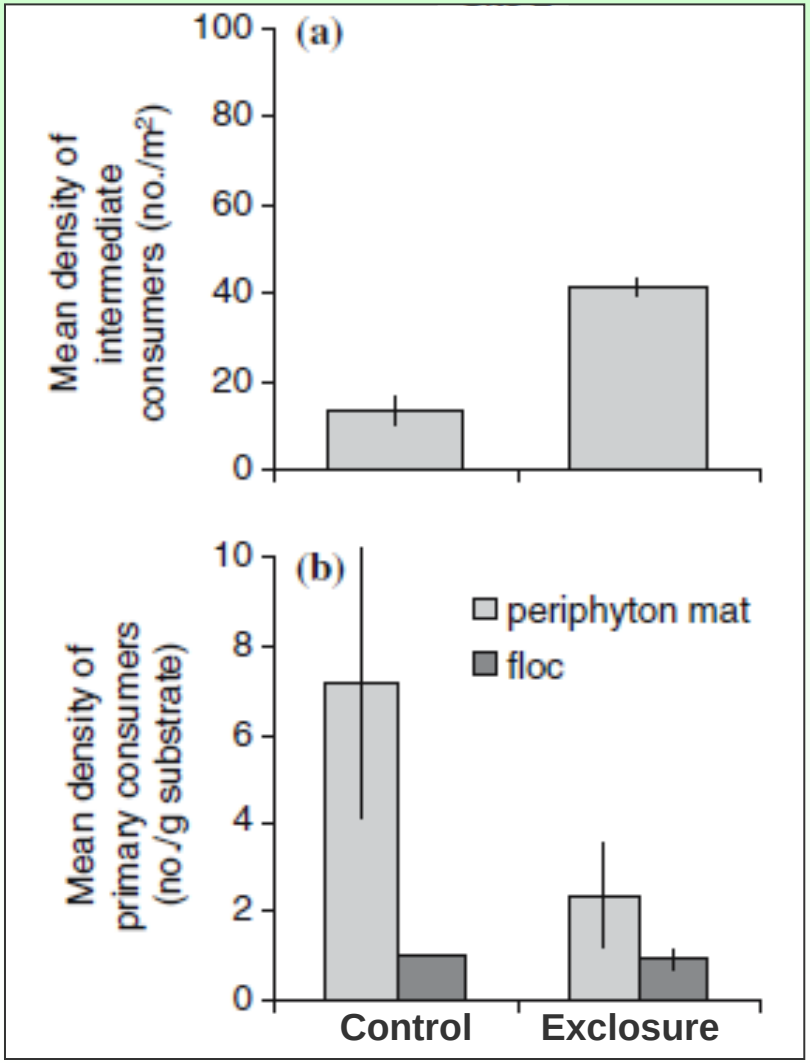


Figure 4

From: Power 1992. Ecology.

Community Structure

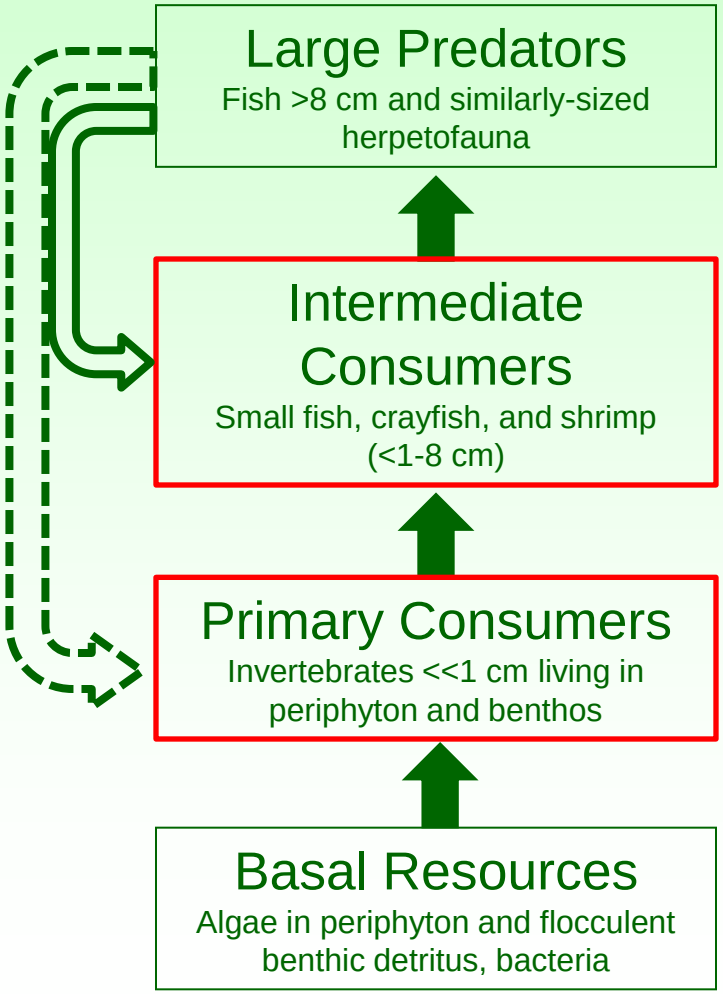
- Experimental manipulations
  - Results limited in space and time
  - Logistically and monetarily challenging to expand



Dorn et al. 2006

Community Structure

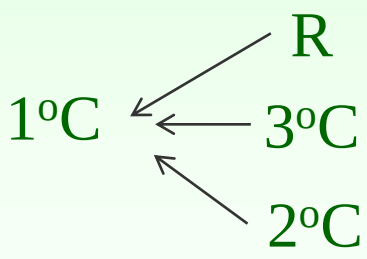
Challenges for Sampling Studies



Model Tested by Common Regression

Causal Path Ignored

$$1^oC = R + 2^oC + 3^oC + \varepsilon$$



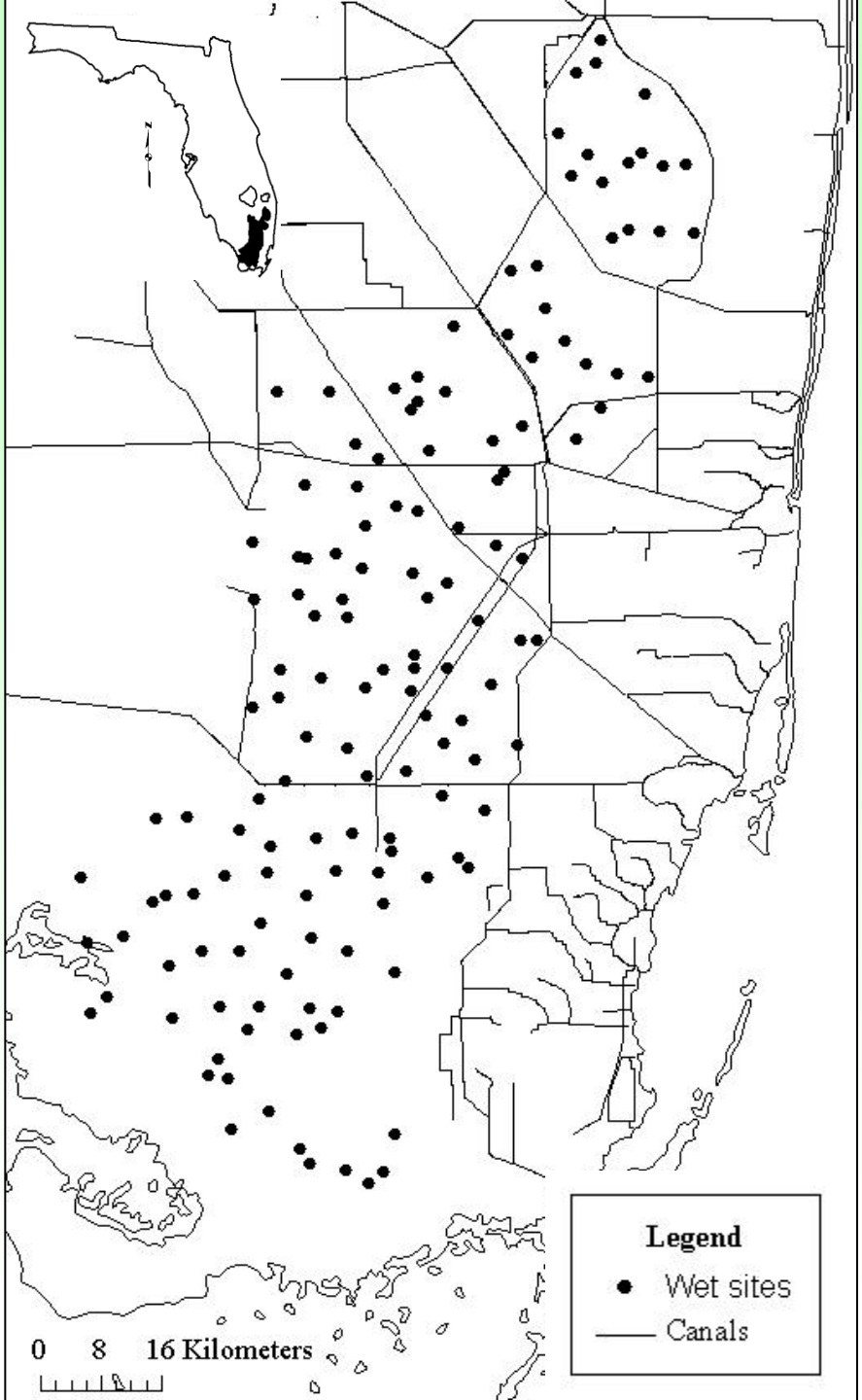
Ignores indirect effect

Only evaluates a single trophic level

The Florida Everglades

Sampling Design

- Annually in October – December, 2005 – 2010
- Approximately 155 sites
- Sampled with 1-m^2 throw trap and periphtyon core samples



Sampling Design

- Three replicates per site
- Periphyton biomass, tissue TP, species composition
- Density of fish (length < 8 cm) and macroinvertebrates (large enough to be captured on 2mm sieve)

Structural Equation Model Variables

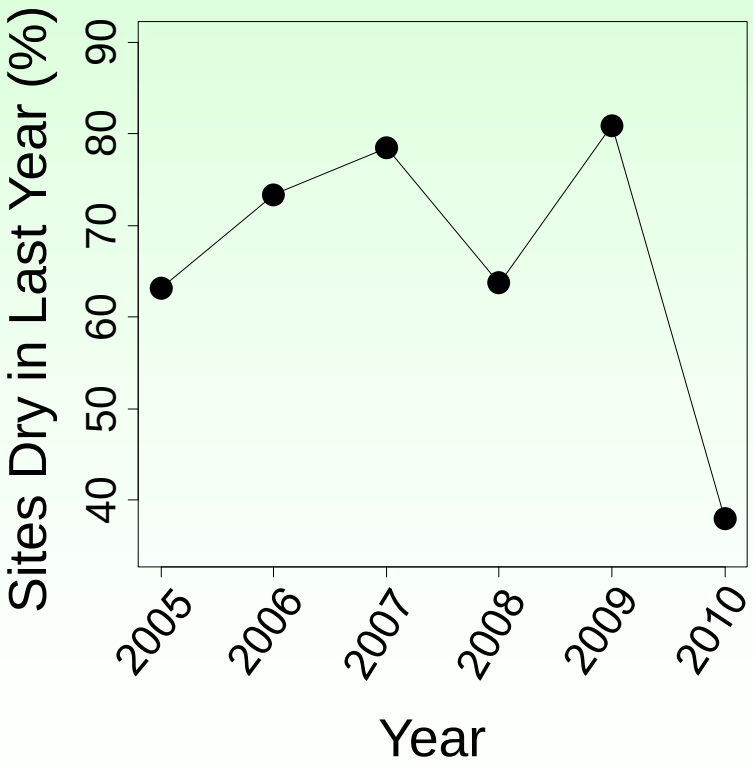
- Hydrololgy: Days since dry (DSD) and depth
- Periphyton: Biomass and % Edible
- Small fish and invertebrates biomass (fish < 15 mm TL, crayfish < 10 mm carapace length)
- Biomass of large fish (> 15 mm TL) and invertebrates
  - Herbivores
  - Omnivores
  - Carnivores

http://www.flmnh.ufl.edu

http://www.nanfa.org

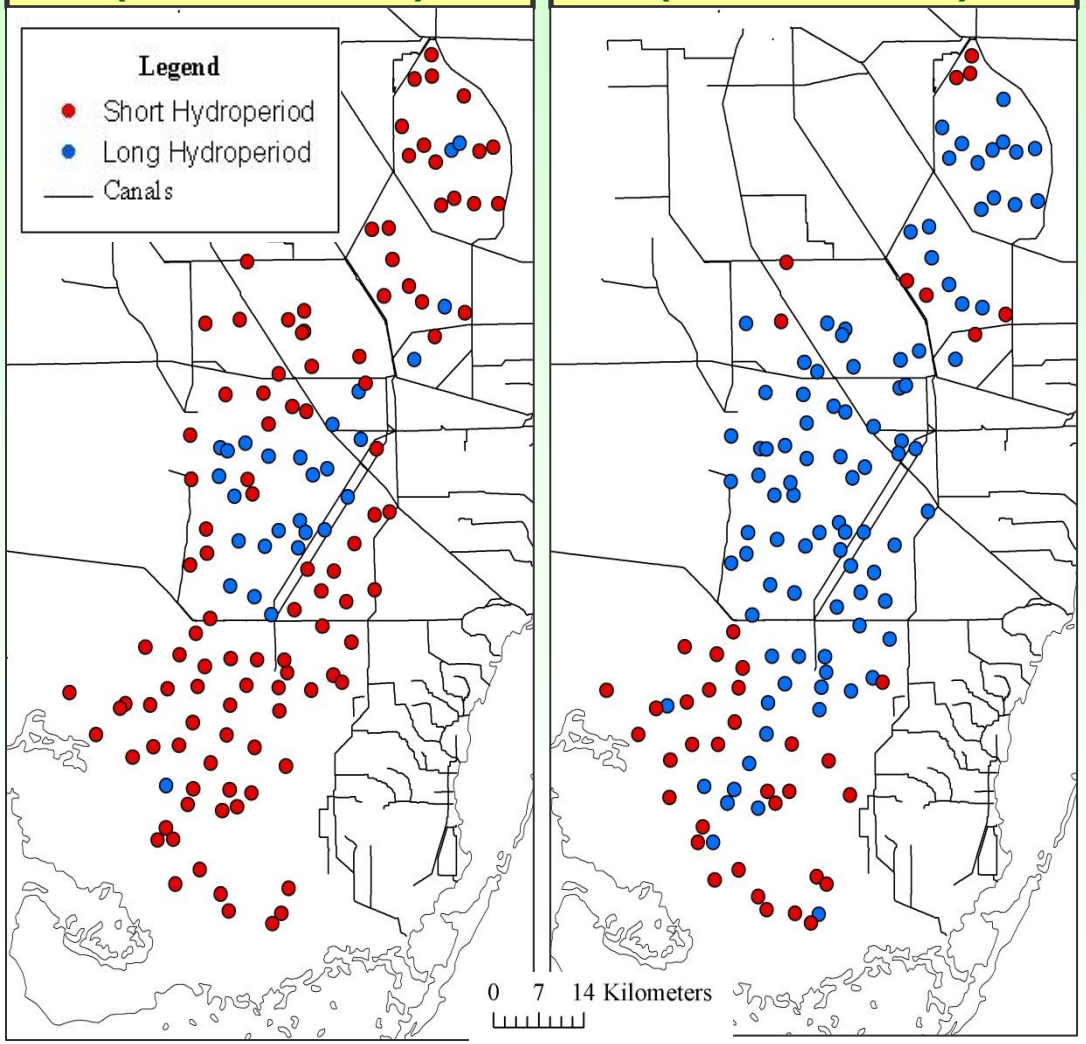
Photo: Liz Huselid

Environmental Fluctuation



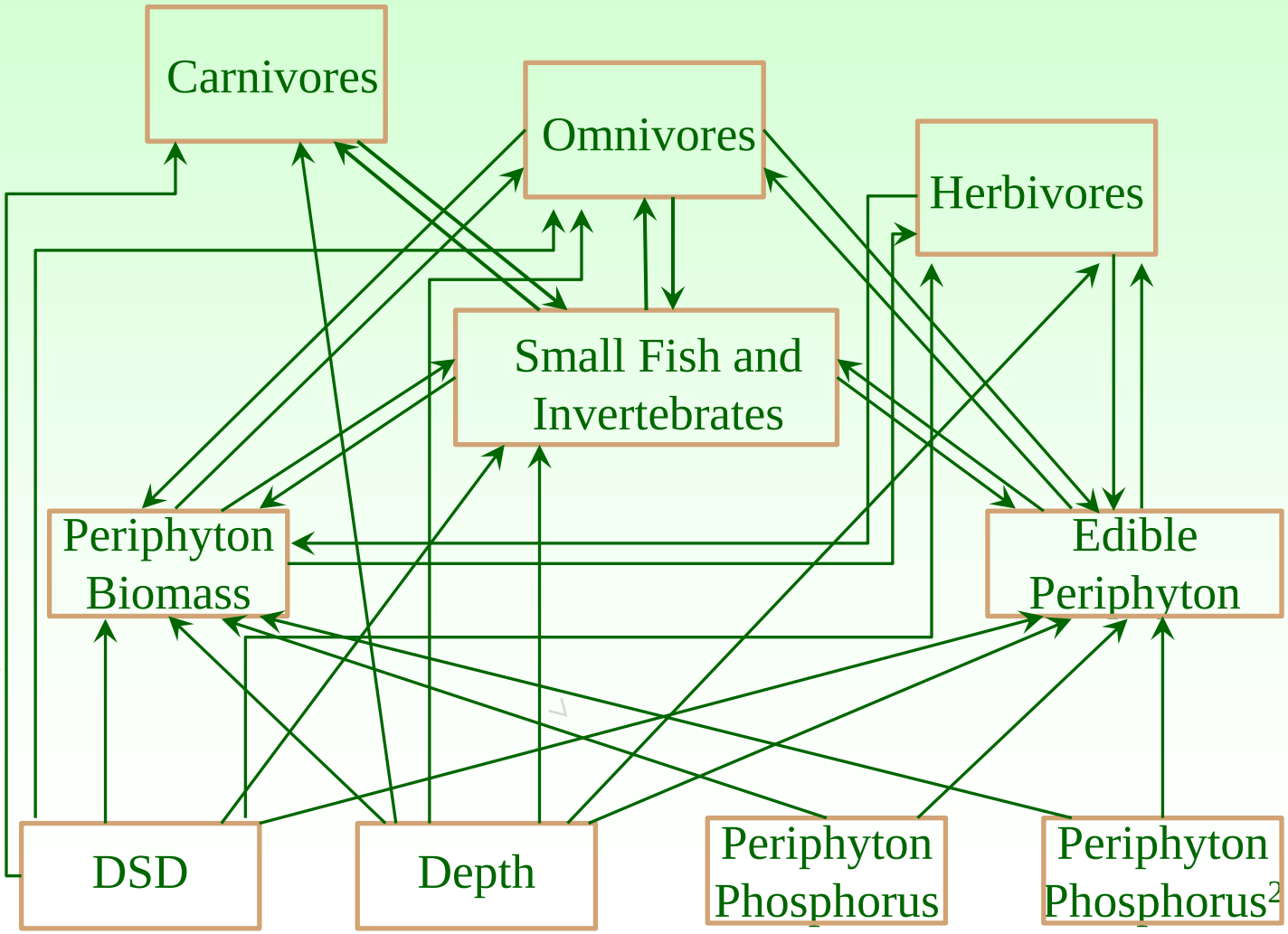
2009: Dry Year (81% dried)

2010: Wet Year (38% dried)

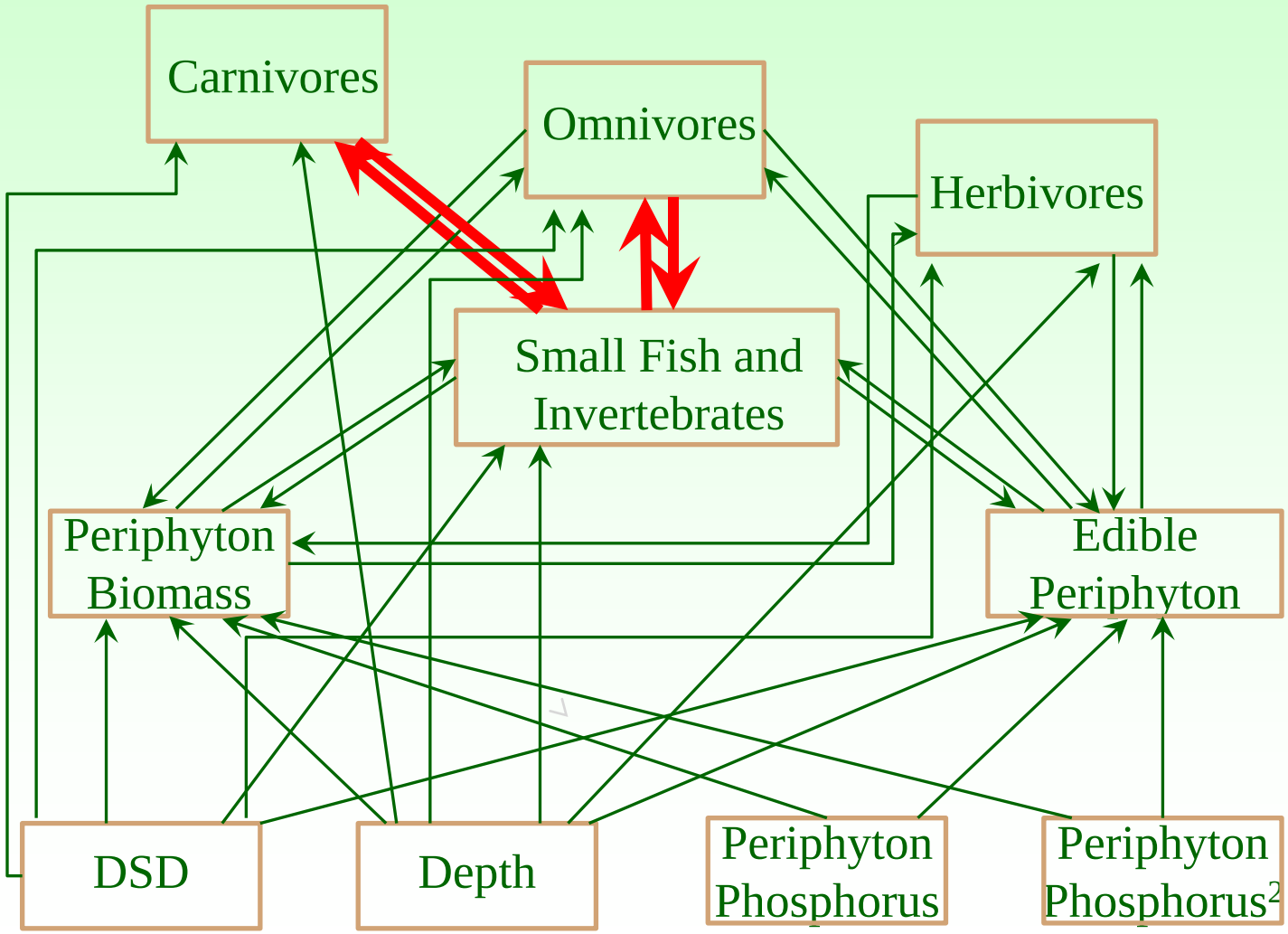


Hypothesis Testing with Structural Equation Models

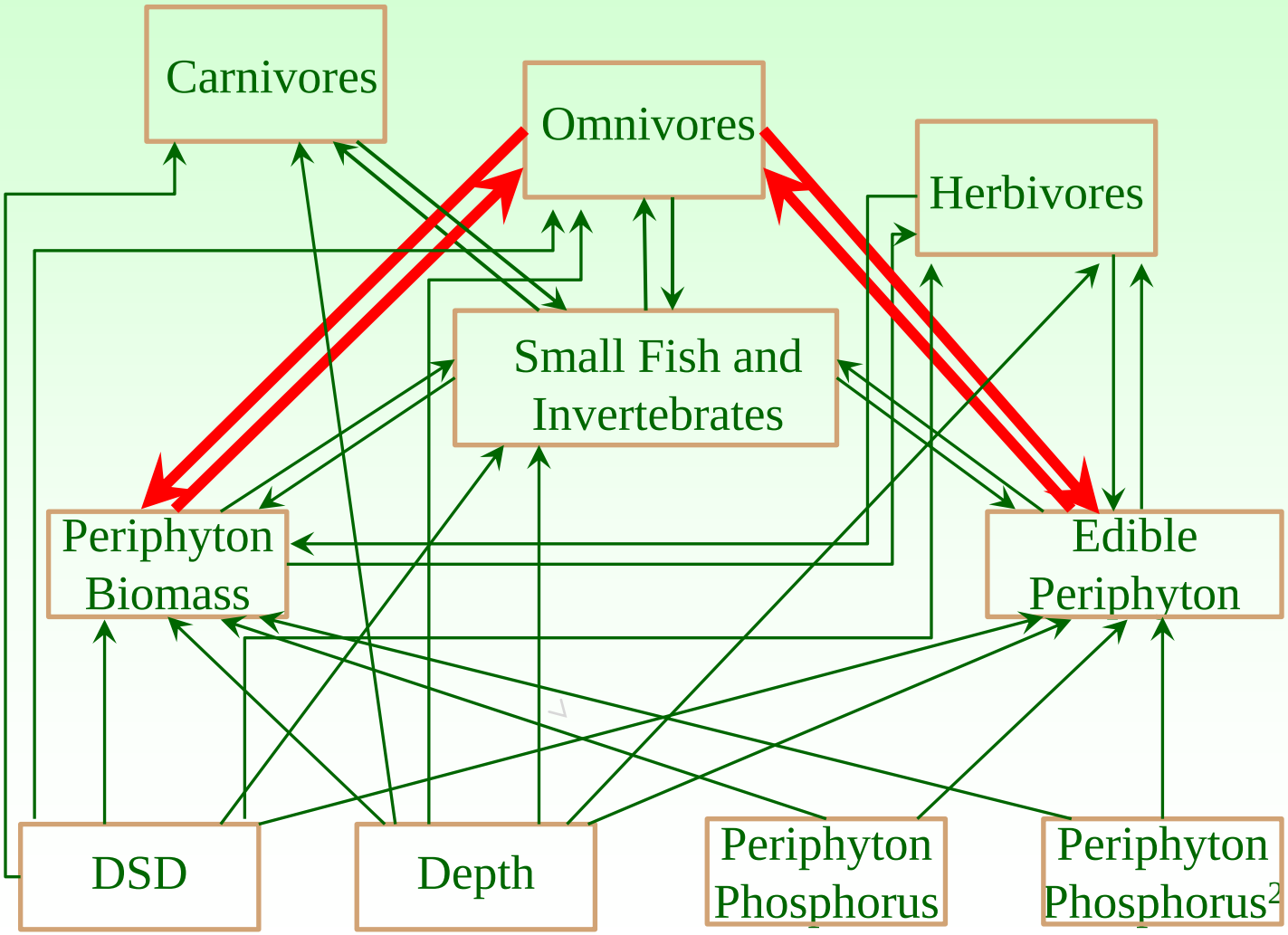
- Construct full models
- Remove paths of interest
- Results from X^2 analysis indicates model fit
- Compare computed AIC values (M*plus* v6.11)



Hypothesis 1: Size-Structured Interactions



Hypothesis 2: Omnivory

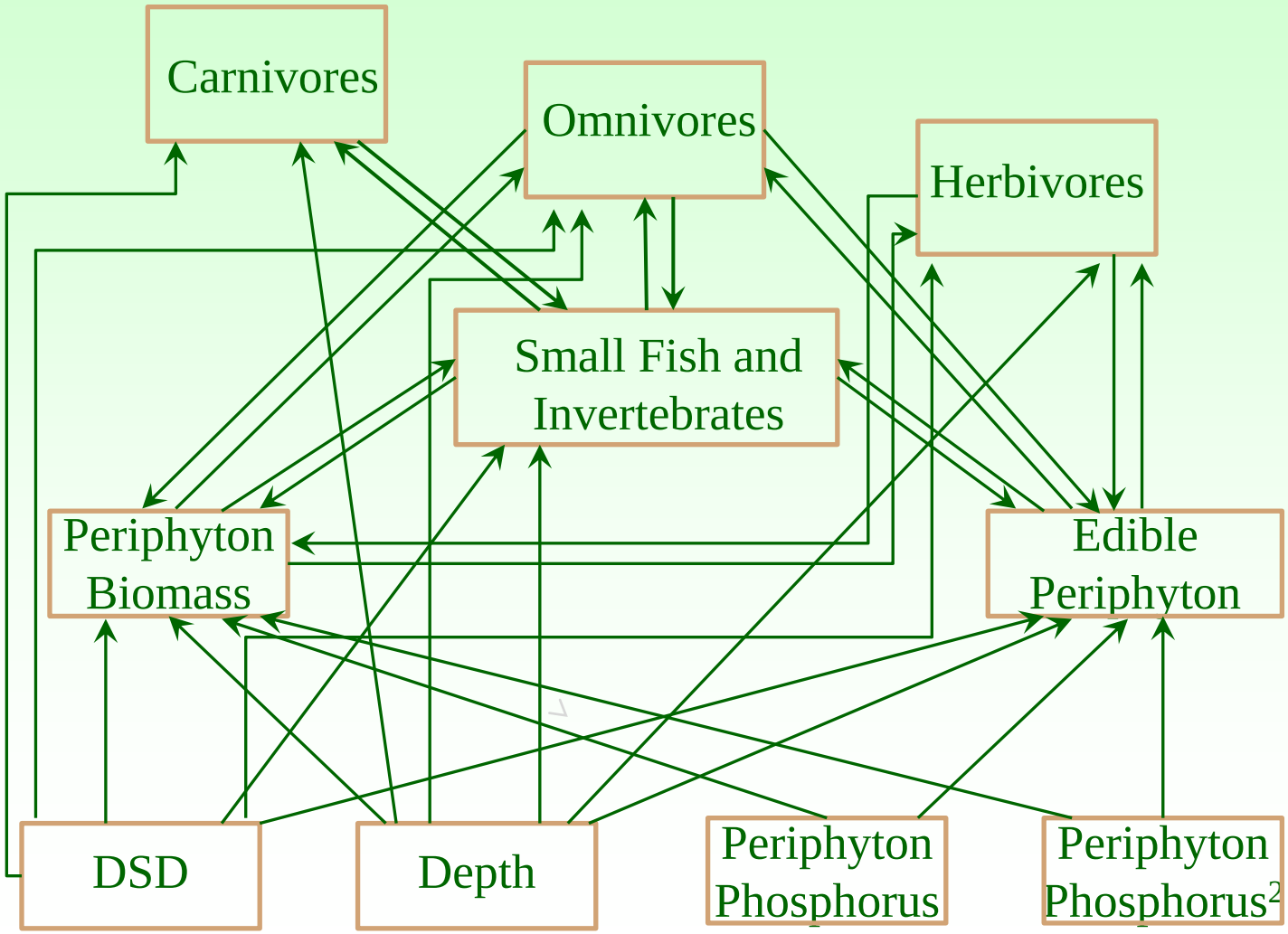


Model Comparison: ΔAIC Values Relative to the Full Model

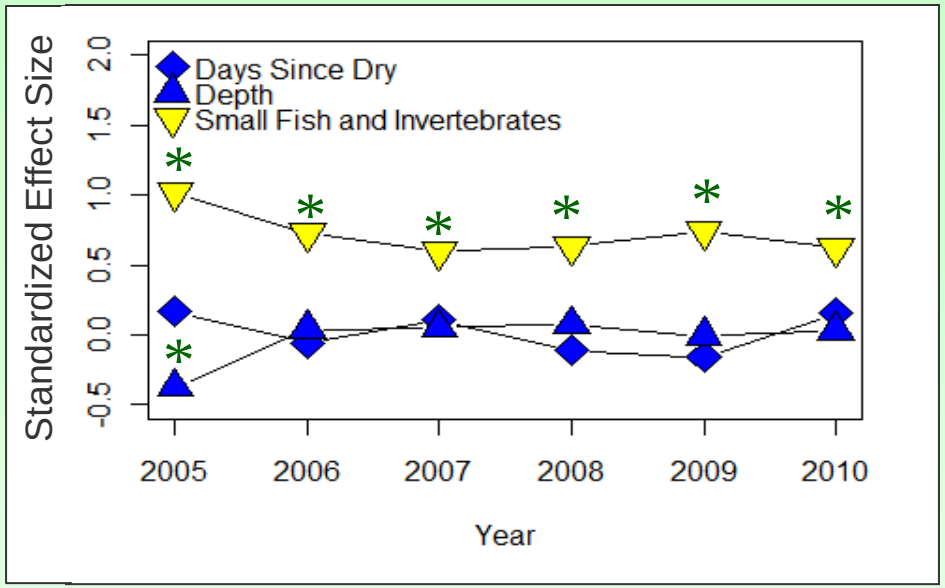
Paths Dropped	2005	2006	2007	2008	2009	2010
Size-Structured	337.20	250.43	249.80	278.69	227.33	325.25
Omnivory	13.11	5.31	23.56	11.20	13.01	21.26

- Large ΔAIC values indicate loss of information
- The full model best reflects community interactions
- Size-structured interactions may be more important than omnivory

Further Analysis of the Full Model



Direct Effects on Carnivore Biomass



Carnivores

Small Fish and Invertebrates

Periphyton Biomass

Edible Periphyton

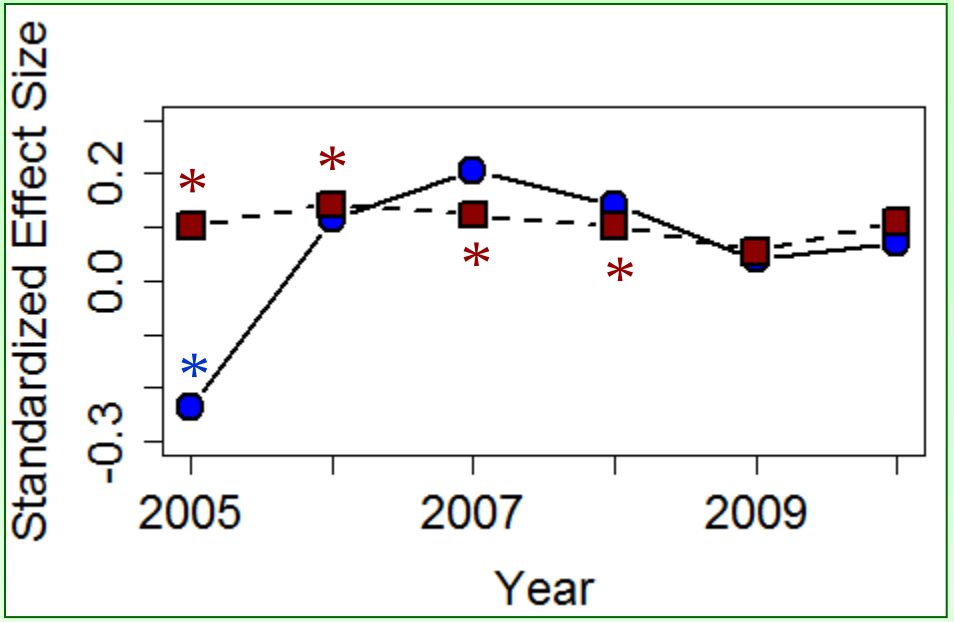
DSD

Depth

Periphyton Phosphorus

Periphyton Phosphorus^2

Indirect Effects of Hydrology on Carnivore Biomass



Carnivores

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Edible Periphyton

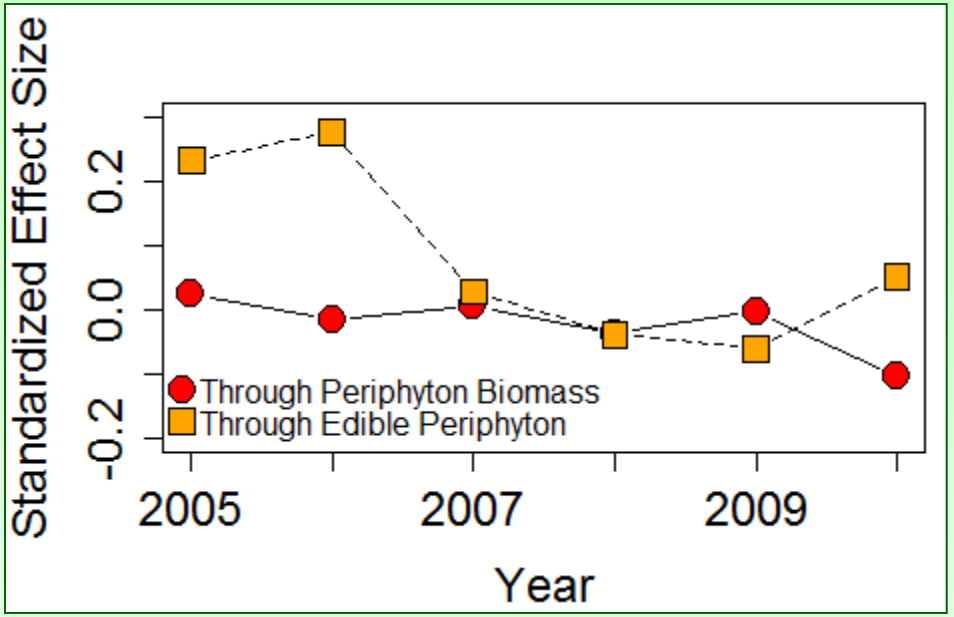
DSD

Depth

Periphyton Phosphorus

Periphyton Phosphorus^2

Indirect Effects of Phosphorus on Carnivore Biomass



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Periphyton Phosphorus

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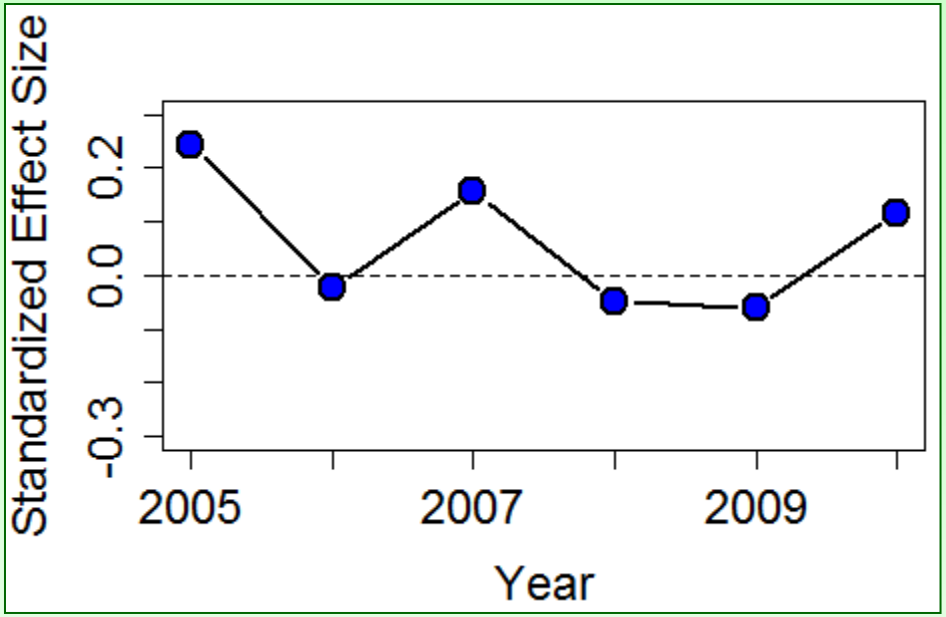
Effect Sizes Vary Over Time



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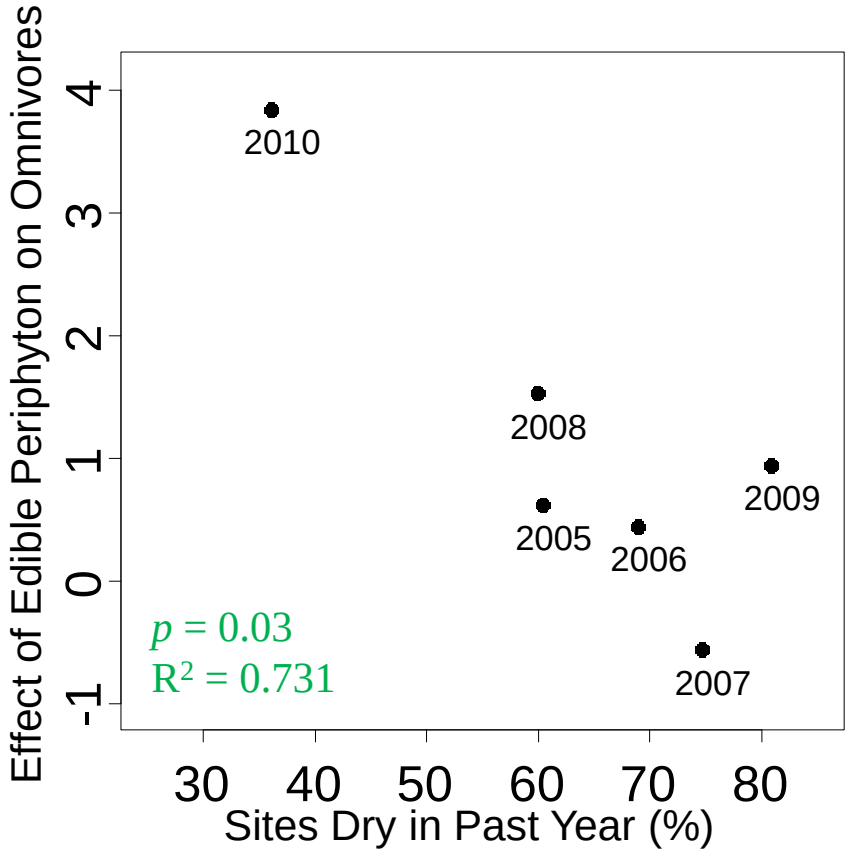
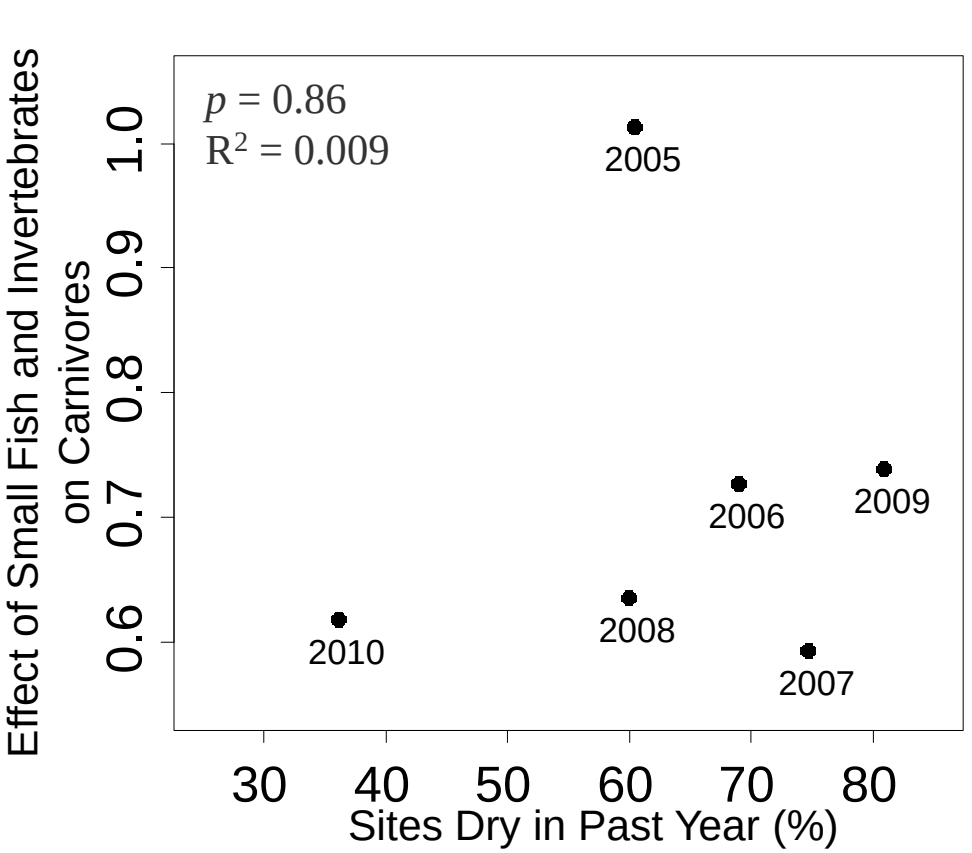
Effect Sizes Vary Over Time

- Hydrology
- Community Structure





Conclusions

- Experimental analysis of community structure
  - powerful
  - limited in spatial and temporal extent
- Combining experimental work with spatially and temporally broad sampling data
- Structural equation modeling provides a powerful analytical tool
  - Evaluate hypotheses
  - Partition direct and indirect effects

Conclusions

- Interaction models including omnivory and size-structured interactions best fit data
- Omnivory was less important than size-structured interactions
- Large-scale hydrology affect inter-annual variation in trophic interactions
- Future work: These results support inclusion of trophic interactions and top-down effects in simulation models

Acknowledgements

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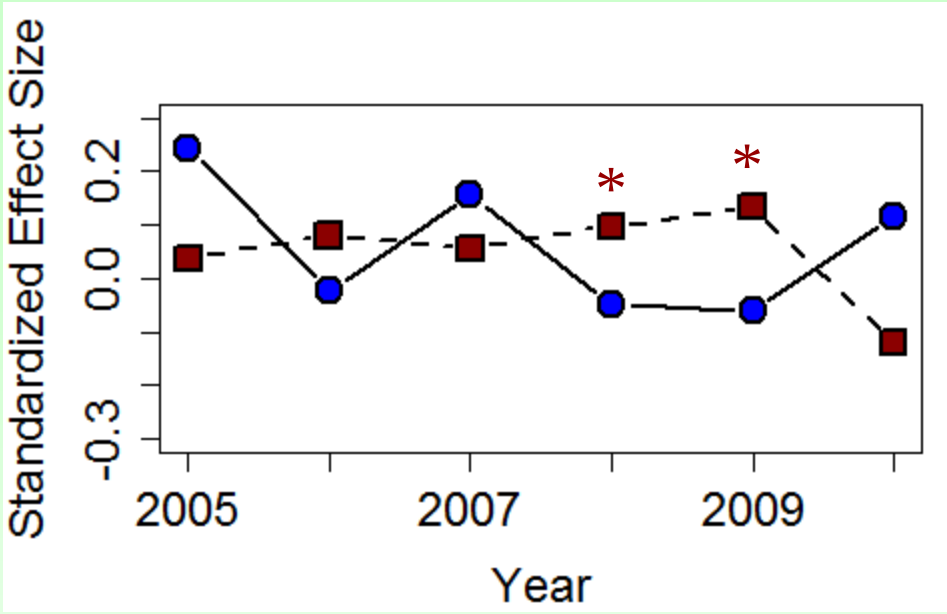
Indirect Effects of Hydrology on Carnivore Density



Large Carnivores

Small Fish and Invertebrates

Periphyton Biomass

Edible Periphyton

DSD

Depth

Periphyton Phosphorus

Periphyton Phosphorus^2