



Restoring Ecosystem Function in the P-Enriched Everglades:

Improving Habitat for Wildlife

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1. Current environmental conditions:
dense emergent vegetation & P storage

2. Create openings → increased habitat complexity
and quality → simulate ridge & slough?



3. Jump start restoration towards native
Everglades sawgrass ridge and slough
landscape?



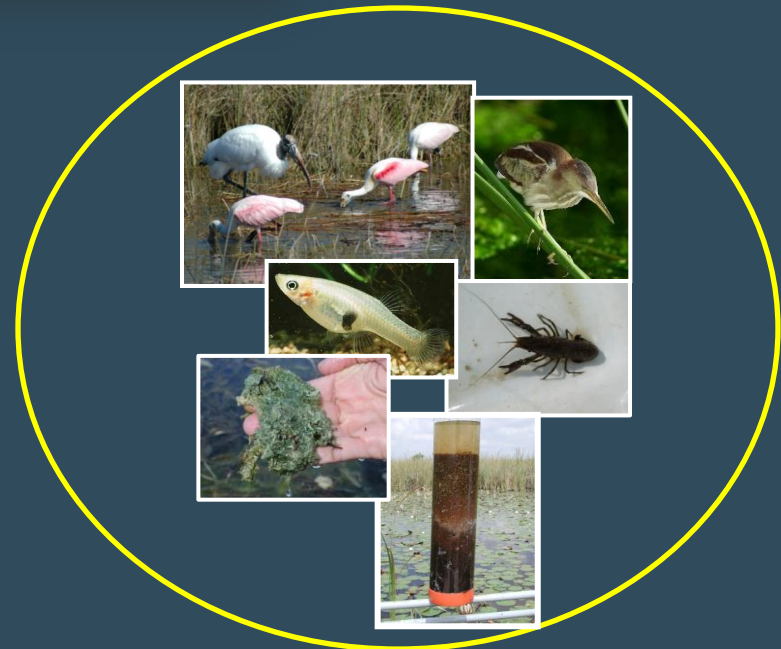
Ecosystem-Scale Experiment: Cattail Habitat Improvement Project

General Approach

1. Create & maintain large open plots (6.25 ha)



2. Measure: Nutrient storage & cycling
Ecosystem metabolism
Food web/community responses
C:N:P stoichiometry

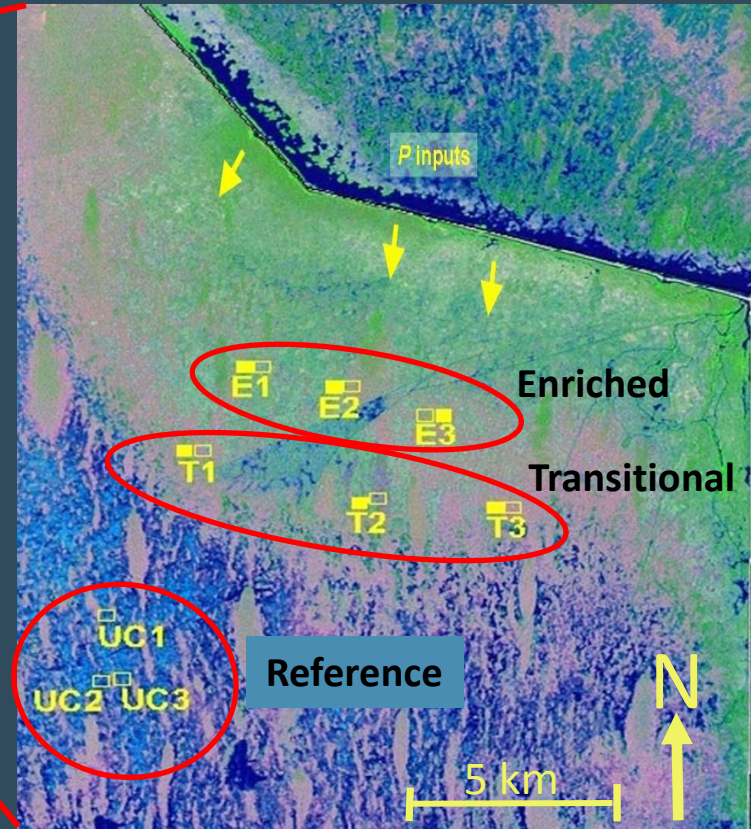
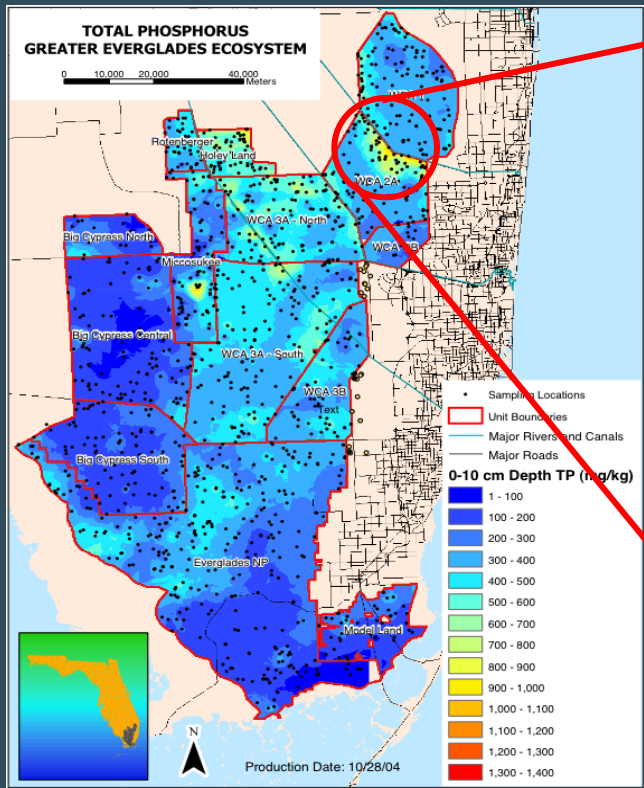


Primary Objectives

1. To test whether creating openings within densely vegetated areas will sufficiently alter trophic dynamics such that wildlife diversity and abundance is increased.
2. Assess to what extent the structure and function of these created open areas compare to the natural Everglades.



Experimental Design



Objective 1: Vegetation Removal

2 Treatments (Control & Open)

2 Regions (Enriched & Transitional)

3 Years (2007 – 2009)

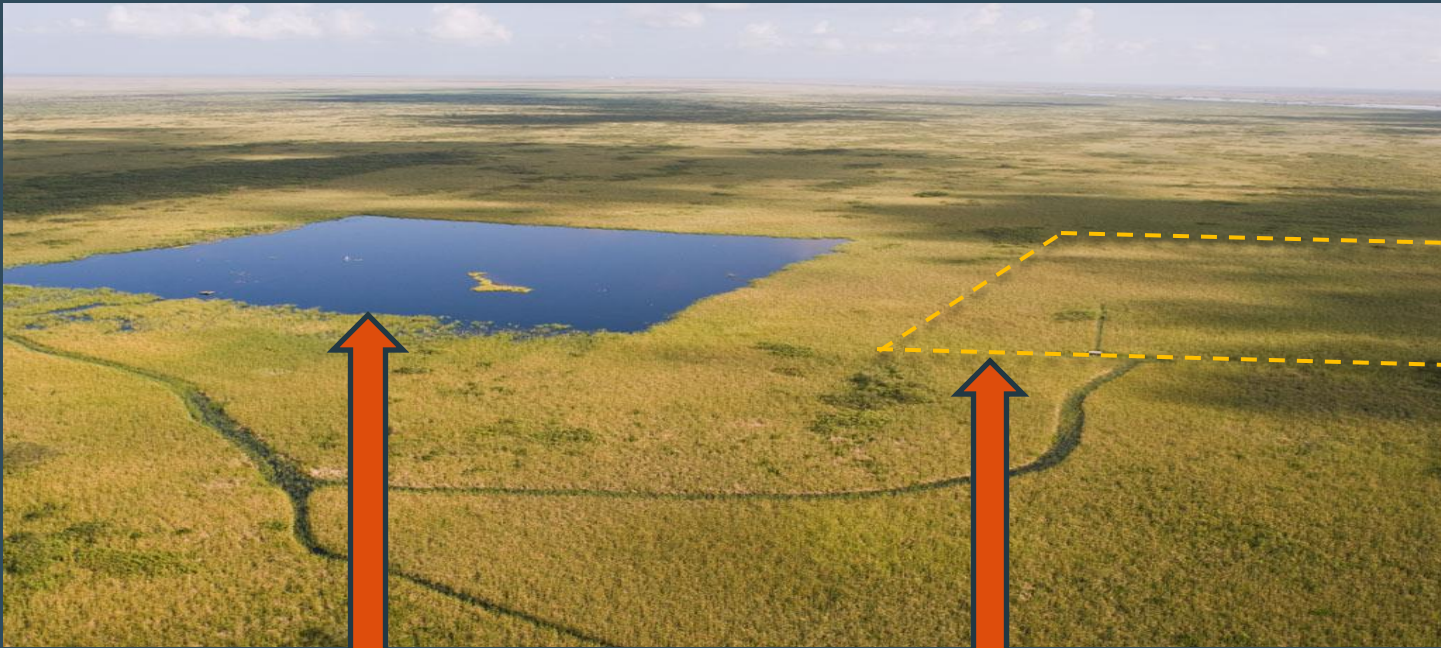
3 Replicates

Objective 2: Nutrient Enrichment

3 Regions (Enriched, Transitional, Reference)

3 Years (2007 – 2009)

3 Replicates



Hypotheses

Objective 1: Relative to emergent controls, **open** plots will :

- Experience greater production (biomass) of aquatic fauna
- Support a greater proportion of herbivores and omnivores
- Promote increased nutritional quality (C:P) of aquatic fauna
- Support increased avian foraging

Objective 2: Relative to oligotrophic reference, **open** plots will :

- Experience greater production (biomass) of aquatic fauna
- Support a greater proportion of herbivores and omnivores
- Promote increased nutritional quality (C:P) of aquatic fauna
- Support increased avian foraging

Habitat Characteristics of Plots

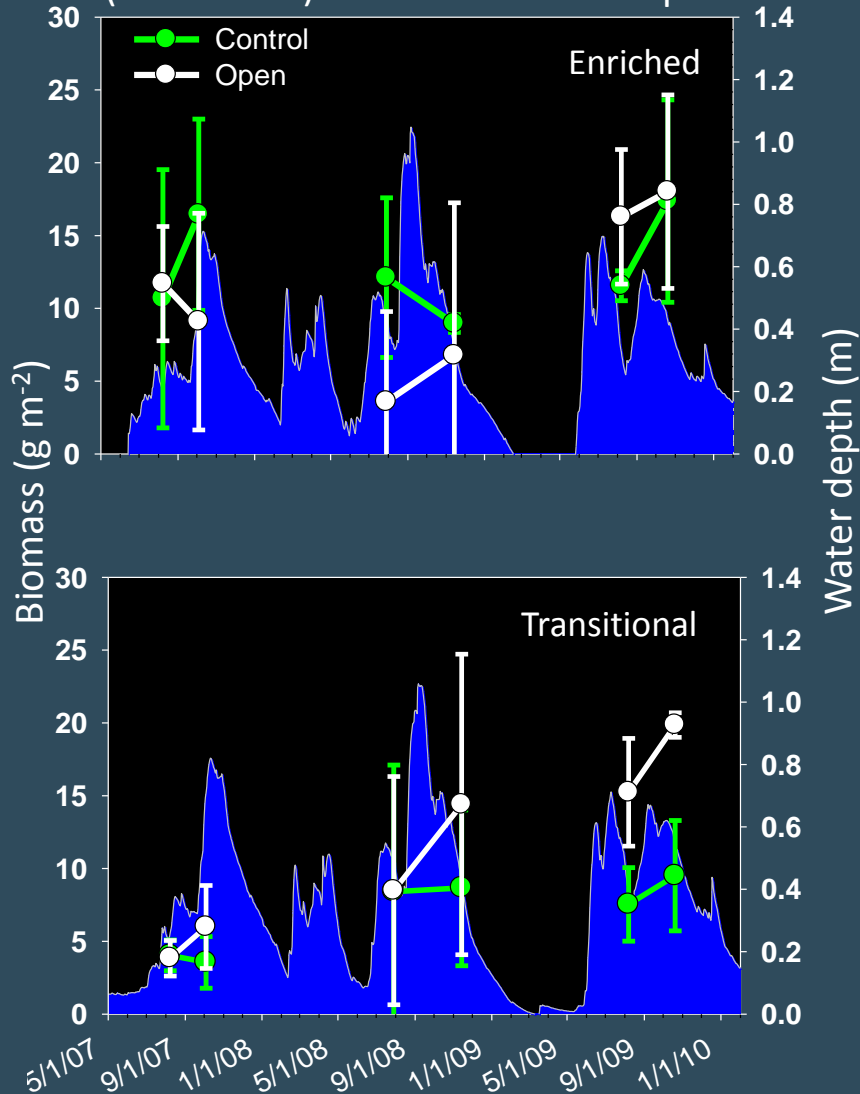
(mean \pm S.D., 2007-2009)

	Enriched		Transitional		Reference
	Control	Open	Control	Open	
Live Biomass (g m ⁻²)	712 \pm 265	103 \pm 229	561 \pm 273	109 \pm 128	37 \pm 13
Percent Emergent	98	13	99	10	35
Periphyton (g m ⁻²)	3 \pm 8	30 \pm 41	9 \pm 13	26 \pm 31	997 \pm 536
Dissolved O ₂ (mg L ⁻¹)	1.4 \pm 1.0	3.9 \pm 3.6	1.9 \pm 1.3	4.2 \pm 3.1	6.8 \pm 2.5

Vegetation treatment resulted in an ecosystem dominated by SAV/openwater

Vegetation Removal Influenced the Production of Aquatic Fauna but Effects Differed by Year & Region

Time series of combined biomass (mean±S.D.) of small fish & decapods



3-way ANOVA (blocked)

Source	Log Biomass	
	d.f.	<i>P</i>
Region x Treatment	1,60	0.02
Treatment x Year	2,60	0.04
Region x Year	2,60	0.01



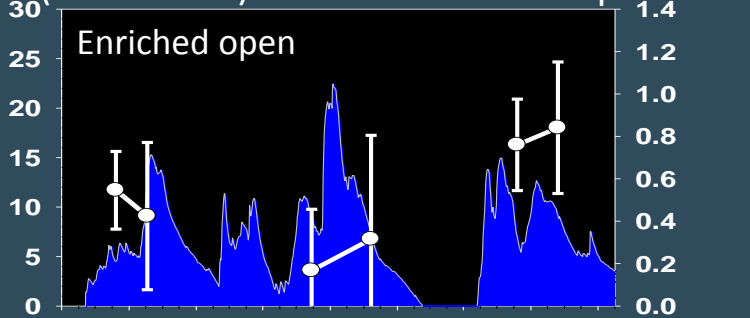
Biomass **similar** in EO and EC (LS Means $P = 0.29$)



Biomass **1.6x greater** in TO than TC (LS Means $P = 0.02$)

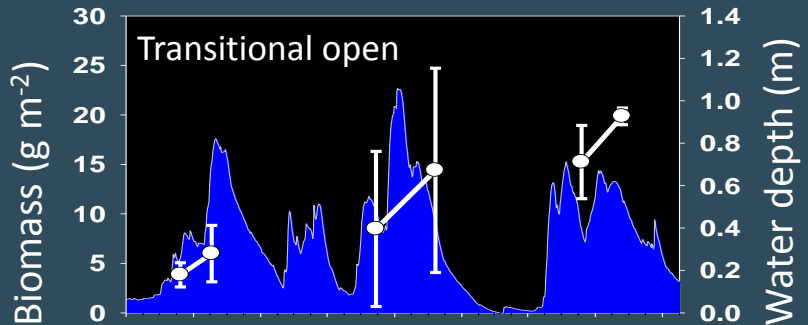
Vegetation Removal Promoted Greater Faunal Production Relative to Oligotrophic Reference

Time series of combined biomass (mean±S.D.) of small fish & decapods

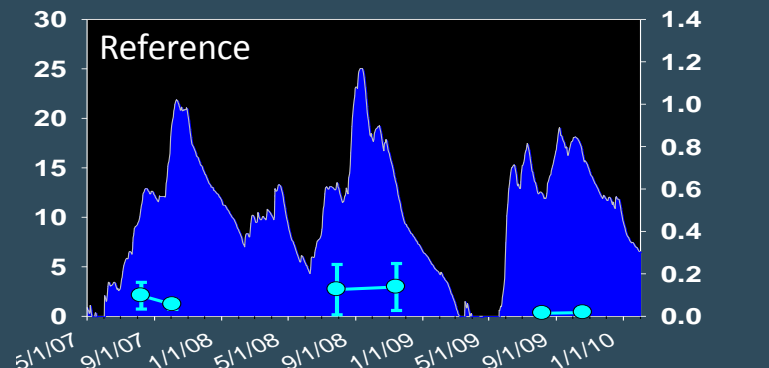


2-way ANOVA

Source	Log Biomass	
	d.f.	P
Region x	4,45	<0.01
Water Year		



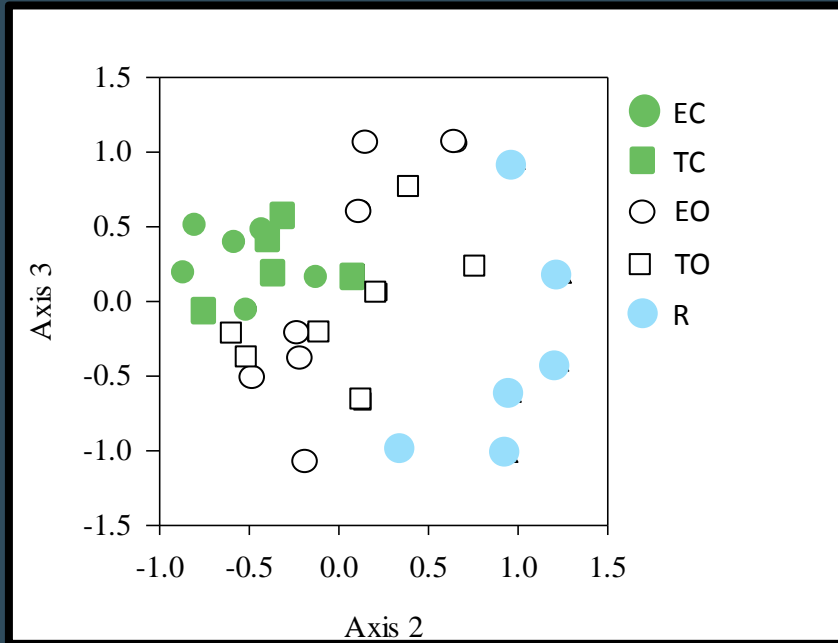
Biomass **similar** in EO & TO (LS Means $P = 0.48$)



Biomass **6.8x greater** in EO/TO than reference (LS Means $P < 0.0001$)

Open Plots were Dominated by Herbivores and Omnivores

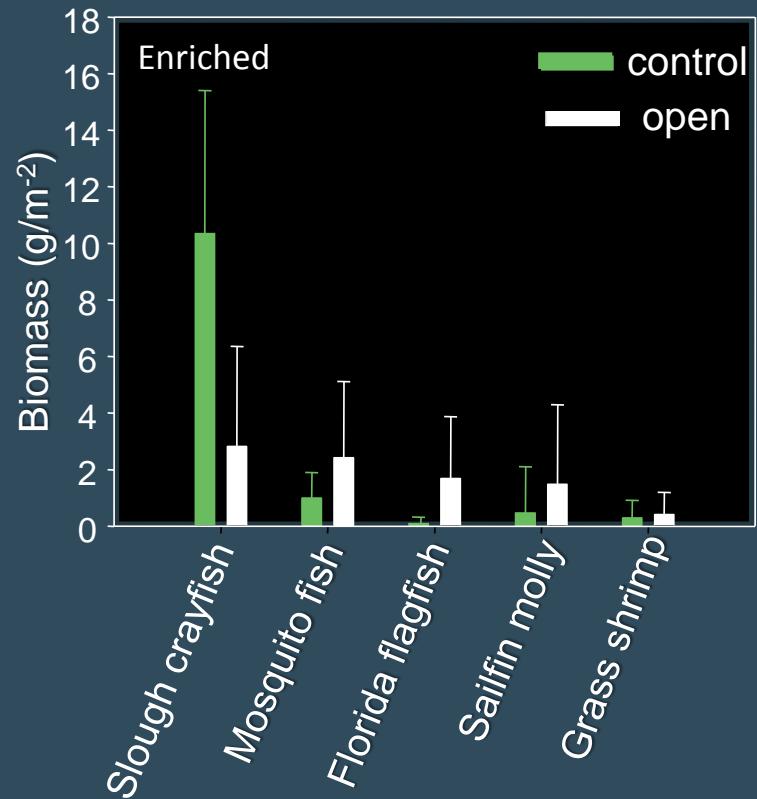
NMDS Ordination of Faunal Biomass



MRPP (control versus open plots):

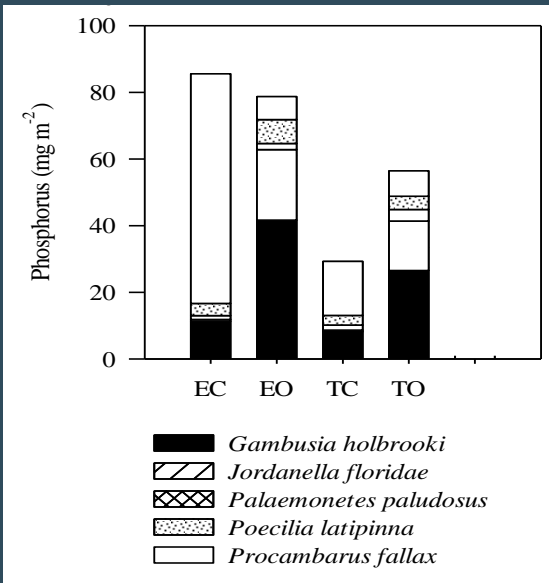
$A = 0.14, P < 0.001$

Biomass (mean \pm S.D.) of 5 species accounting for 83% of community dissimilarity



Vegetation Removal did not Improve the Quantity or Quality of Individuals

	Sailfin molly		Crayfish		fish relative to crayfish
	EC	EO	EC	EO	
C %	44.0 ± 1.9	47.0 ± 2.7	35.4 ± 4.2	37.6 ± 4.8	↑
N %	10.2 ± 0.7	10.4 ± 1.2	8.1 ± 1.0	8.6 ± 1.0	↑
P %	2.6 ± 0.1	2.2 ± 0.5	1.3 ± 0.2	1.2 ± 0.1	↑
C:P (quality)	43.5 ± 3.1	53.0 ± 12.6	74.5 ± 21.2	85.5 ± 15.8	↑
Calories (kcal ind⁻¹)	0.93 ± 0.4	0.36 ± 0.38	1.31 ± 1.16	1.15 ± 1.32	↓



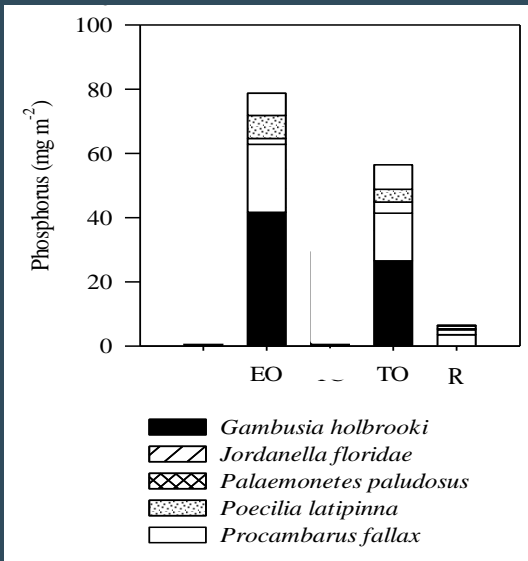
Average total & proportional mass of phosphorus/m²

Openings improved ecosystem function through improved quality & diversity of the prey community.



Quantity & Quality of Individuals were Greater in Eutrophic Openings than in Oligotrophic Everglades

	Sailfin molly		Crayfish		Reference vs. Opens
	EO	Reference	EO	Reference	
C %	47.0 ± 2.7	53.7 ± 2.6	37.6 ± 4.8	36.4 ± 3.6	↑/=
N %	10.4 ± 1.2	7.9 ± 1.6	8.6 ± 1.0	7.7 ± 1.1	↓
P%	2.2 ± 0.5	1.1 ± 0.1	1.2 ± 0.1	0.8 ± 0.2	↓
C:P	53.0 ± 12.6	126 ± 19.7	85.5 ± 15.8	126 ± 34.5	↑
Calories (kcal ind ⁻¹)	0.36 ± 0.38	0.26 ± 0.29	1.15 ± 1.32	0.32 ± 0.2	↓



Average total & proportional mass of phosphorus/m²

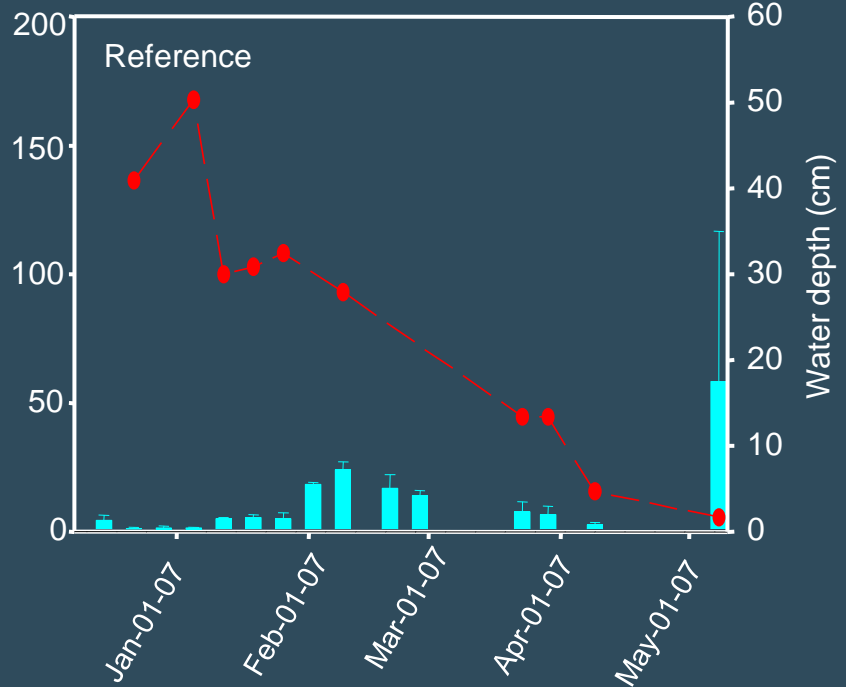
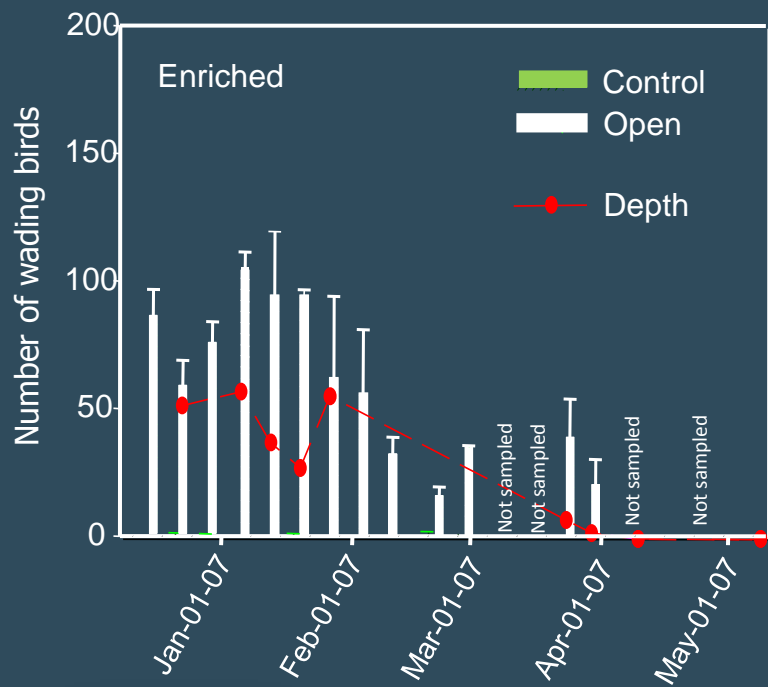




Vegetation Removal Considerably Improved Foraging Conditions for Wading Birds

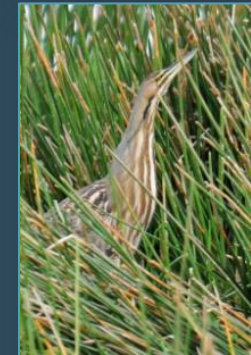
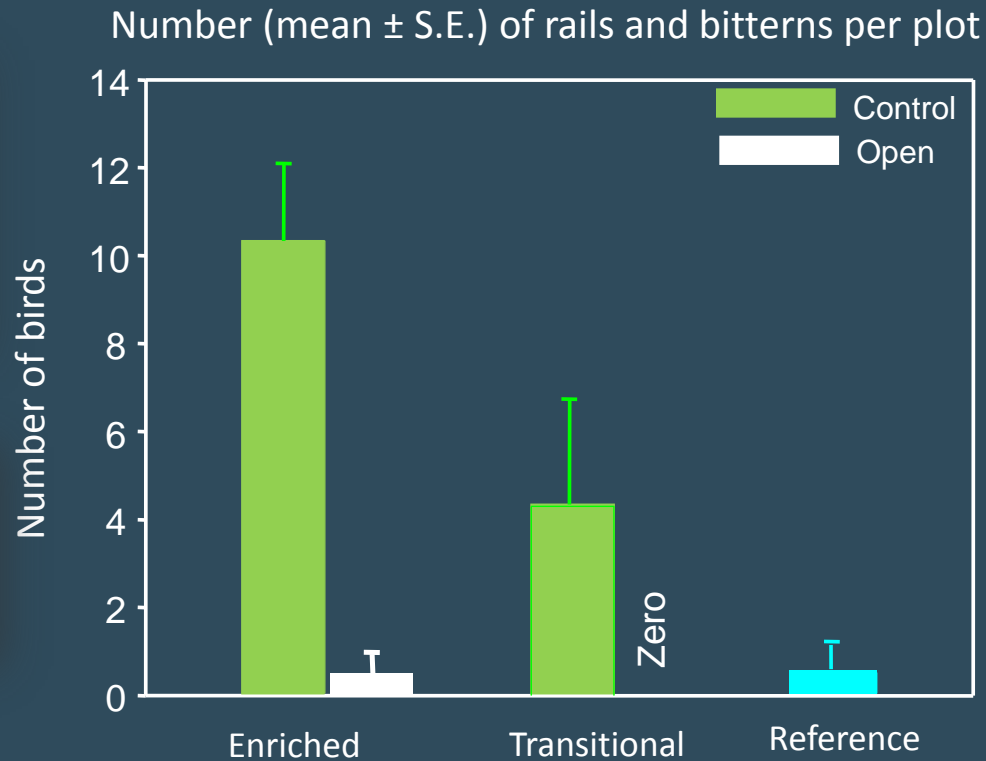


Time series of number of wading birds (mean \pm S.E.) per plot in 2007



Invertivorous white ibis dominated (>50%) the wading bird community in open plots

Dense Cattail is an Important Habitat for Listed Species of Rails & Bitterns

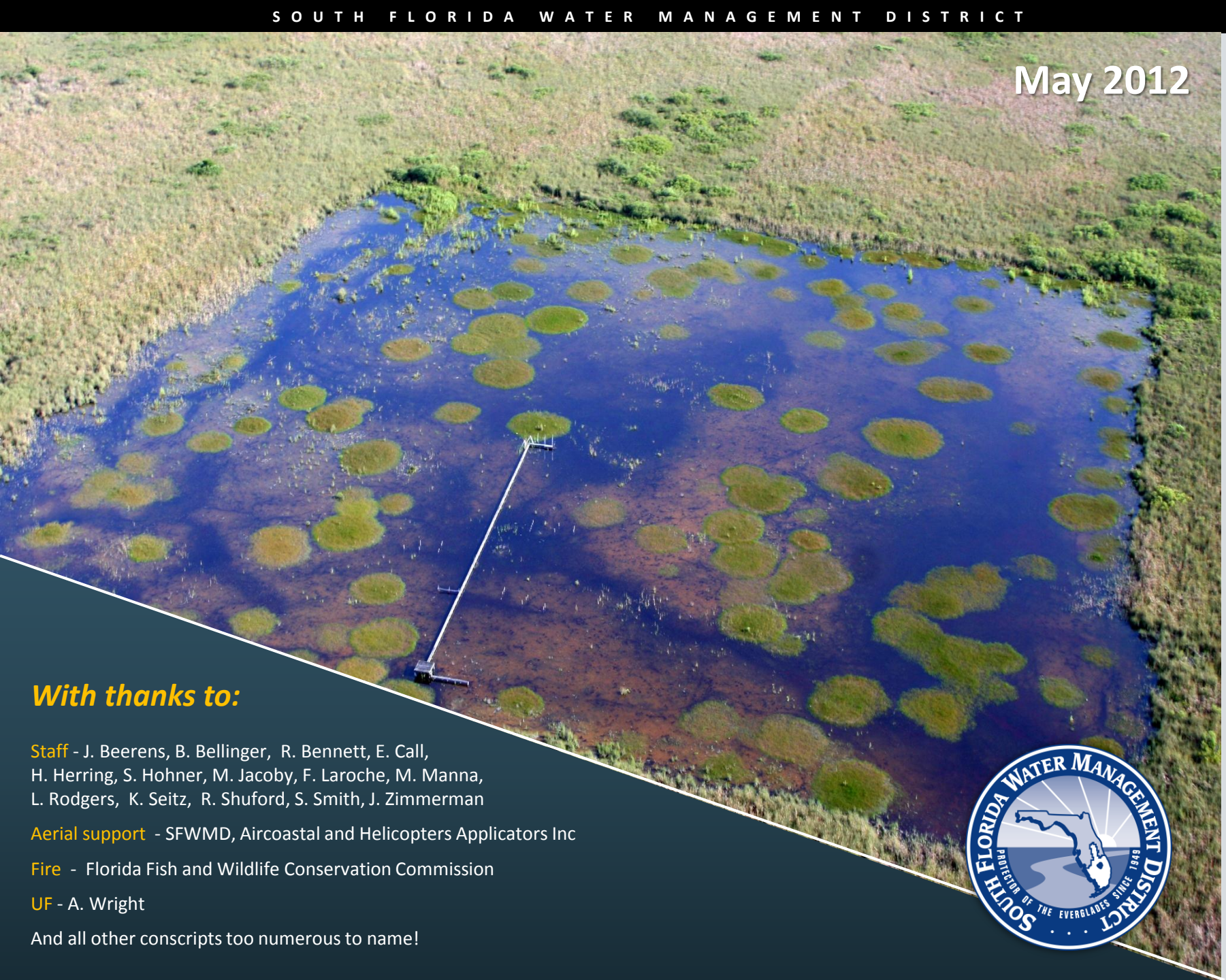


Consider employing a mosaic of openings and dense vegetation as a restoration strategy?

Summary

- Eutrophication increases secondary production in the oligotrophic Everglades (greater biomass of crayfish in the cattail region).
- But invasive emergent vegetation creates a physical barrier to many predators.
- Active management (openings)
 - Maintained abundance and biomass
 - Resulted in a compositional shift towards a higher quality, more varied prey resource
- Openings are therefore different in function from the oligotrophic Everglades but provide benefits by providing abundant high quality prey.
- Cattail is an important habitat for rails and bitterns.

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