Quantifying the Nitrogen Cycle in Freshwater Marshes of the Southern Everglades Using *In Situ* Mesocosms and Natural Abundances

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Abstract

This project addresses the question of how hydrologic restoration of the Southern Everglades impacts the overall nutrient dynamics of the ecosystem. Specifically, this project analyzes these effects by quantifying the nitrogen cycle in the region via stable isotope tracer techniques. ***In situ*** studies of the natural isotopic abundance of C and N are an intriguing complement to our 15N mesocosm tracer research. One might question the importance of studying nitrogen cycling in ecosystems that we know are phosphorus limited. We argue that N-cycling dynamics are important because: 1) the fate of canal borne N is an important management issue; 2) how Everglades wetlands process N likely plays an important role in determining the magnitude and composition of N being supplied to downstream estuaries and coastal ecosystems, and; 3) the N cycle may be an excellent barometer of the degree of P limitation in all Everglades ecosystems. Our first marsh transect sampling generated intriguing results: Periphyton, plants, and soils at the site adjacent to the C-111 canal were relatively enriched (heavier in N15), presumably because of inputs of older, heavier N from the canal. This demonstrates substantial N uptake adjacent to the canal, even in a system that is being regulated by P availability. What was most surprising, though, was that only 4 km from the canal, the N in periphyton, soils, and plants was considerably lighter or less enriched. These lighter values are likely because more of the nitrogen being cycled at this location is being derived from atmospheric fixation or lighter upstream sources. This also suggests that there is much less canal N influence at this location, suggesting that canal borne N may be taken up and processed surprisingly rapidly by these southern Everglades wetlands. We will be expanding our annual sampling of natural N isotope abundances along several water flow transects in the southern Everglades. These data, coupled with our process-based information from the mesocosm studies, will provide valuable information to water managers on the transformation and fate of nutrients in the Everglades.

Study System

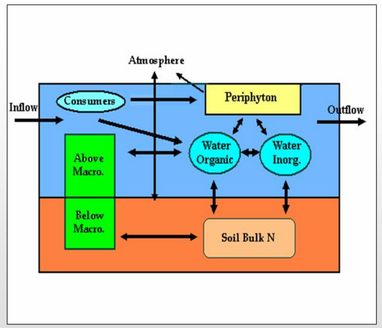

Figure 1: Conceptual diagram of primary ecosystem components and processes that were studied in the mesocosm experiment.

⇒ In 1996, the removal of the C-111 levee completely altered the regions hydrology.

⇒ Water from canal currently flows across the marsh, through the basin, and finally into Florida Bay.

⇒ Hydrology of region controlled by SFWMD (via water control structures) and through precipitation inputs to the basin.

⇒ Phosphorus is the limiting nutrient in the marshes studied. The marsh system is a sink for TP.

⇒ The marsh is also a source of TN, DOM, and a sink for inorganic nitrogen

⇒ Figure 1 depicts the nitrogen cycle of the region and the components that were studied in this experiment. Study sites are show in Figure 2.

Figure 2: Landsat map of South Florida with FCE sites overlaid. Red box show C-111 basin and the study sites (TS/PH 4 & TS/PH-5).

Methodology

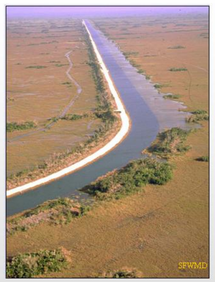

Figure 3: C-111 canal site TS/PH-4 after levee removal.

⇒ Six (6) $2m^2$ mesocosm (aprox 1.6m diameter) were installed at TS/PH-4.

⇒ ^{15}N labeled $Ca(NO_3)^2$ was added to three (3) of the mesocosms the day following mesocosm installation.

⇒ The tracer added possessed a $d^{15}N$ value of 300‰ & 1.5µM nitrogen concentration.

⇒ Periphyton and water sampled: T=0, 5, 10, 20, and 30min, 1, 3, and 6hours, 2, 3, 5, 9, 15, and 21days.

⇒ Soil Cores soil core was taken and sectioned into 0-1cm, 1-5cm, and 5-10cm samples. Soil sampled: T=0, 9day, and 21day.

⇒ Macrophytes samples: T=0, 5, 9, 15, and 21days. Both above and below ground samples of *Cladium jamaicense* were collected

⇒ Consumers sampled: T=0, 3hour, 2, 5, 9, 15, and 21days.

⇒ Samples were collected at two sites, TS/PH-4 and TS/PH-5 to determine the natural abundances of both C^{13} and N^{15}. Samples collected: soil, above-belowground macrophytes, and periphyton.

Figure 4: Picture of ***in situ*** mesocosm at TS/PH4.

^{15}N Natural Abundances

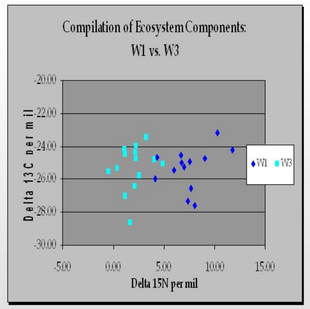

Figure 5: Natural abundance of $d^{15}N$ and $d^{13}C$ of soil, above- belowground macrophytes, and periphyton collected at TS/PH-4 (near canal) & TS/PH-5 (4km from canal).

⇒ ^{15}N natural abundance samples were collected at the near canal site TS/PH-4 and at the down marsh site TS/PH-5.

⇒ Figure 1 illustrates the isotopic differences in the samples for these two sites; Figures 2 & 3 show the individual sites.

⇒ The near canal TS/PH-4 possesses much heavier (more enriched) delta 15N values than the down mash TS/PH-5 site that consists of lighter (less enriched) isotopic values.

⇒ These more enriched values directly adjacent to the canal lead us to believe that the marsh is highly active in N uptake, presumably of older/heavier N derived from the canal.

⇒ The values at TS/PH-5 demonstrate that the nitrogen being cycled is derived from a lighter source (atmospheric or upstream source)

⇒ Based on these data, we propose natural abundance sampling on a system wide scale. Two cross-system transects will be sampled during the 2004 wet season. One in both Shark and Taylor Sloughs.

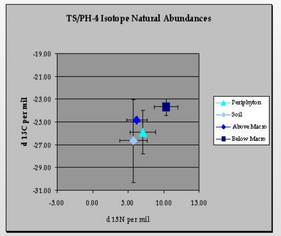

Figure 6: Natural abundance of $d^{15}N$ and $d^{13}C$ of primary ecosystem components at TS/PH-4.

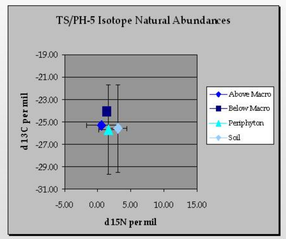

Figure 7: Natural abundance of $d^{15}N$ and $d^{13}C$ of primary ecosystem components at TS/PH-5.

In situ Mesocosm Experiment

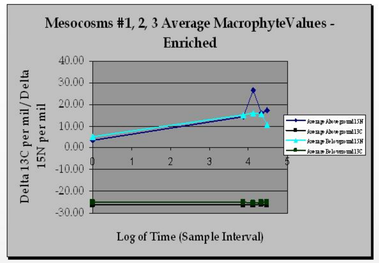

Figure 8: $\delta^{15}N$ and $\delta^{13}C$ values for above-belowground macrophytes (*Cladium jamaicense)* collected from three enriched mesocosms.

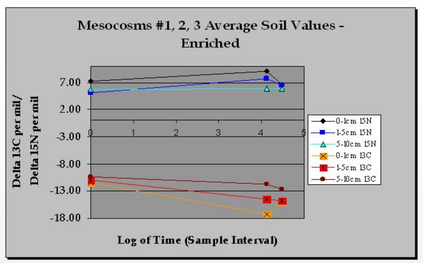

Figure 9: $\delta^{15}N$ and $\delta^{13}C$ values for soil samples. Sample were divided into 0-1, 1-5 and 5-10 cm sections.

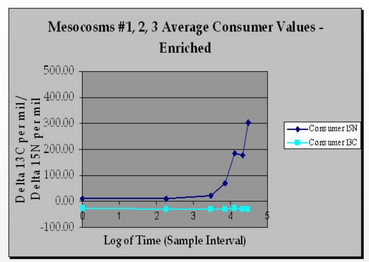

Figure 10: $\delta^{15}N$ and $\delta^{13}C$ values for consumers. All samples collected were composed solely of *Gambusia holbrooki* collected from three enriched mesocosms.

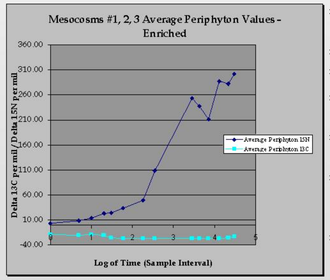

Figure 11: $\delta^{15}N$ and $\delta^{13}C$ values for periphyton samples collected from three enriched mesocosms.

⇒ Mesocosms 1, 2, and 3 were enriched with the isotopic tracer; mesocosm 4, 5, and 6 acted as controls.

⇒ All control mesocosm $\delta^{15}N$ values remained constant throughout the entire 21day trial.

⇒ Tracer uptake occurred in all ecosystem components that were sampled.

⇒ Aboveground macrophytes were more enriched than belowground samples.

⇒ 0-1cm soil samples had the greatest uptake of tracer while the 5-10cm layer of soil remained at natural abundance levels throughout the experiment.

⇒ Consumer samples (*Gambusia holbrooki*) increased throughout the experiment and on day 21 had a delta ^{15}N of 304.43 per mil.

⇒ Periphyton showed tracer uptake within the first five minutes after dosage (initial=3.93 & 5min=8.55 per mil). The maximum value of 302.63 per mil occurred on day 21.

⇒ There was an unexplained drop in ^{13}C values for both the enriched and non-enriched periphyton samples. The drop occurred between the 20 and 30minute sample intervals.

⇒ A second six (6) mesocosm experiment was carried out at TS/PH-4 in the '03 wet season. Two more six mesocosm experiments will be conducted at TS/PH-5 in the '04 wet season. Two of these experiments will include phosphorus dosing.

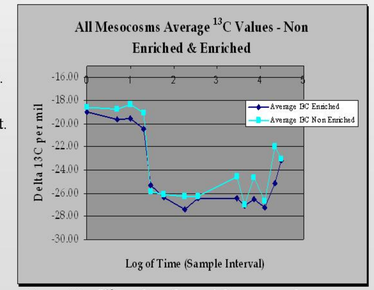

Figure 12: $\delta^{13}C$ values for periphyton samples collected from all 6 mesocosms - both enriched and non-enriched values are shown.