Nutrient Cycling, Litter Accumulation, and Decomposition in Seasonally Flooded Tree Islands of the Southern Everglades

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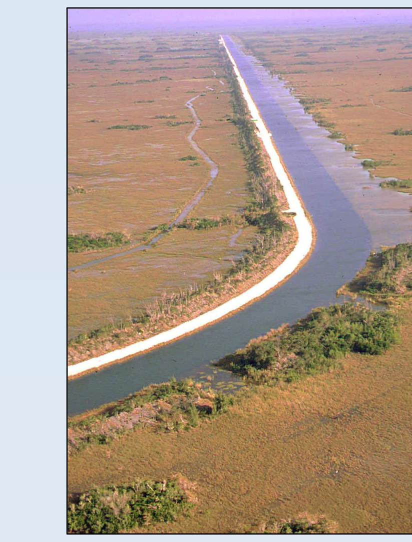


Abstract

Freshwater flow is the subject of great interest concerning Everglades restoration. Restoring freshwater flow to the system will not only increase flow, but may also increase nutrient inputs to downstream communities. The southern Everglades is one of the first regions to undergo hydrologic restoration, and is thus a good test for predicting the effect of large-scale Everglades restoration. In this study, part of an ongoing, long-term experiment, we characterized pool sizes and fluxes of phosphorus, nitrogen, and the primary organic matter cycles through southern Everglades tree islands. Our goal is to utilize this base ecosystem model to quantify the affects of increased freshwater flow through hydrologic restoration of the southern Everglades. In seasonally flooded tree islands, leaf litterfall contributes the greatest proportion of organic matter, and approximately 60% is accumulated on the forest floor. Our modeling effort shows that P and N are also largely retained within the tree island system, with limited remineralization to soil porewater. However, preliminary decomposition estimates show that 40% of cocoplum leaf litter undergoes decomposition within 18 months. Large accumulation and low remineralization would suggest that decomposition rates must be influenced by surface water flowing through tree islands seasonally. We estimated that a relatively large proportion of tree island litterfall is available for marsh ecosystem processes through decomposition, and will likely have a greater influence if loading of available nutrients increases with increasing freshwater flow through the southern Everglades.

Introduction

Tree island communities are a unique component of the Everglades landscape. The existence of these islands increases habitat complexity, and consequently, increases the diversity of the Everglades flora and fauna. Hydrologic restoration of the Everglades landscape is currently underway, and the effects of increased freshwater flow on Everglades biotic communities, including tree islands, are unknown. Wetland ecosystem studies are complex, but necessary to understand how ecosystems will respond to landscape-scale perturbations. With this project, we have established an ecosystem experiment to characterize the ecological structure and function of wetland tree islands and their ecosystem response to increased freshwater flow in the southern Everglades. The primary objectives of our research are: 1) to describe the ecosystem properties of seasonally flooded tree islands and 2) to determine the effects of hydrologic restoration (increasing water flow and nutrient inputs) on the structural and ecosystem properties of tree islands in the southern Everglades. We are addressing our objectives by testing several hypotheses guided by a prominent theory in wetland ecology that increased freshwater flow is a subsidy to forested wetland communities, oxidizing wetland soils and increasing nutrient supply (Odum et al., 1979).

Methods

In the southern Everglades, the C-111 levee was removed in 1997 to restore freshwater inputs to the downstream marsh and to Florida Bay. We selected nine islands downstream of or adjacent to the levee removal segment of the C-111 canal. The islands were chosen based on similar size, vegetation composition, and general relief. To address our objectives and hypothesis, we are quantifying vegetation composition, primary production, plant nutrient-use efficiency, soil biogeochemical properties, decomposition rates, litter turnover rates, island geomorphology, and key hydrologic parameters of the landscape in the southern Everglades. The research began in August 1999, and will continue through July 2004. Here, we present only a subset of the larger research project.

Experimental Design

Three treatments groups

1) **"Flow"**- islands encounter both flow and nutrient effects of canal water delivery
2) **"Walled"** - sheetflow is reduced by experimental manipulation, but island experience similar hydroperiod as flow islands
3) **"No Flow"**- islands are located in an area of the marsh where levee removal has not been implemented and therefore have greatly reduced flow and nutrient effects

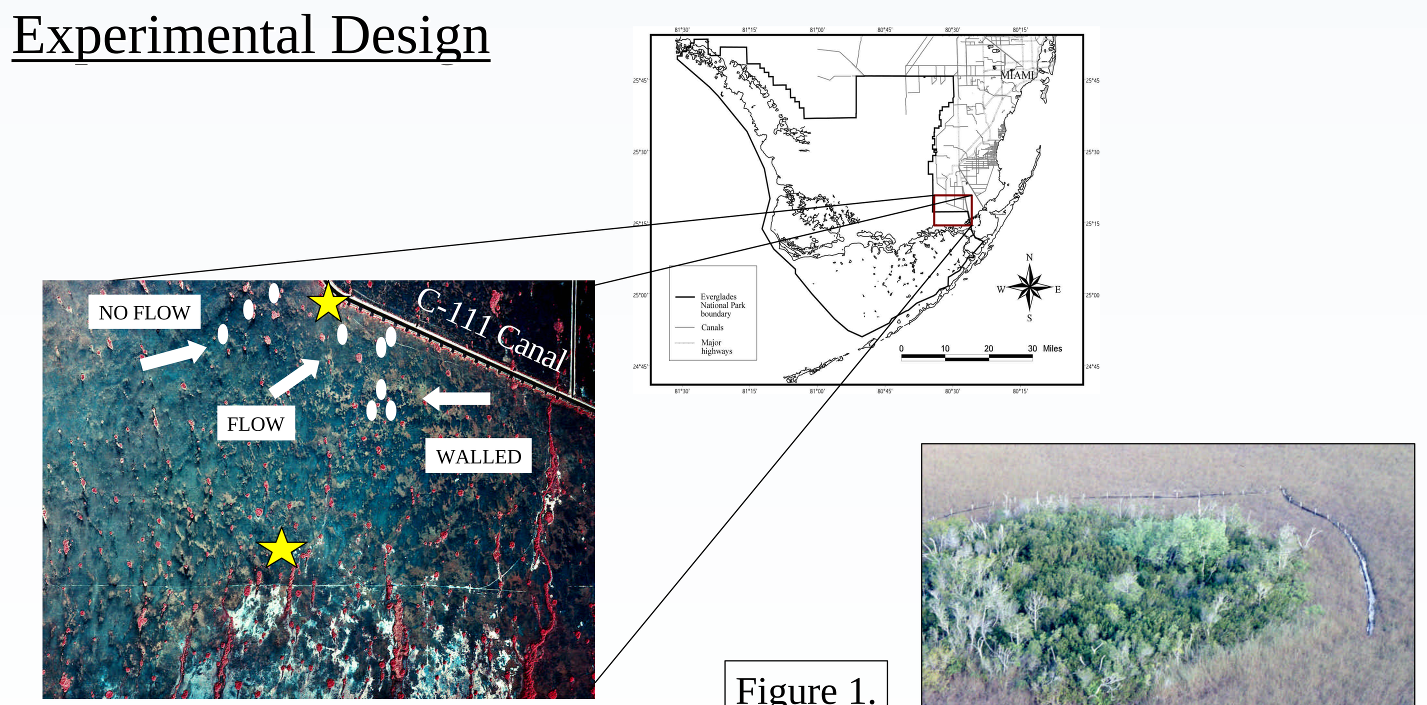


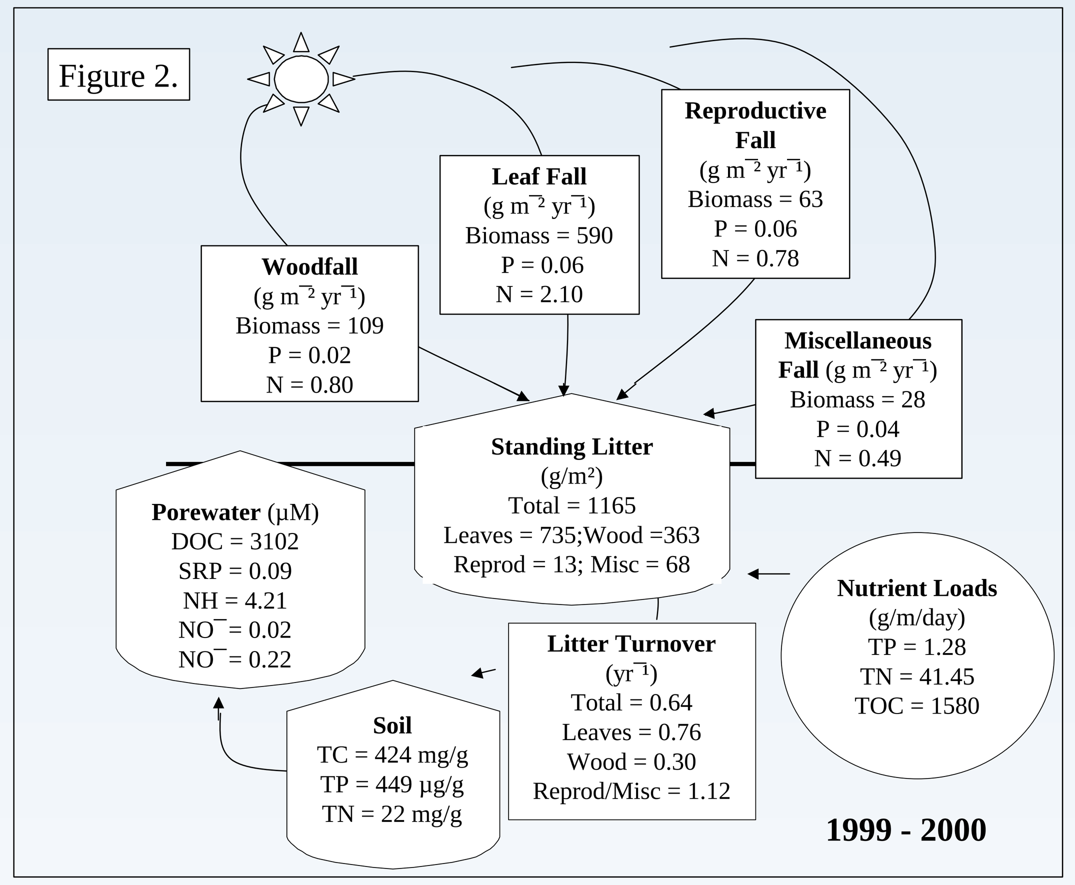
Figure 1.

☆ Our study area corresponds to LTER sites TS/Ph 4 and TS/Ph 5.

Results and Discussion

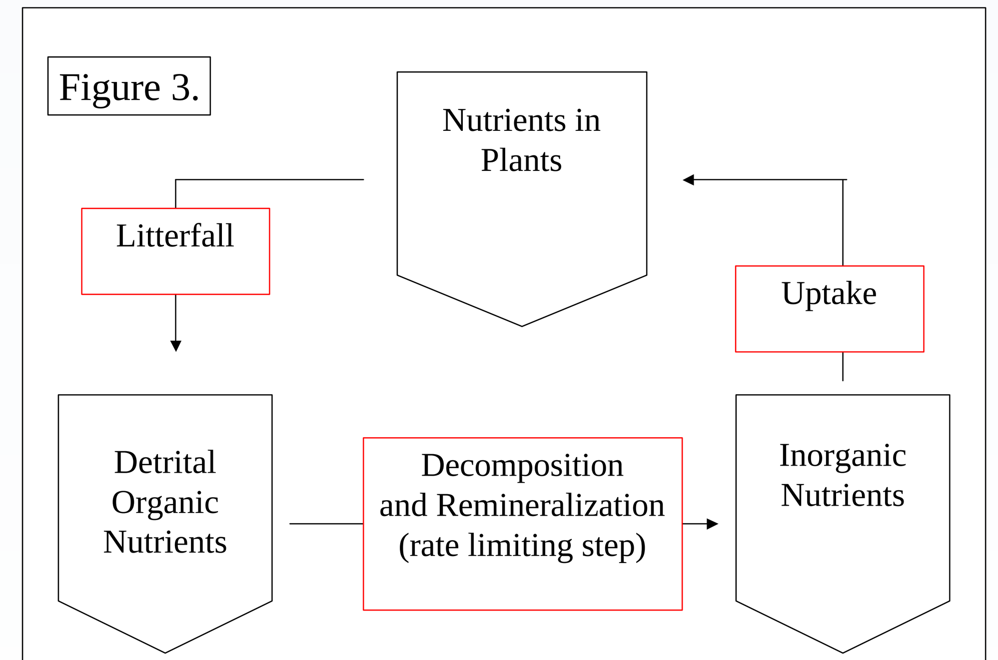
We estimated average values for annual biomass and nutrient fluxes through southern Everglades tree islands (Figure 2). By quantifying the changes to these pools and fluxes over the five year research project, we will determine how increasing freshwater flows through hydrological restoration of the Everglades affects ecosystem processes of southern Everglades tree islands.

Figure 2.



Two important factors immediately become clear when analyzing flows and pools sizes in seasonally flooded tree islands: 1) leaf fall contributes the greatest proportion of organic matter to these systems, and this leaf fall is retained in forest soils 2) phosphorus and nitrogen in leaf fall and porewater is low, but P and N in soils is relatively high. These factors suggest that these systems are accumulating organic matter, P and N, and that decomposition is limited by the remineralization of P and N (Figure 3).

Figure 3.

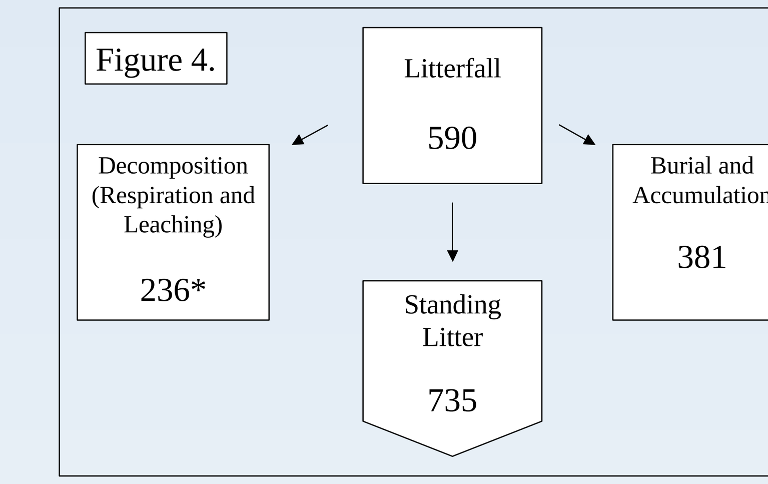


Annual leaf litterfall cycling in seasonally flooded tree islands ($g\ m^{-2}\ yr^{-1}$) – average values for six islands (*estimated value)

Tree islands of the southern Everglades generate large pools of organic matter which may contribute to marsh ecosystem processes.

A closer look at tree island leaf litterfall cycling shows that while a large proportion of litterfall is buried causing organic matter accumulation, a significant proportion is lost through decomposition processes.

Figure 4.



Litterfall + Burial – Decomposition = Standing Litter

Landscape Estimates: Implications for Marsh Ecosystem Processes

Utilizing aerial photography, we estimated the relative area covered by tree islands and sawgrass in the C-111 Basin. Approximately 10% of the study area is composed of tree islands. Extrapolating the average grams of litterfall lost to decomposition, assuming all decomposed material is lost to marsh ecosystem processes, tree island litterfall contributes approximately 377 kg of organic matter annually. Assuming a 40% annual decomposition rate and an average sawgrass production rate of 240 $g\ m^{-2}\ yr^{-1}$, sawgrass contributes 1382 kg of decomposed organic matter to marsh ecosystem processes (Davis, 1991; Childers et al., 2001). We also calculated TOC loads from surface water concentrations, flow rates, and water levels. In the 1999 – 2000 season, TOC loads into the C-111 basin averaged 379 kg (Gann, 2001).

Therefore, tree island litterfall contributes an estimated 18 – 21 % of organic matter potentially available for marsh ecosystem processes, compared with an estimated 65 – 79 % organic matter produced through the decomposition of sawgrass (the higher estimate excludes marsh TOC loads – likely much TOC is produced within the marsh) . While these values are likely overestimates of carbon readily available for marsh ecosystem processes, TOC values in marsh surface water have been shown to be up to 90% DOC (Parker, 2000).

Conclusions

Seasonally flooded tree islands of the southern Everglades are conservative systems, not only retaining high proportions of leaf litterfall, but also conserving litterfall inputs of phosphorus and nitrogen. However, preliminary estimates of leaf litterfall cycling show that 40% of deposited leaf litterfall is potentially available for marsh ecosystem processes. With low nutrients in litterfall and low available nutrients in porewater, decomposition must be highly influenced by surface water inputs of phosphorus, nitrogen, or both. About 60% of leaf litterfall inputs are buried in the forest floor, and a significant proportion of carbon, phosphorus and nitrogen is accumulated in tree island soils via this pathway. Fluctuations in surface water nutrients are likely to affect the balance of litterfall deposition, accumulation, and decomposition in seasonally flooded tree islands of the southern Everglades, ultimately influencing the contribution of tree island litterfall to marsh ecosystem processes.

References

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