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Contribution of different wetland plant species to the DOC exported from a mesocosm experiment in the Florida Everglades

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ABSTRACT

Carbon stable isotopes were used to investigate the contribution of different wetland plant communities commonly found in the Everglades to the dissolved organic carbon (DOC) exported from a mesocosm experiment. The species conforming the different treatments in the mesocosms were: *Typha domingensis* Pers, *Cladium jamaicense* Crantz, *Nymphaea* sp., *Nymphaea* sp./*Eleocharis* sp., *Najas guadalupensis* [Spreng] Magnus/*Chara* sp. and *Najas guadalupensis*. Results indicate that *Nymphaea* sp./*Eleocharis* sp. and *Najas guadalupensis*/*Chara* sp. treatments functioned as temporary sinks for DOC, but over the study period all treatments were net sources of DOC. A two-source carbon isotope mixing model was used to estimate the contribution from inflow water and biomass into the outflow DOC in each treatment. DOC from biomass was relatively higher in treatments with emergent and floating vegetation (24–30%) than in treatments containing submerged aquatic vegetation (≤5%). The relevance of these findings for restoration and management in the context of the Everglades region, specifically its implications for organic phosphorus exports, are discussed.

1. Introduction

Dissolved organic matter (DOM) export from wetlands may exert a significant control over productivity, biogeochemical cycles and attenuation of visible and UV radiation over adjacent freshwater ecosystems (Pastor et al., 2003). Previous studies have shown that external DOM inputs can regulate the amount of dissolved organic carbon (DOC) available for microbial growth (Amon and Benner, 1996; Young et al., 2005; Davis et al., 2006). DOM is also important in the transport of nutrients. For example, more than 90% of carbon and nitrogen and 25% of phosphorus in the Everglades is transported as dissolved organic compounds bonded to the DOM (Qualls and Richardson, 2003). In addition, DOM export can influence the mobility and toxicity of metals bonded to refractory forms of DOM (Grybos et al., 2007), meanwhile impacting water quality in terms of color, taste, safety and aesthetics (Worrall et al., 2003). Therefore, estimating the effect of different management and restoration strategies on DOM export is required. This is of particular importance in wetlands with high carbon reactivity and transport such as the Florida Everglades, where DOM production and export is very high (Aiken et al., 2011).

The Florida Everglades were a vast natural system comprised of different wetland habitats that dominated the landscape of south Florida. Now the Everglades are a heavily managed system encompassing a series of hydrological units connected by canals, weirs and pump stations (Chimney and Goforth, 2001). Downstream from the south shore of Lake Okeechobee, the Everglades receives runoff from the Everglades agricultural area (EAA) which increases nutrient loading and deteriorates water quality. As a mitigation measure, the South Florida Water Management District (SFWMD) constructed about 17,000 ha of treatment wetlands, known as Stormwater Treatment Areas (STAs) (Chimney and Goforth, 2001). The STAs were designed to intercept the EAA runoff and improve the water quality of water reaching the water conservation areas (WCAs) and ultimately the Everglades National Park by reducing nutrient (primarily phosphorus) concentrations.

DOM concentrations and sources in the Everglades are variable in its flow from north to south. Near the EEA, DOM

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concentrations are higher and more likely the result of desorption from organic peat soils used for agriculture (Stern et al., 2007; Qualls and Richardson, 2008). This DOM is transported through canals and superficial flow while is subject to photo and biodegradation (Aiken et al., 2011). As it flows, it becomes diluted by rainwater inputs and eventually is gradually replaced by DOM originated mainly from the degradation and leaching of organic detritus from macrophytes and algae within the STAs and the less impacted downstream ecosystems (Wang et al., 2002; Qualls and Richardson, 2003; Yamashita et al., 2010). Consequently, there is a need to better understand the role of plant species as contributors to the DOM and possible modulators of DOM cycling in these environments (Davis et al., 2006). This, especially when considering the importance of plant communities in the improvement of water quality in the STAs (e.g. Dierberg et al., 2002). Plant tissue concentration of nutrients and structural components can significantly influence the chemical characteristics of the DOM produced and thus, the rates at which this DOM is decomposed and cycled in the system (Osborne et al., 2007). For example, DOM from plant species with higher C:P ratios (e.g. emergent macrophytes) have lower decomposition rates and cycle relatively slower in the system that those plants with lower C:P ratios (e.g. submerged aquatic vegetation) (Chimney and Pietro, 2006).

In an effort to better understand the role of wetland vegetation in DOM dynamics of the Everglades, we determined the contribution of different plant communities in a mesocosm study to the DOC in the water exported downstream. This study was conducted using 6 different treatments. A sub-set of these mesocosms, consisting of four different treatments were planted with emergent and floating vegetation: *Typha domingensis* (cattail), *Cladium jamaicense* (sawgrass), *Nymphaea* sp. (water lily), *Nymphaea* sp./*Eleocharis* sp. combination. Another sub-set consisting of two treatments was dominated by submerged aquatic vegetation (SAV): *Najas guadalupensis*/*Chara* sp., and a control without planting but with naturally colonizing *N. guadalupensis* at the time of the study. These species or their combinations were selected based on their abundance in the existing wetland ecosystems of the Everglades and their potential for phosphorus removal (Chimney and Goforth, 2006; Gu et al., 2006). For example, *T. domingensis*, *N. guadalupensis* and *Chara* sp. are currently found in the STAs, while the rest of species are commonly found in more pristine landscapes of the Everglades (Noe et al., 2001; Inglett and Reddy, 2006; Osborne et al., 2007). Our hypothesis was that DOC inputs from vegetation in treatments dominated by SAV are lower than those from treatments dominated by emergent vegetation. Results from this study are expected to give useful insights for the design and management of wetlands in the Everglades region in regards to DOM production and its associated organic phosphorus exports.

2. Methods

2.1. Study site

This study was part of a three year study (August 2010–August 2013) to test on a mesocosm scale different plant communities as treatment alternatives to improve the water quality of the waters flowing out of the STAs in south Florida (Fig. 1). The mesocosms consisted of 18 fiberglass tanks (6 m *L* × 1 m *W* × 1 m *D*) that were filled with 30 cm of soil obtained from STA-1W. The water supply system to the mesocosms consists of a pump located in the southern canal of the STA-1W connected via pipelines to the tanks located at the inflow of each fiberglass tank. Flow rates in the system are controlled using electric and manual ball valves gauged to maintain a constant hydraulic retention time of 14 days. After its pass through the fiberglass tanks, water is conducted through an outlet pipeline to an outflow tank and from there is pumped back into the STA-1W (Fig. 2). Mean inflow DOC concentrations measured during the study period were 28.3 ± 1.8 mg-C L^{-1} (Mitsch et al., 2010–2012). This average concentration was within the range previously reported by Aiken et al. (2011) for the WCA-2A and WCA-2B and higher than those of the WCA-3A and the Everglades National Park.

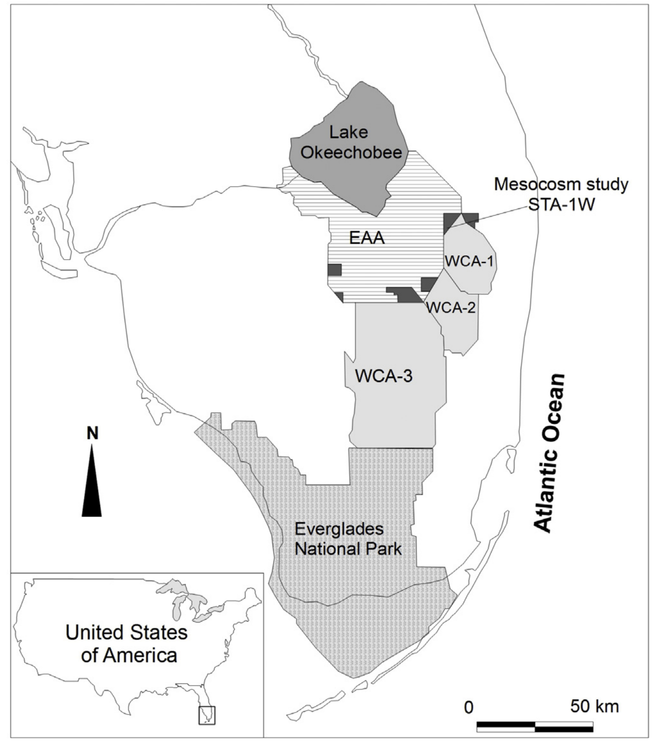

Fig. 1. Everglades region showing the major hydrological units (WCA: water conservation areas, EAA: Everglades agricultural area and STA: storm treatment area) and the relative location of the study site at the outflow of STA-1W.

The tanks were planted from April to July 2010 using soils from the nearby STA 1W in a randomized block design with one factor (type of vegetation stocked) at the following six levels (treatments): *T. domingensis*, *C. jamaicense*, *Nymphaea* sp., *Nymphaea* sp./*Eleocharis* sp. combination, *N. guadalupensis*/*Chara* sp., and a control without planting. Despite the efforts to control vegetation growth, this latter treatment underwent a natural colonization process. Each treatment had 3 replicates. Up to the start date of the present study this treatment was dominated by *N. guadalupensis* and will be referred in the rest of the text as the self-design treatment. The initial TC:TN of the soils used in the treatments were: 16.1 for *T. domingensis*, 14.4 for *C. jamaicense*, 15.3 for *Nymphaea* sp., 14.9 for *Nymphaea* sp./*Eleocharis* sp. combination, 15.5 for *N. guadalupensis*/*Chara* sp. combination and 15.4 for the self-design treatment (Mitsch et al., 2010–2012).

2.2. Sampling and analytical methods

Sampling for this study was conducted from March to September 2011. Our first sampling date took place 10 months after the initial operation of the tanks, which was assumed to be enough for those mesocosms to reach stable conditions.

2.2.1. Surface water sampling

Superficial water samples were collected in order to estimate DOC production or consumption within the mesocosms. Water