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Design of real-time and long-term hydrologic and water quality wetland monitoring stations in South Florida, USA

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ABSTRACT

Hydrologic regimes in tropical and subtropical regions (e.g. hurricanes, tropical storms, and droughts) impact biogeochemical processes in created and restored wetlands with variability of wet/dry seasons and extreme weather events. Our South Florida Wetland Monitoring Network (SFWMN) with three real-time hydrologic, water quality, and meteorological field stations was established by the Everglades Wetland Research Park of Florida Gulf Coast University in the subtropical Southwest Florida, USA, beginning in 2012. The stations include a restored freshwater marsh (RFM) and adjacent meteorological field station; a restored brackish water marsh (RBM); and a created freshwater treatment wetland system and adjacent meterological station (CFTW). Continuous observations of water depth, temperature, salinity, and pH for the period of January 2012 to January 2016 indicate significant differences among the restored freshwater marsh, the restored brackish marsh, and the created freshwater treatment wetlands for water temperature and pH for wet and dry seasons. The brackish wetland salinity fluctuated between 26.16 (in the dry season) to 1.03 ppt (in the wet season).

The real-time dataset allowed up-to-date information of the frequency and duration of severe weather events illustrating, for example, that 70% of the 2012 annual rainfall (1129 mm) occurring in July and August with a 75.4 mm precipitation during one event—tropical storm Isaac on August 26–28, 2012. This storm led to a water stage peak in the brackish wetland due to excessive watershed runoff, not tidal surges, and salinity decreased from 22.3 to 5.5 ppt.

The coefficient of variation (CV) for water depth and water quality from all wetland monitoring stations exhibited similar variations during all seasons, except when the salinity for the brackish marsh (RBM) had the highest CV values (1.02) in the wet season. Principal component analysis (PCA) at each station identified the variance in water depth and water quality parameters as due to seasonal changes of precipitation in distinct wet and dry seasons. The data from these monitoring stations are also used for research by scholars and students as well as for teaching a better understanding of wetlands dynamics and function in the classroom. As a whole, these stations are being used to bring awareness about the fragile and unique hydrological conditions of wetlands in subtropical Southwest Florida, especially for long-term conditions related to sea level changes and more frequent tropical storms.

1. Introduction

Long-term and continuous monitoring of hydrology and water quality patterns of created and restored freshwater and coastal wetlands in tropical and subtropical regions is essential (Junk, 2002; Mitsch et al., 2010; Mitsch and Gosselink, 2015). In particular, long-term real-time data collection in wetlands is of prime importance for research and education needs since seasonal and multi-year hydrologic fluctuations in tropical/subtropical climates have a great influence on wetland ecosystem function and structure such as vegetation community productivity and diversity (see, e.g., Keddy and Reznicek, 1986; Mitsch et al., 2008; Mitsch et al., 2012, 2014b; Mitsch and Gosselink, 2015; Mander et al., 2013; Grabas and Rokitnicki-Wojcik, 2015). The hydrologic regime (e.g. changes in water level, flooding duration, and flood pulses) affects the biogeochemical cycles responsible for improving water quality, groundwater recharge, and heat exchange via evapotranspiration (ET). These hydrologic functions in wetlands not only affect nutrient dynamics at a watershed scale, as has been illustrated in the Mississippi-Ohio-Missouri (MOM) river basin and its delta (Mitsch et al., 2001; Mitsch and Day, 2006; Costanza et al., 2006; Day et al., 2007) and the Florida Everglades (Mitsch et al., 2015; Mitsch, 2016),

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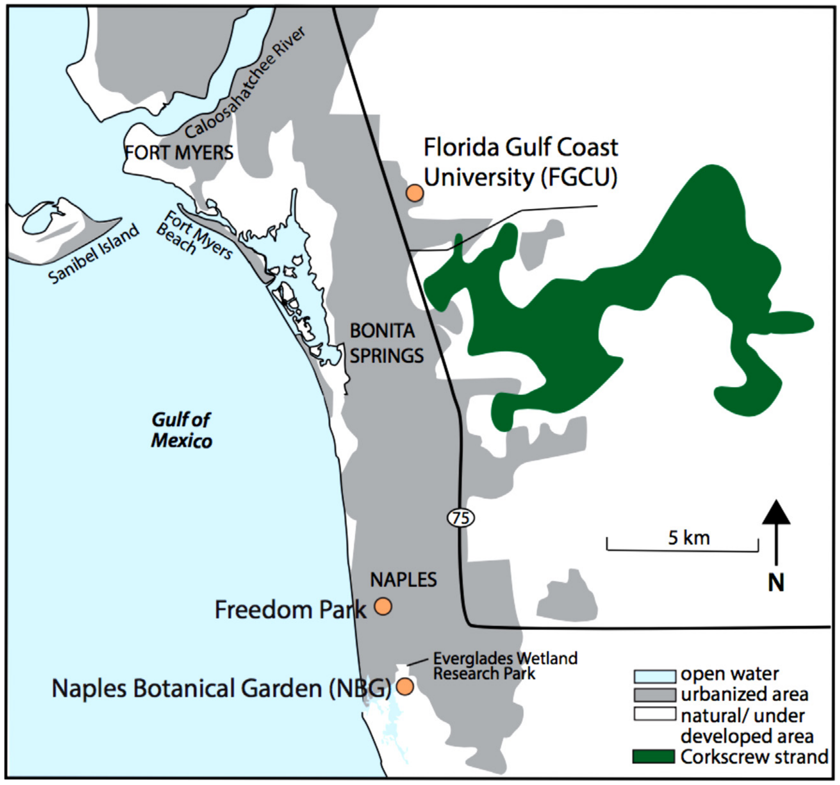

Fig. 1. Location of the stations in Everglades Wetland Research Park's South Florida Water Monitoring Network (SFWMN) in Ft. Myers/Naples Florida, USA: restored freshwater marsh (RFM) and adjacent meteorological station at Florida Gulf Coast University (FGCU); restored brackish marsh (RBM) at the Naples Botanical Garden (NBG); and created freshwater wetlands (CFTW) at the Freedom Park in Naples.

Table 1
Description of monitoring stations located in the three southwest Florida wetlands studied.

Station site	Wetland type	Coordinates	Wetland surface Area, (ha)	Year created or restored	Date monitoring station was implemented	Annual precipitation (mm)
Florida Gulf Coast University	restored freshwater marsh	26°27.896′N, 81°46.669′W	35.5	1995	January 2013 for water level and water quality; and November 2015 for weather station	1410 ± 13 (1980–2016)
Naples Botanical Garden	restored brackish marsh	26°06.181′N, 81°46.534′W	68	2007	February 2012	1254 ± 16 (2001–2016)
Freedom Park, Naples	created freshwater treatment wetlands	26°10.521′N, 81°47.231′W	50	2006–2007	April 2014 for weather station; and August, 2016 for water level and water quality	1254 ± 16 (2001–2016)

but they also impact greenhouse gas emissions and carbon cycles in the wetlands themselves (Bernal and Mitsch, 2012, 2013; Mitsch et al., 2013; Turetsky et al., 2014; Villa and Mitsch, 2014, 2015; Shoemaker et al., 2015; Marchio et al., 2016).

In recent years, many monitoring programs have relied on *in situ* detectors to collect data used by regulatory agencies and research institutions such as the United States Geological Survey (USGS) and the National Oceanic and Atmospheric Administration (NOAA) along with stations monitoring real-time water quality parameters (Glasgow et al., 2004). Glasgow et al. (2004) additionally showed that most stations adapted the remote sensing approach to watershed and regional scales and suggested that such systems are a critical need for early warning and rapid response to extreme events such as harmful algal bloom or flooding events. Furthermore, the same authors concluded that monitoring programs have progressively become a more important tool for evaluating water quality since the idea was first proposed in the 1970s (see Mitsch, 1973).

To date there have been relatively few investigations dealing with real-time and multi-year water hydrology and water quality data for created and restored wetlands within subtropical and tropical regions. Previous long-term monitoring work focused largely on forest streams (Coweeta Hydrologic Lab, North Carolina, e.g. Swank et al., 2001; Elliott and Vose, 2011) or temperate wetland research parks such as the 20-ha Olentangy River Wetland Research Park (ORWRP) on the Ohio State University campus (see summary of its development in Mitsch et al., 2014a). The ORWRP wetland construction began in 1993 and soon included an on-site meteorological field station (built in 1994) and subsequently, beginning in 2002, a real-time wetland monitoring system with a hydrologic sensor and YSI 6000 series multi-parameter (water temperature, pH, specific conductance, dissolved oxygen) sensors at the inflows and outflows of the experimental wetlands as well as downstream