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Hydrology and water quality of isolated wetlands: Stormflow changes along two episodic flowpaths

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ABSTRACT

The Dougherty Plain in southwest Georgia is a flat, karstic, depressional-landscape dominated by irrigated and dry-land agriculture devoted to row-crops and pasture with interspersed wetlands and forests. Stormwater runoff rarely discharges into perennial rivers and streams, except during large storms that induce hydrologic connectivity between fields, wetlands, and streams (event return period is less than one per year).

We report the hydrologic and water-quality effects of a 173-mm rainfall event that generated three weeks (Feb 15 to Mar 9, 2014) of continuous flows through and between three normally isolated wetlands. A suite of water-quality parameters (physical, nutrients, and pathogen indicators) was monitored daily from offsite (agricultural) and onsite (forested) sources at two sites along one flowpath and five sites along a second at the Joseph W Jones Ecologic Research Center at Ichauway.

Decreasing sediment, nutrient, and pathogen concentrations were observed as water moved across the forested landscapes with embedded wetlands. Two physical parameters (specific conductance and turbidity) were strongly-to-moderately correlated ($r > 0.8, 0.5$, respectively) with laboratory-measured parameters (e.g., nutrients, suspended solids, pathogens), which suggest their utility for routine stormwater monitoring and prioritizing sample collection for laboratory analyses at this site.

1. Introduction

Water-resource managers in the southeastern United States are facing new challenges due to increased agricultural development and burgeoning populations (Rugel et al., 2012). Aquatic systems in the region routinely suffer from water-quality impairments due to stormwater inputs of sediments, nutrients, and pathogens. Once generated, stormwater is rapidly discharged to nearby waterways, with occasional detention prior to discharge.

Isolated wetlands are a frequent feature within agricultural landscapes across the United States. While many of these wetlands occur in glaciated (e.g., the prairie-pothole region of the Midwest) or karstic regions (e.g., coastal plains of northern Florida and southwestern Georgia), isolated wetlands of less obvious geologic origin are also common along the coastal plain of the mid-Atlantic (e.g., Delmarva bays) and other Southeastern states (e.g., Carolina Bays).

Wetland complexes may play a disproportionate role in the ecology and hydrology of the watershed relative to their spatial area (Rains et al., 2016). Also, episodic connectivity between isolated wetlands and streams potentially serve important functions to downstream perennial streams through temporary inputs of materials and energy, particularly in regions with few low-order streams.

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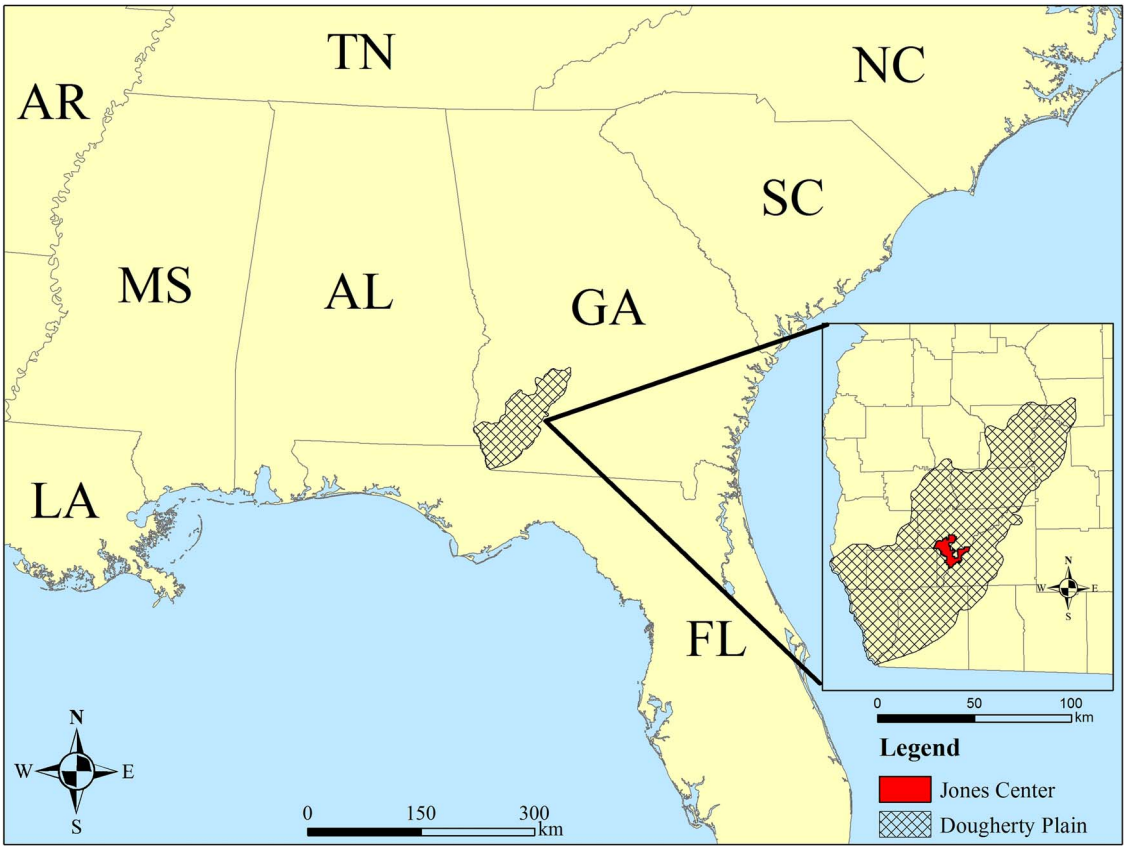

Fig. 1. The Joseph W. Jones Ecological Research Center at Ichauway is located on the Dougherty Plain of southwest Georgia (A).

Stormflows provide episodic sources of water (Wilcox et al., 2011; Hosen et al., 2014; McDonough et al., 2015) as well as dissolved and suspended matter ranging from nutrients and dissolved carbon to sediments and coarse woody debris (Fenner et al., 2011; Yang et al., 2013). In some ecosystems, such short-duration inputs of matter and energy can have lasting impacts on nearby perennial streams or provide pulses that contribute to temporal variation in stream communities (Gu et al., 2012; Strayer 2014). While pulses of nutrients or carbon stimulate microbial communities (Buffam et al., 2001) and can lead to episodic blooms of algae or filter feeding organisms, lasting impacts can be in the form of woody debris or sediment deposition in the channel (O'Hop and Wallace, 1983; Rickenmann and Koschni, 2010).

Isolated wetlands can improve water quality by fostering sedimentation and increased biogeochemical processing (Pennock et al., 2010; Laudon et al., 2016). Wetlands can also collect and store upland stormflows during periods of intense precipitation (Lane and Damico, 2010). The small area of wetlands embedded along flowpaths may act disproportionately to improve stormwater quality relative to larger upland areas due to their longer residence times and concomitant ability to assimilate pollutants.

The Dougherty Plain of southwestern Georgia (Fig. 1) is a 669,000-ha physiographic region with approximately 12,000 isolated wetlands (Hicks et al., 1987; Martin et al., 2012). The region lacks headwater streams because deep sands are underlain by highly permeable, vuggy carbonate bedrock that serves as the primary landscape drainage system. Overland and concentrated flows are rare (return periods < 1/yr), only occurring in response to large storm events (Hicks et al., 1987).

Depressional features with embedded wetlands are common within this weathered carbonate environment (Hicks et al., 1987; Martin et al., 2012). Wetlands form over clay lenses interbedded within deep sandy soils (Hicks et al., 1987) When overland flows occur, water accumulates in depressional features (commonly wetlands), which may then spill into normally dry flowpaths, and thence into other wetlands or perennial waterways. Spill duration can be short 1 week events or last for several months. For most rainfall events, this fill-and-spill system effectively retains stormwater flows and entrains pollutants.

The landscape was originally forested, but the region was converted to pasture and row-crop agriculture over the past century (Martin et al., 2013). These agricultural practices have altered both the timing and quality of stormwater runoff, which results in increased nonpoint discharge and loading of sediments and nutrients. Within this agriculturally dominated landscape lies a remnant longleaf-pine (*Pinus palustris*), and wiregrass (*Aristida stricta*) forest ecosystem with embedded wetlands on a 12,000-ha property managed by the Joseph W. Jones Ecologic Research Center at Ichauway, in Baker County, Georgia (Drew et al., 1998). At Ichauway, episodic stormflows arise in upland areas that then pass through normally isolated wetlands, which may flow into perennial streams following extreme rainfall events.

Recent findings concerning surface and groundwater interactions have highlighted a need for further understanding of hydrologic