

Assessing the Transport Characteristics of Flocculent Organic Sediment in the Florida Everglades

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Problem Overview

The patterned ridge and slough landscape, a dominant landscape component of the historic Everglades, has been degrading over the past century, resulting in a loss of biodiversity. As depicted in Fig. 1, the landscape is characterized by elongated, elevated ridges of sawgrass (*Cladium jamaicense*) interspersed among lower, open-water sloughs containing floating and emergent vegetation. Landscape features are aligned parallel to the historic flow direction, and topography is strictly due to differences in the elevation of peat (partially decomposed organic detritus) rather than to patterning in the underlying bedrock. Historic elevation differences between ridge and slough are thought to approach 1 meter, but maximum elevation differences in the present-day landscape are approximately 20 cm. Throughout much of the original historic ridge and slough landscape, the topography has undergone complete flattening, concurrent with the overtaking of open-water slough environments by sawgrass from ridges. Despite the apparent role of flow in the formation of the landscape, mechanisms for pattern degradation are not well understood and may be partially attributable to a suite of anthropogenic impacts, including decreased flow velocities, altered flow directionality, changes in hydroperiod (the temporal patterns in the depth of surface water inundation), and changes in surface water chemistry.



Figure 1. Aerial photograph of a well-preserved portion of the ridge and slough landscape, acquired from helicopter during the dry season. Darker features are ridges, which are oriented parallel to flow. Adjacent ridges are spaced on the order of 100 m.

Hypothesis

This project assesses the potential role of flow and sediment transport patterns in maintaining the ridge and slough landscape under historic regional discharges and in contributing to landscape degradation under current conditions. A previous modeling exercise* involving the simulation of feedback between sawgrass productivity and subsequent peat production, hydrology, and water chemistry revealed that, in the absence of advective sediment transport, ridges gradually expand outward into sloughs through the diffusive transport of flocculent organic particles, colonization of the expanded ridge/slough transition area by sawgrass, and

gradual building of the topography through higher rates of peat production in sawgrass than in the adjacent slough. We hypothesize that under historic flows (2-4 cm/s, possibly higher during storm events), shear stress in sloughs was sufficient to redistribute organic particles from the edge of sloughs to ridges, thereby preventing the indefinite expansion of ridges into sloughs.

Methodology

Our strategy for evaluating the hypothesis of sediment redistribution involves simulating local velocity profiles as a function of regional average discharge, stem density and diameters, and microtopography and coupling this flow simulation to a simulation of sediment transport. Due to fundamental differences in structure and transport characteristics between flocculent organic sediment and mineral sediment, the relationship between flow profiles and sediment transport must be empirically-based. Consequently, we have undertaken a suite of experiments in the IMCS rotating annular flume and racetrack flume to adequately characterize this relationship for modeling purposes.

Racetrack Flume

Initiation-of-motion experiments were performed in the racetrack flume to determine aggregate sizes of flocculent organic sediment (floc) entrained under different flow velocities and shear stresses. Two different bed configurations (1. an “unvegetated” configuration, consisting of a deposited bed of Everglades floc overlying peat [Fig. 2] and 2. a “vegetated” configuration, consisting of floc and peat distributed among an array of dowels with characteristics that mimic Everglades vegetation stems[Fig. 3]) resulting in fundamentally different flow profiles were subjected to 16 different flume speeds. A high-resolution digital SLR camera fitted with a macro lens captured images of floc aggregates entrained near the bed, while a laser Doppler velocimeter (LDV) acquired vertical profiles of flow statistics for each flume speed.



Figure 2. A snapshot of the “unvegetated” peat/floc bed through the glass wall of the racetrack flume. Reflection of the laser from the LDV is visible at left.



Figure 3. The array of dowels for the “vegetated” run in the racetrack flume, viewed from above. Dowel diameter and spacing was selected to duplicate mean sawgrass stem statistics within Everglades ridges.

Rotating Annular Flume

In the rotating annular flume (Fig. 4), a deposited bed of floc was subjected to three different flume speeds and monitored via digital SLR camera and LDV to determine (1) the aggregate size distribution profiles in equilibrium with flow profiles and (2) aggregation/disaggregation timescales involved in the attainment of equilibrium profiles.

Aggregation/disaggregation processes were observed during both a ramping-up of flume speed and a ramping-down, as hysteresis is likely.



Figure 4. The LDV acquires a velocity profile during the high velocity test in the rotating annular flume. Near-complete entrainment of floc is apparent.

* Larsen, L.G., J.W. Harvey, and J.P. Crimaldi. 2006. A delicate balance: Feedback between landscape morphology, water flow, vegetation dynamics, and sediment transport in a low-gradient, lotic peatland ecosystem. Submitted to *Ecological Monographs*. In review.