Flow impacts on P and OM Cycling in the Ridge and Slough: Lessons from landscape budgets in the Decomp Physical Model and Shark Slough, ENP

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Outline

1. Introduction and DPM findings
2. Objectives
3. Approach: Phosphorus Mass Balance
4. Results
5. Summary and Next Steps
Restoring Connectivity to the Everglades Landscape

Central WCA-3A

Flow direction

South

North

Modified from McVoy et al. 2011
Restoring Connectivity to the Everglades Landscape


What is the Decomp Physical Model (DPM)?

- **Uncertainty 1**: Do high velocities (>2 cm/s) generate sediment movement needed to restore the ridge and slough topography?

- **Uncertainty 2**: To what extent does sheetflow alter P and OM cycling and ultimately foodwebs?
Flows did not follow the ecologically preferred (north-south) pattern

- Velocities ranged from 0.5 - 10 cm s\(^{-1}\)
- High flows (2-5 cm s\(^{-1}\)) were limited to ~500-m
Tracking particle movement: slough to ridge

Velocity
2-5 cm s\(^{-1}\)

Velocity
1-2 cm s\(^{-1}\)
Flow alters slough structure

Mechanisms by which flow alters landscape

- Periphyton/Utricularia collapses/slough clearing (periphyton disappears)
- Velocities increase with sustained flow
- Floc disappears
Other flow observations

- **Velocity, sediment transport increase with flow duration**
  - Sediment traps, Flowtracker ADVs (C. Saunders)

- **Aquatic primary production & respiration reduced**
  - Metabolism studies (Tate-Boldt et al., GEER)

- **Floc more erodible, more labile(?) with flow**
  - Benthic flume (S. Newman, M. Manna)
  - Molecular biomarkers (R. Jaffe’, P. Regier)
  - Algal taxonomy (B. Rosen)
2. Objectives for DPM data synthesis: Phosphorus mass balance model

- Which flow-mediated mechanisms are needed to explain observed changes in ecosystem P stocks (mainly water TP and floc P)?

- Using a “linked” mass balance, to what extent does flow impact P cycling beyond 500-m? How fast do changes migrate downstream?
3. Approach – P budgets of Landscape “Ribbons”

Noe & Childers (2007) summarized P stocks, fluxes for ridge & slough habitats, Everglades-wide

FCE LTER data to generate ridge, slough budgets for conceptual landscape “ribbons” in ENP: near-canal, interior, coastal ecotone

Highlights most important fluxes, discrepancies among data, data gaps, & uncertainties
3. Approach – P budgets of Landscape “Ribbons”

Periphyton P Uptake (gP m\(^{-2}\) yr\(^{-1}\))

** Uptake\(_{\text{max}}\)

* \(K_{TP}\)

Water TP (ug L\(^{-1}\))

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Phosphorus budget: SRS-2 slough

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Highlights most important fluxes, discrepancies among data, data gaps, & uncertainties

Dynamic budget models in STELLA to compare observed & predicted time series of P stocks & fluxes

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** Noe et al., 2002 & FCE LTER data
* Hwang et al., 1998
Application to DPM landscape

- Slough habitats in three 500-m landscape ribbons
  - High-, Medium-, Low-Flow
- Simulation period 2012–2016
  - 2 Baseline Years
  - 3 Flow Events
- Drivers:
  - Daily water depth & velocity
  - Upstream TP (S152 inflow TP)
- Observed vs predicted time series
  - Periphyton P (g P m\(^{-2}\))
  - Floc P (g P m\(^{-2}\))
  - Water TP, TPP (ug/L)
  - Sediment transport (g cm\(^{-2}\) FA d\(^{-1}\))
Application to the DPM study

High Flow Slough

High Flow 2-5 cm/s

Water

atmos. dep

inflow

outflow

floc

peri

soil

cons

deadAG

roots

liveAG

Control

S-152, L-67A, L-67C
Application – High Flow Conditions
Flow-mediated Mechanisms

- Peri/SAV sinking
Flow-mediated Mechanisms

- Peri/SAV sinking
- Peri/SAV stays low (-uptake, +turnover)
Application – High Flow Conditions

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- Partic-P into ridge
Flow-mediated Mechanisms

- Peri/SAV sinking
- Peri/SAV stays low (-uptake, +turnover)
- Floc more erodible (+turnover)
- Partic-P into ridge
- Partic-P settling reduced
4. Results – Baseline (no-flow)

Depth & Peri-P

Floc-P

Water TP & TPP

Sediment Transport

Model

Obs (RS1)

Model

Obs (C1)
4. Results – All Flow Mechanisms (what we expected to see)

- Depth & Peri-P
- Floc-P
- Water TP & TPP
- Sediment Transport

**Model**
- Obs (RS1)

**Flow event**

- Depth (cm) or P stocks (g m\(^{-2}\))
- P stocks (g m\(^{-2}\))
- P stocks (g m\(^{-2}\))
- P stocks (g m\(^{-2}\))
- P stocks (g m\(^{-2}\))

**Water TP & TPP**

**Sediment Transport**
4. Results – All Flow Mechanisms

- **Depth & Peri-P**
  - Flow event

- **Floc-P**
  - Model
  - Obs (RS1)
  - Obs (C1)

- **Water TP & TPP**
  - Model TP
  - Model TPP

- **Sediment Transport**
4. Results – “Fitted” Model

Depth & Peri-P

Floc-P

Model
Obs (RS1)
Flow event

Water TP & TPP

Sediment Transport

Model
Obs (RS1)
Obs (C1)
4. Results – What mechanisms are needed to fit to the data?

**Flow-mediated Mechanisms**

- Peri/SAV collapses
- Peri/SAV reduced
- Floc more erodible, potentially more labile
- Partic-P into ridge
- Partic-P settling reduced
- **Partic-P capture (veg)**

**Post-flow: uptake, turnover remain high**

++uptake, ++turnover

**Capture**

Dissolv-P → Partic-P → Capture

Peri/SAV → Cons → Atmos. dep

Soil → Roots → DeadAG → LiveAG

Flow arrows indicate direction of movement.
Objective 2 – Linked P Budgets

High Flow Slough

Moderate Flow Slough

Dissolv-P
Partic-P
Peri/SAV
Capture

atmos. dep

Water

soil

cons

deadAG

roots

liveAG

Ultra Flow
2-5 cm/s

Medium Flow
1-2 cm/s

Low-Flow
<1 cm/s
Summary and Next Steps

- Mass balance provides a “common currency” to integrate physical and biological responses to flow
- Although flow “clears out” sloughs, floc-P stocks doubled
- **Preliminary** model suggests 2-20x increase in periphyton uptake and turnover (including post-flow)
- **contrary** to aquatic metabolism modeling (Tate-Boldt et al.) and periphyton incubations (Newman et al.)
- **consistent** with increases in periphyton TP on periphytometers, including post-flow effects (Newman et al.)
- synthesis with other DPM data still in progress…
4. Results – Baseline (no-flow)

- Depth & Peri-P
- Floc-P
- Water TP & TPP
- Sediment Transport

Model TP vs. Obs (RS1) vs. Obs (C1)
“Linked” Moderate Flow – Floc P

Linked Baseline-Flow

Linked High-Flow

P stocks (g m⁻²)

Model
Obs (RS1)