Sheet Flow Velocity in Everglades National Park, Florida

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Flow Monitoring Program

Flow velocities, temperatures, and conductivities were measured at five sites with different vegetative characteristics in ENP. At four sites, flow velocities were measured bi-hourly at a fixed point in the water column using acoustic Doppler velocity (ADV) meters. At all sites, temperatures were monitored at 5- or 30-minute intervals in 5- or 10-cm increments above the plant litter layer using thermally sensitive resistors. At three of the four ADV monitoring sites, conductivities were measured bi-hourly near the litter layer. A brief description of the vegetation and a list of parameters collected at each site are given in Table 1. Photographs in figure 1 show the composition of vegetation at the four ADV monitoring sites.

Table 1. Parameters measured and vegetation description at monitoring sites.
[v = flow velocity, t = temperature, c = conductivity]

Site Name	Parameters Measured	Vegetation Description
GS-203	v,t,c	Medium dense sawgrass
GS-33	v,t,c	Patchy medium-dense spikerush
SH1	v,t	Medium-dense spikerush
GS-36	v,t,c	Sparse spikerush
NP202	t	Dense cattail

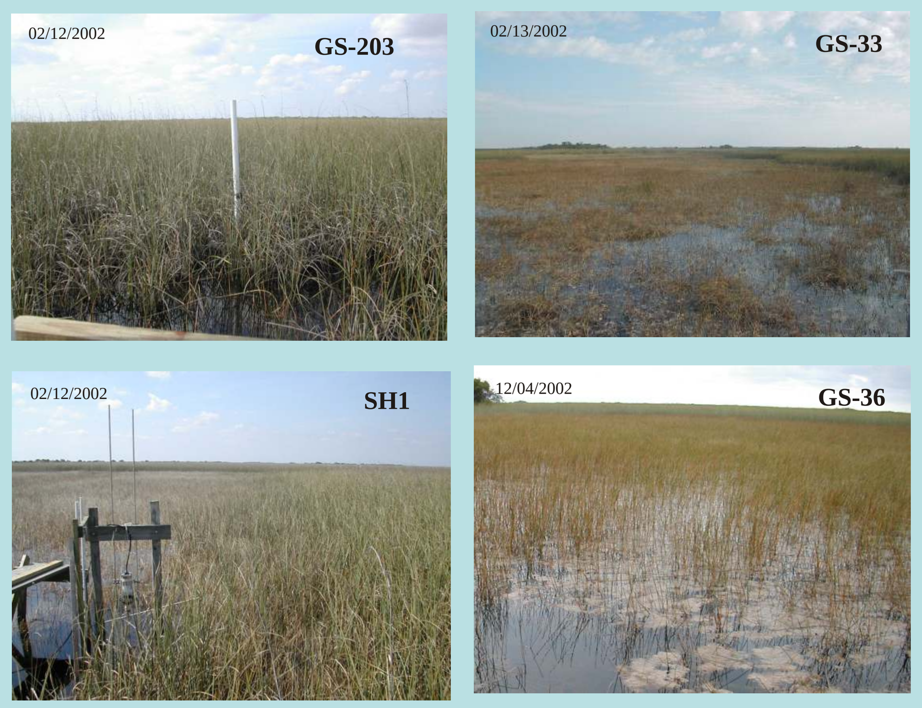


Figure 1. Photographs of vegetation at ADV monitoring sites.

Data Availability

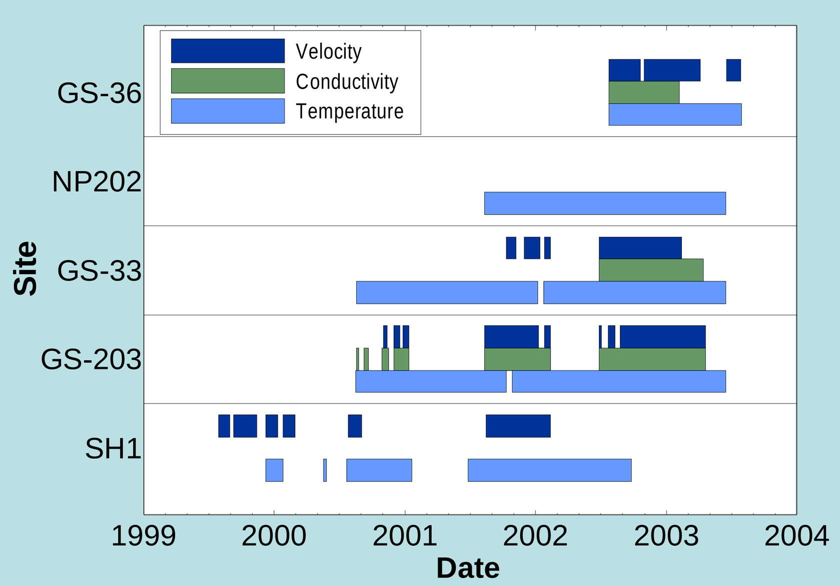


Figure 2. Dates of processed and edited flow-velocity, temperature, and conductivity data.

Continuous sets of flow-velocity, temperature, and conductivity data were collected from July 1999 to July 2003. Data-collection techniques and methods used to process and edit the data are presented in USGS Open File Reports by Riscassi and Schaffranek (2002, 2003, and 2004). All quality-checked and edited data are available in digital form in a USGS Data Series Report published on CDROM by Schaffranek and Riscassi (2004). Dates for which flow-velocity, temperature, and conductivity data are available at each monitoring site are identified in figure 2.

Sheet Flow Velocity

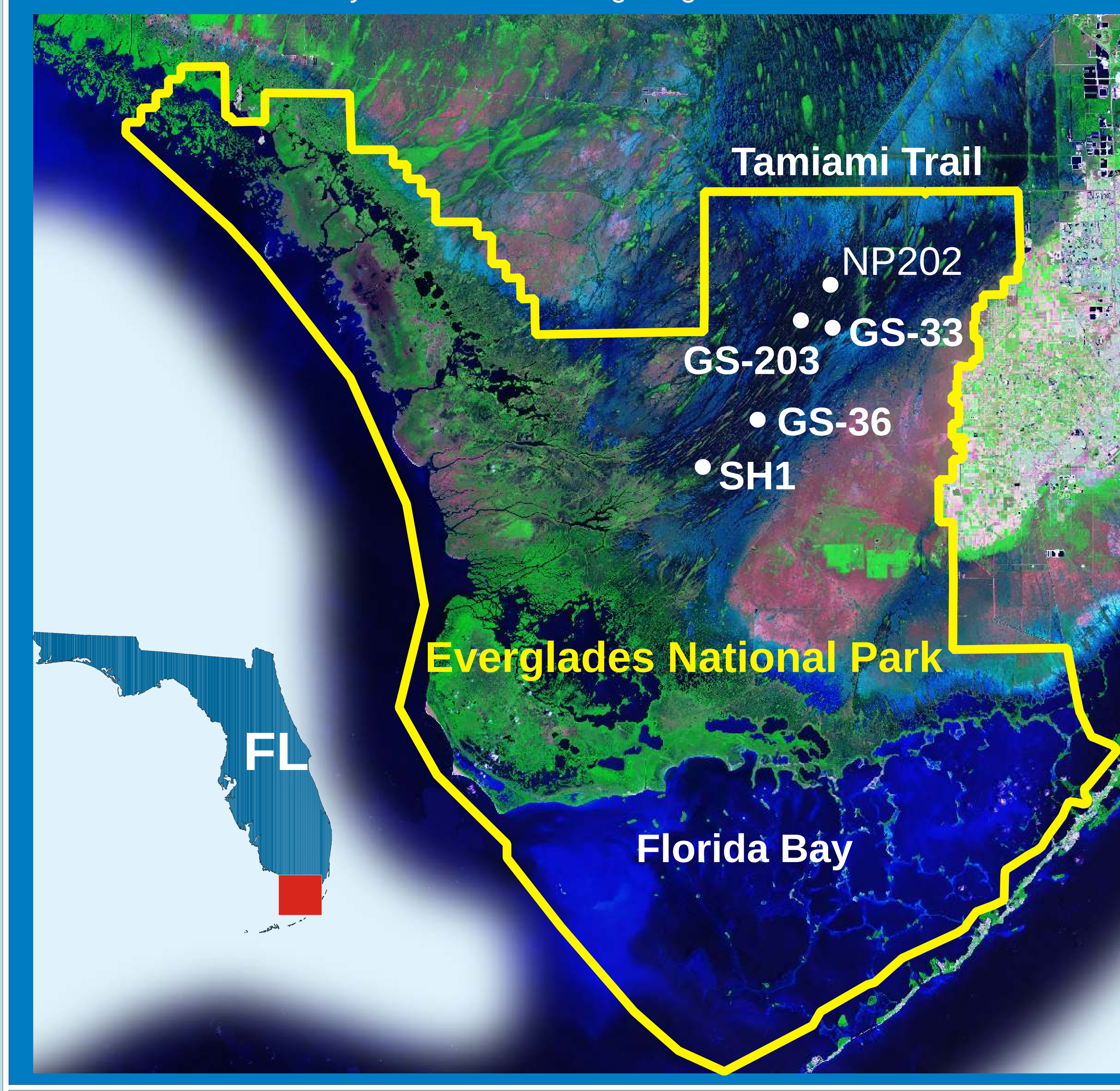
Continuous flow data collected in the wetlands of ENP identify typical sheet flow velocities in varied vegetative communities. During all deployments (1999 - 2003 wet seasons) daily mean flow velocities ranged from 0.20 to 5.16 cm/s at all sites, with an overall mean of 1.15 cm/s. Ninety percent of all daily mean flow velocities were between 0.46 and 2.29 cm/s. Daily mean flow directions were 224° at SH1, 243° at GS-203, 200° at GS-33, and 229° at GS-36. Mean, maximum, and minimum bi-hourly flow speeds and directions at all sites are listed in Table 2.

Table 2. Mean, maximum, and minimum bi-hourly flow velocities at monitoring sites.

Site	Velocity	Speed (cm/s)	Direction (deg)
SH1	Max.	5.66	208
	Mean	1.63	225
	Min.	0.06	93
GS-203	Max.	1.83	259
	Mean	0.82	243
	Min.	0.02	341
GS-33	Max.	1.48	190
	Mean	0.68	200
	Min.	0.02	194
GS-36	Max.	2.56	222
	Mean	1.40	229
	Min.	0.01	215

Study Area

The study area of this project is the wetlands of the south Florida Everglades ecosystem within Everglades National Park (ENP). Low-gradient wetlands in ENP are a mixture of tree islands, sawgrass marshes, wet prairies, and sloughs. Freshwater inflows released from hydraulic structures and discharged through culverts into ENP are conveyed to the coastal mangrove ecotone bordering the Gulf of Mexico and Florida Bay as sheet flow through vegetated wetlands.



Project Objectives

The objectives of this study are to quantify the extremely slow flows in the vegetated wetlands and to investigate forces that affect sheet flow behavior. Insight into sheet flow behavior in the wetlands, coupled with identification of factors that influence the flow regime, is critical to the development of models and interpretation of model results being used to assess and compare restoration scenarios for the Everglades ecosystem.

Summary and Conclusions

A study of sheet flow in ENP has produced data defining typical flow velocities in varied vegetative communities and yielded insight into factors affecting sheet flow behavior. Daily mean sheet flow velocities ranged between 0.20 and 5.16 cm/s. The mean of all daily mean flow velocities was 1.15 cm/s. Mean flow directions were southwesterly ranging between 200 and 243 degrees from magnetic north at all sites. Flows at velocities greater than 0.5 cm/s were more consistent in direction than flows at slower velocities. Vertical flow structure was fairly uniform and correlated to vegetation composition. Thermal-driven vertical mixing was found to occur almost daily in the absence of storm events or passage of major weather fronts.

References

Riscassi, A.L., and Schaffranek, R.W., 2002, Flow velocity, water temperature, and conductivity in Shark River Slough, Everglades National Park, Florida: July 1999 August 2001, U.S. Geological Survey Open-File Report 02-159, 32 p.

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Factors Affecting Sheet Flow Behavior

Dynamics in the magnitude, direction, and nature of sheet flows are attributed to internal and external forcing mechanisms, both locally and regionally driven. Local factors include water depth, micro-topography and the type, amount, and properties of vegetation. Regional factors include water-surface slope, land-surface gradient, and vegetative heterogeneity.

Water Depth

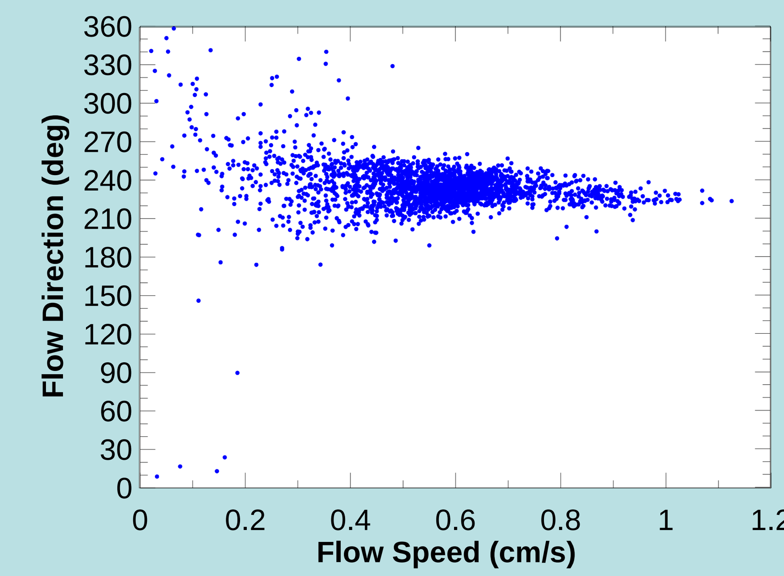

Figure 3. Flow speeds and directions at site GS-203 during the 2000-2001 wet season.

A plot of bi-hourly flow speeds versus directions measured at GS-203 during the 2000-2001 wet season is shown in figure 3. Flow velocities greater than about 0.5 cm/s are more consistent in direction than flows at slower velocities. Analysis of velocity data in conjunction with water levels revealed that the most significant velocity fluctuations occurred during low water depths. Implications are that when water levels are high, regional factors drive flows more uniformly; however, as water levels fall, flow velocities decrease, momentum is reduced, and flow becomes more susceptible to local forcing mechanisms.

Vegetation

Vertical profiles of flow velocities and volumes of organic material measured at site GS-33 are illustrated in figure 4. The reduced flow velocity near the water surface is due to the high concentration of periphyton floating as mats near the water surface. Flow velocities are damped about 10 cm above the top of the plant litter layer. Vertical velocity profiles at each of the other ADV monitoring sites revealed similar damped velocity magnitudes above the plant litter layer and relatively uniform flow structure throughout the mid-to upper part of the water column for uniform vegetation composition. Flow speed and direction measured by the self-recording ADV meter near the time of the vertical velocity profile are plotted on the graph (in red) at its sampling depth to show the agreement of the two independent velocity measurements.

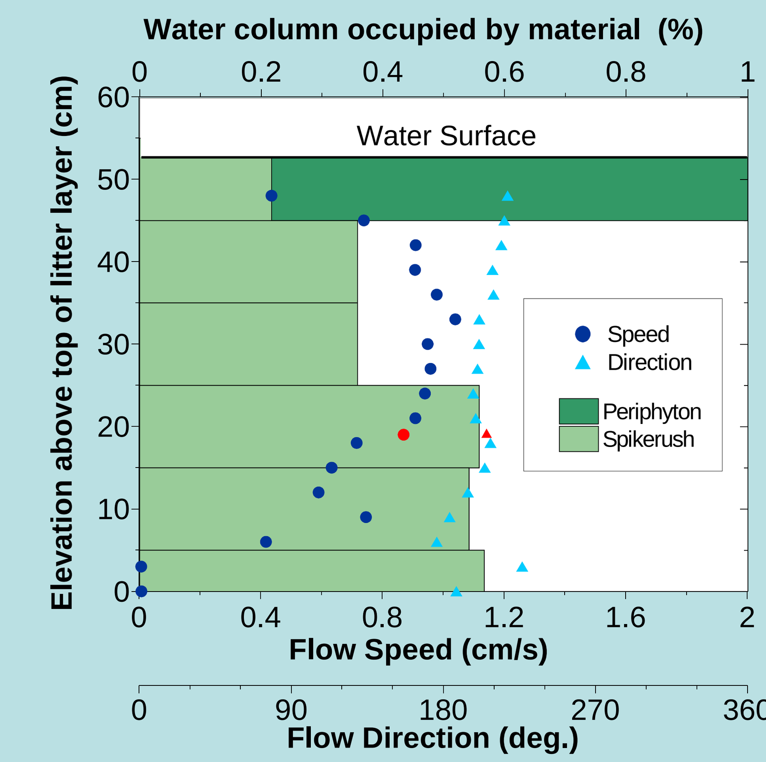

Figure 4. Flow velocity and vegetation volume at site GS-33 on 10/30/02.

Temperature

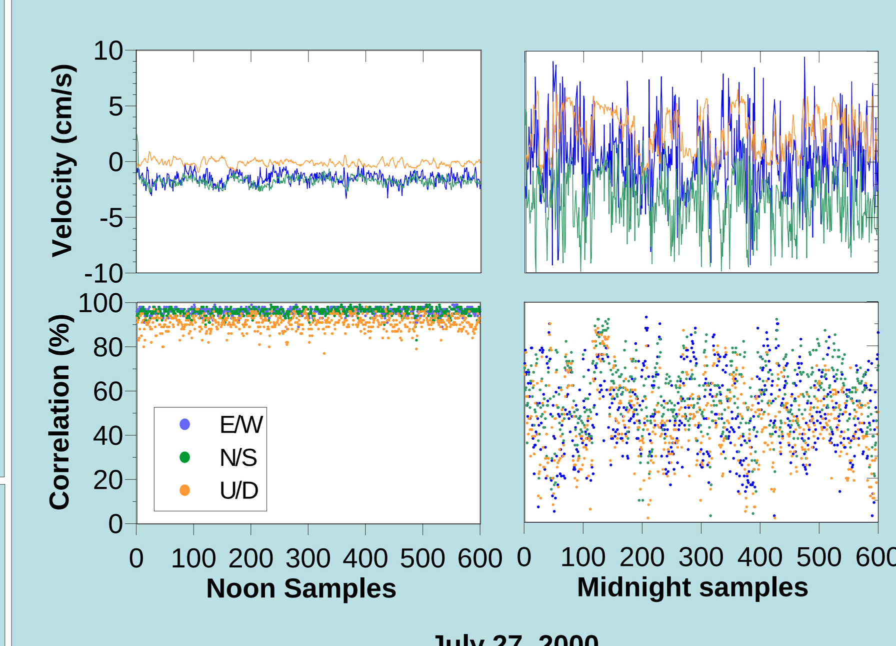

Figure 5. Velocity samples collected at noon and midnight on July 27, 2000 at site SH1.

Concurrent temperature-profile and flow-velocity data collected at each of four ADV sites have documented thermal effects on internal flow structure. Temperature profiles link large fluctuations in flow velocities measured and recorded after sunset to thermal convection. Temperature data indicate that the water column is typically isothermal at the beginning of each day, stratifies during the daytime, and de-stratifies during the night due to mixing driven by thermal convection. The contrast between the steady, highly correlated velocity data measured at noon during the stable stratified period and the variable, poorly correlated velocity data collected at midnight during the unstable mixing period is clearly evident in figure 5.