The Role of Wetlands in Regulating the Hydrology and Biogeochemical Cycling in Headwater Watersheds, Southeastern United States

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INTECOL

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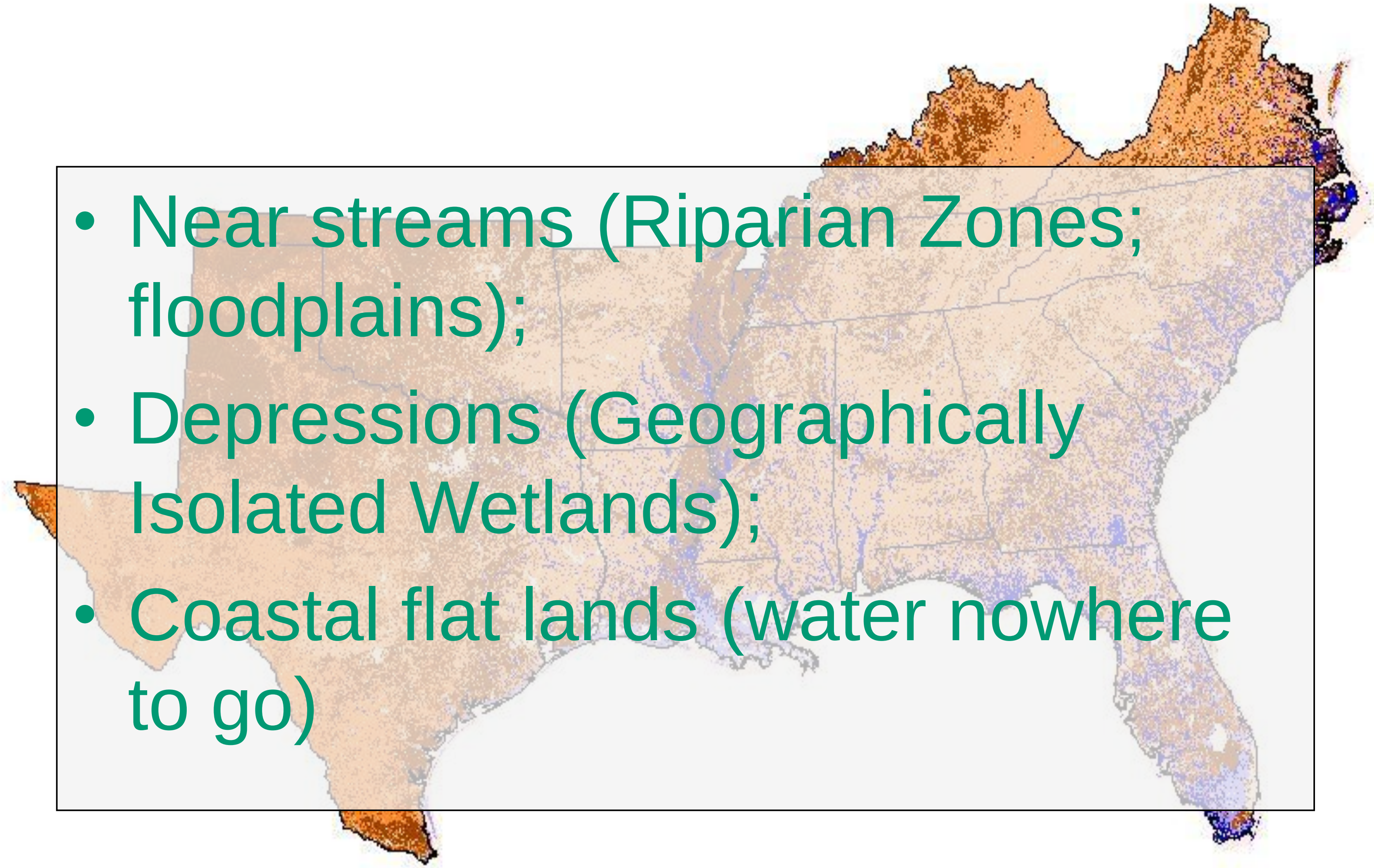
Objectives

- **Review four case studies of wetland hydrology of low order (0-1) forested watersheds with a focus on understanding hydrologic connectivity (upland-wetland; GW-SW);**

- **Discuss role of wetlands in regulating hydrological and biogeochemical processes at the landscape scale.**

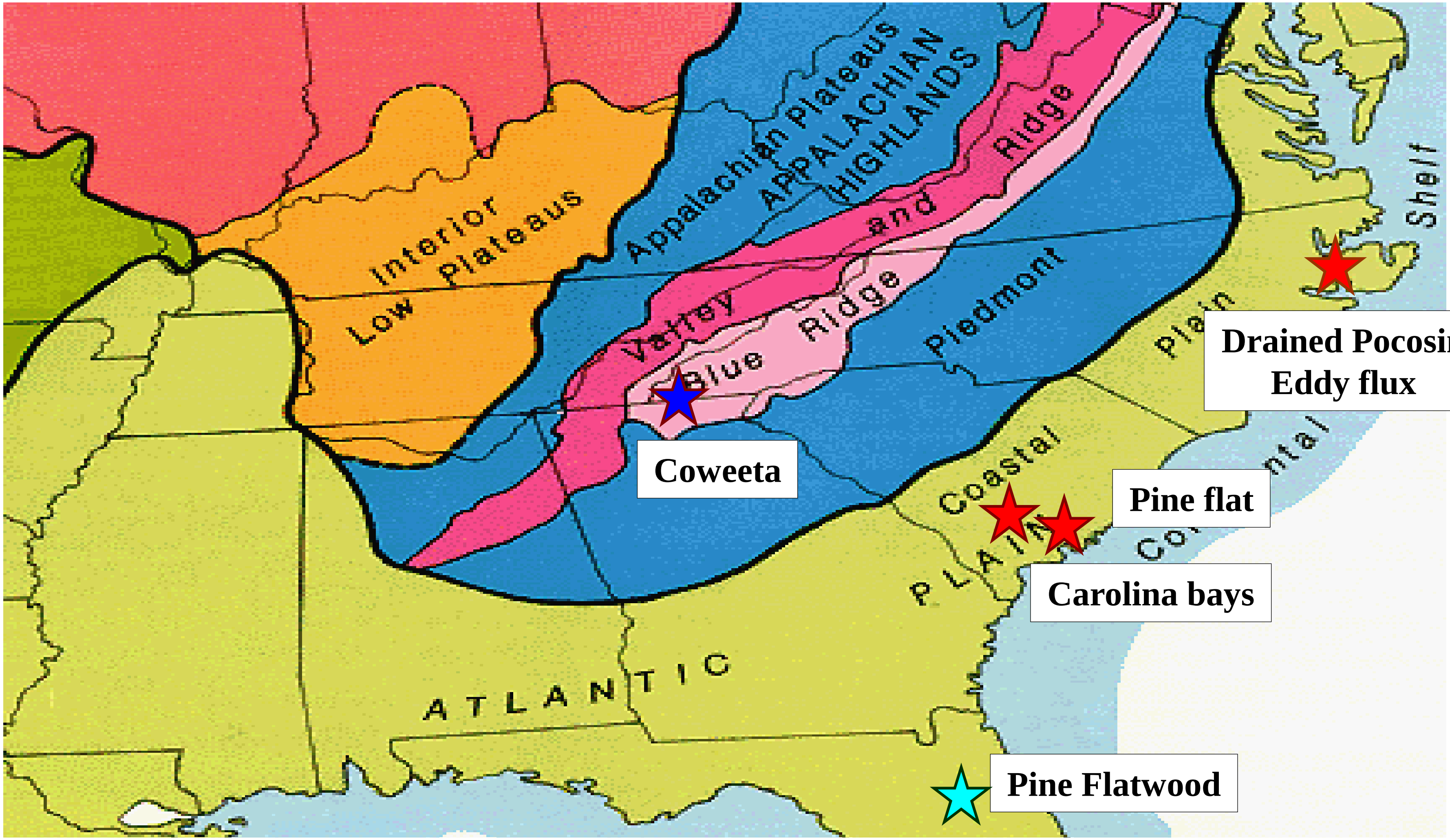
Southern Wetlands on Landscape



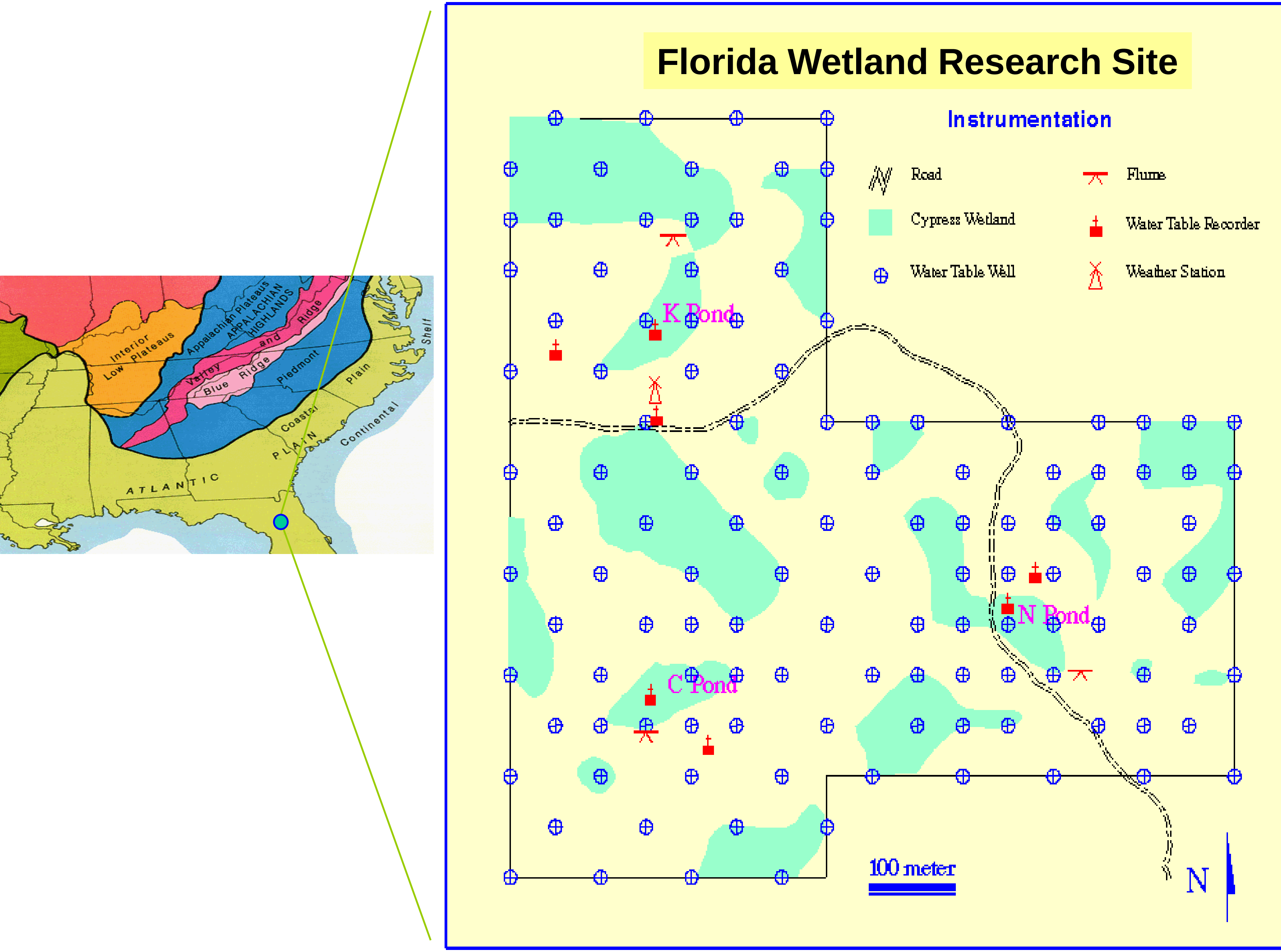
- Near streams (Riparian Zones; floodplains);
- Depressions (Geographically Isolated Wetlands);
- Coastal flat lands (water nowhere to go)

Wetland Processes and Functions

- Stormflow generation;
- Groundwater-Surface interactions: Hydrological Connectivity
- Water balances (ET=PET; disproportional high ET?)
- Biogeochemical hotspots;



Interior Low Plateaus
Appalachian Plateaus
APPALACHIAN HIGHLANDS
Valley and Ridge
Blue Ridge
Piedmont
Coastal Plain
ATLANTIC PLAIN
Continental Shelf
Drained Pocosin
Eddy flux
Coweeta
Pine flat
Carolina bays
Pine Flatwood


Florida Wetland Research Site
Instrumentation
Road
Flume
Cypress Wetland
Water Table Recorder
Water Table Well
Weather Station
K Pond
N Pond
C Pond
100 meter
N
Interior Low Plateaus
Appalachian Plateaus
APPALACHIAN HIGHLANDS
Valley and Ridge
Blue Ridge
Piedmont
Coastal Plain
ATLANTIC PLAIN
Continental Shelf

Cypress-
Slash Pine
Ecosystem,
Florida, USA
(42 ha)

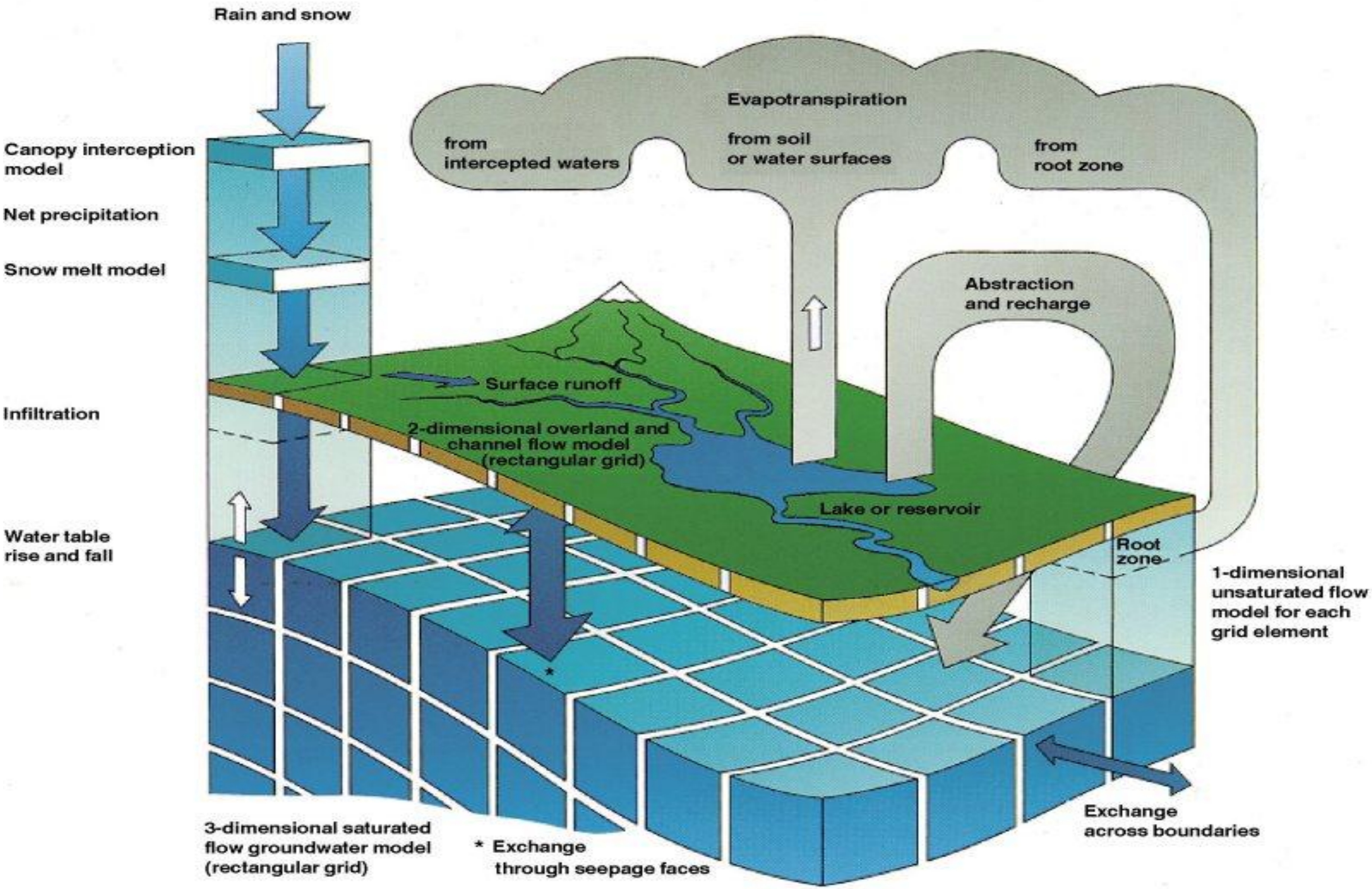
Latitude:29’30”

PPT=1300 mm

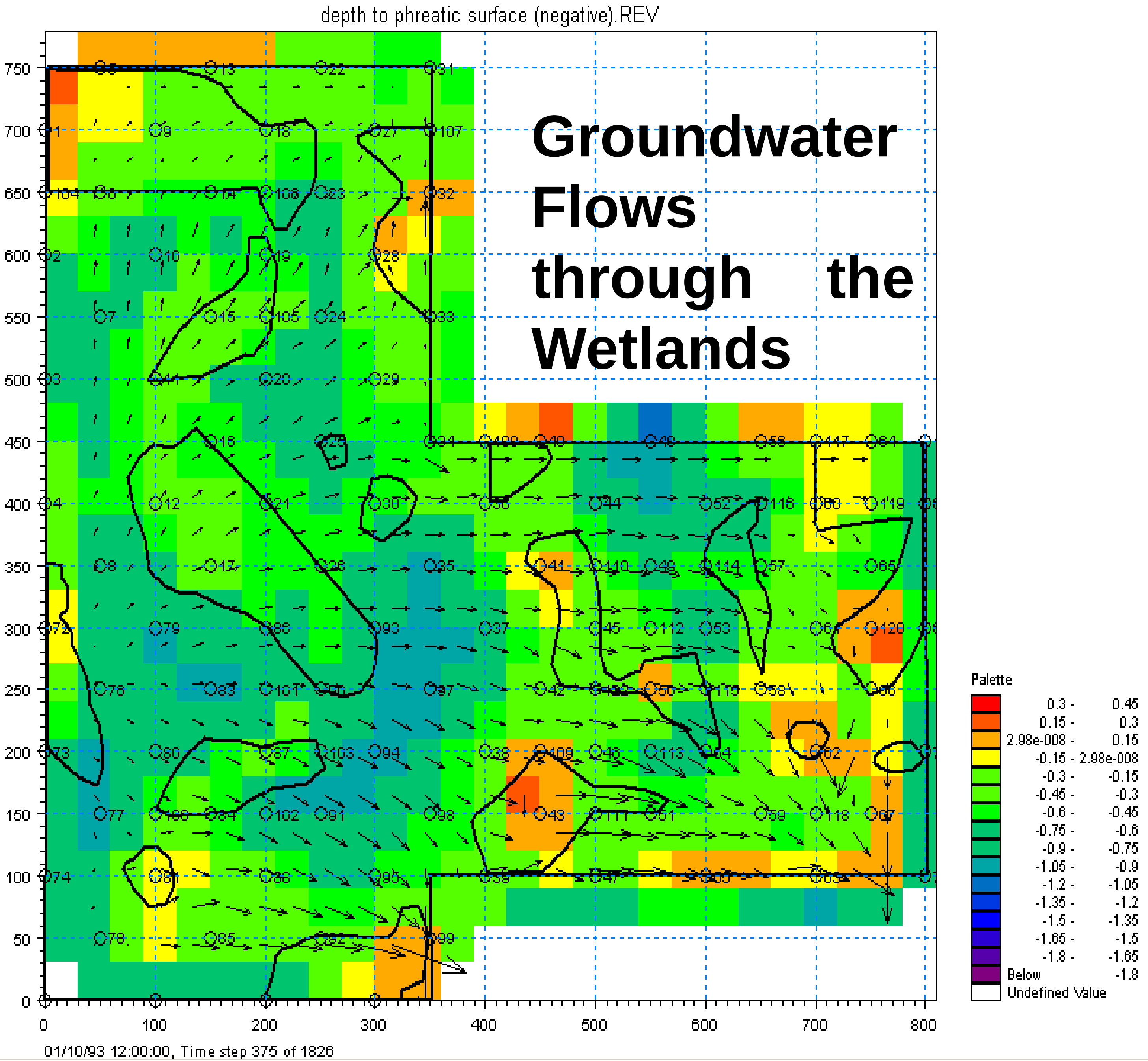
Avg. T = 21 ^{o}C

Sandy Soil

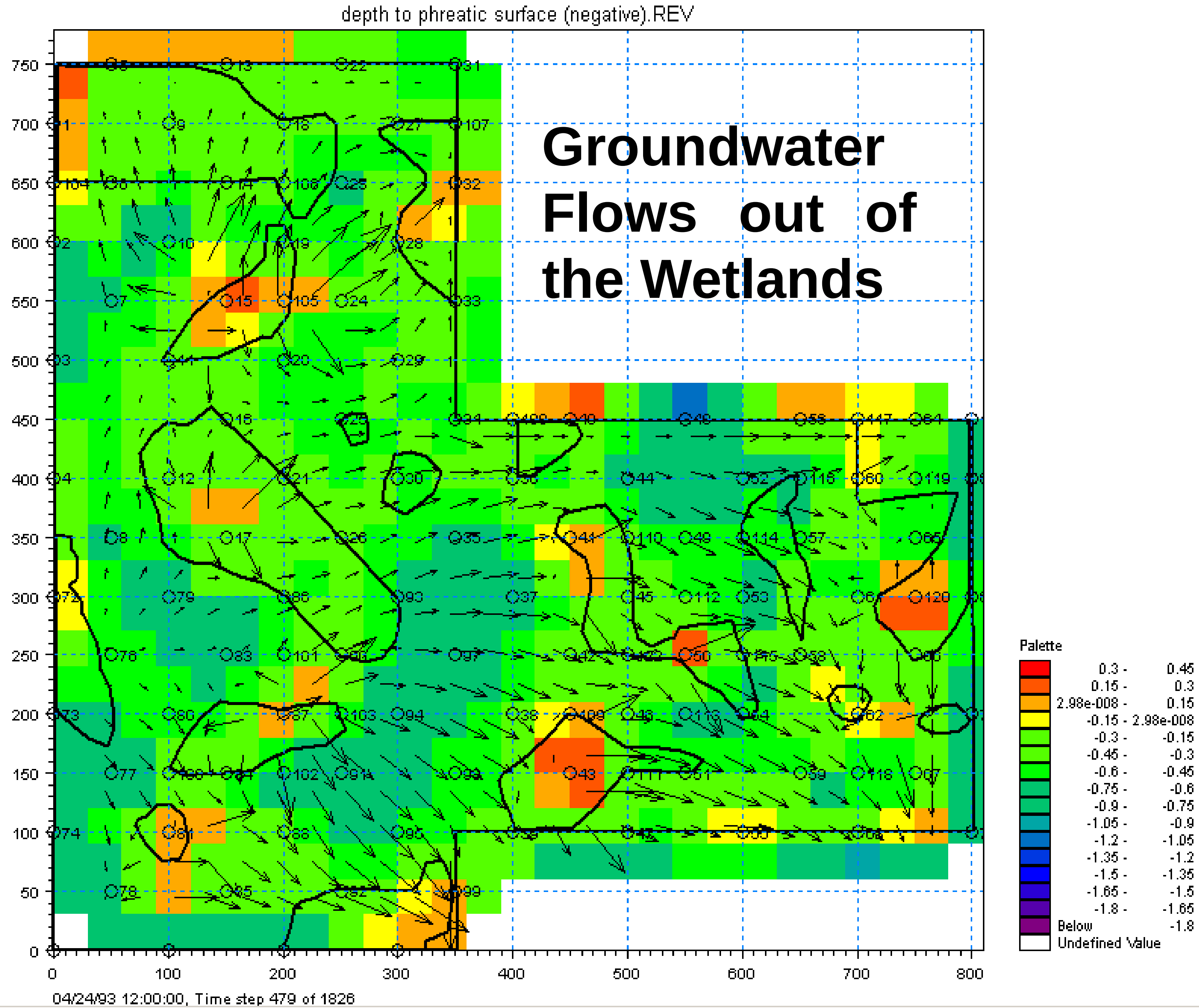
MIKE SHE Hydrologic Model



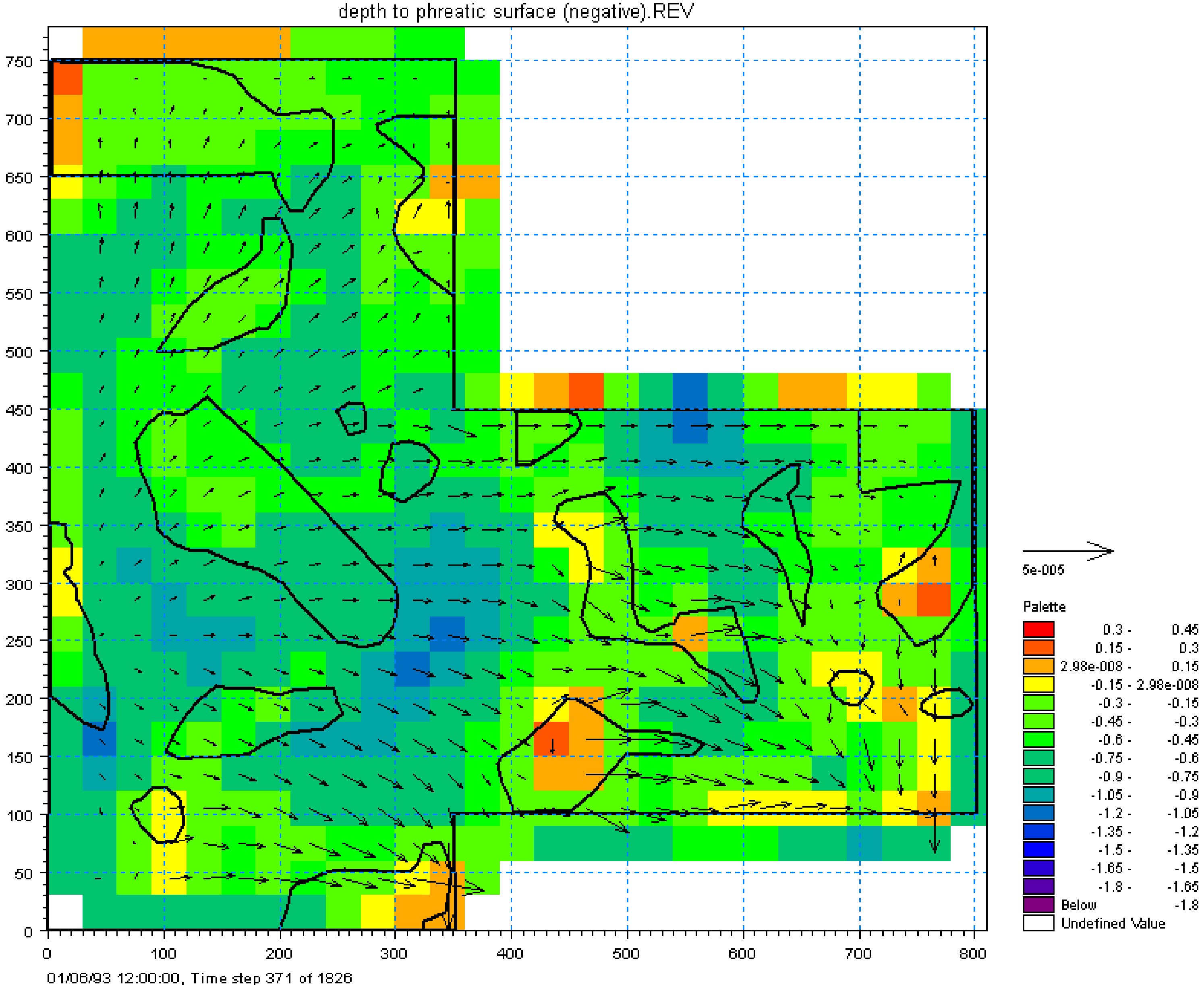
Groundwater Flows through the Wetlands



Groundwater Flows out of the Wetlands



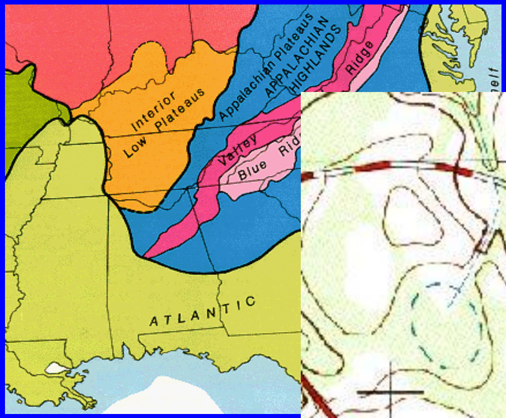
Groundwater Table Depth and Flow Directions

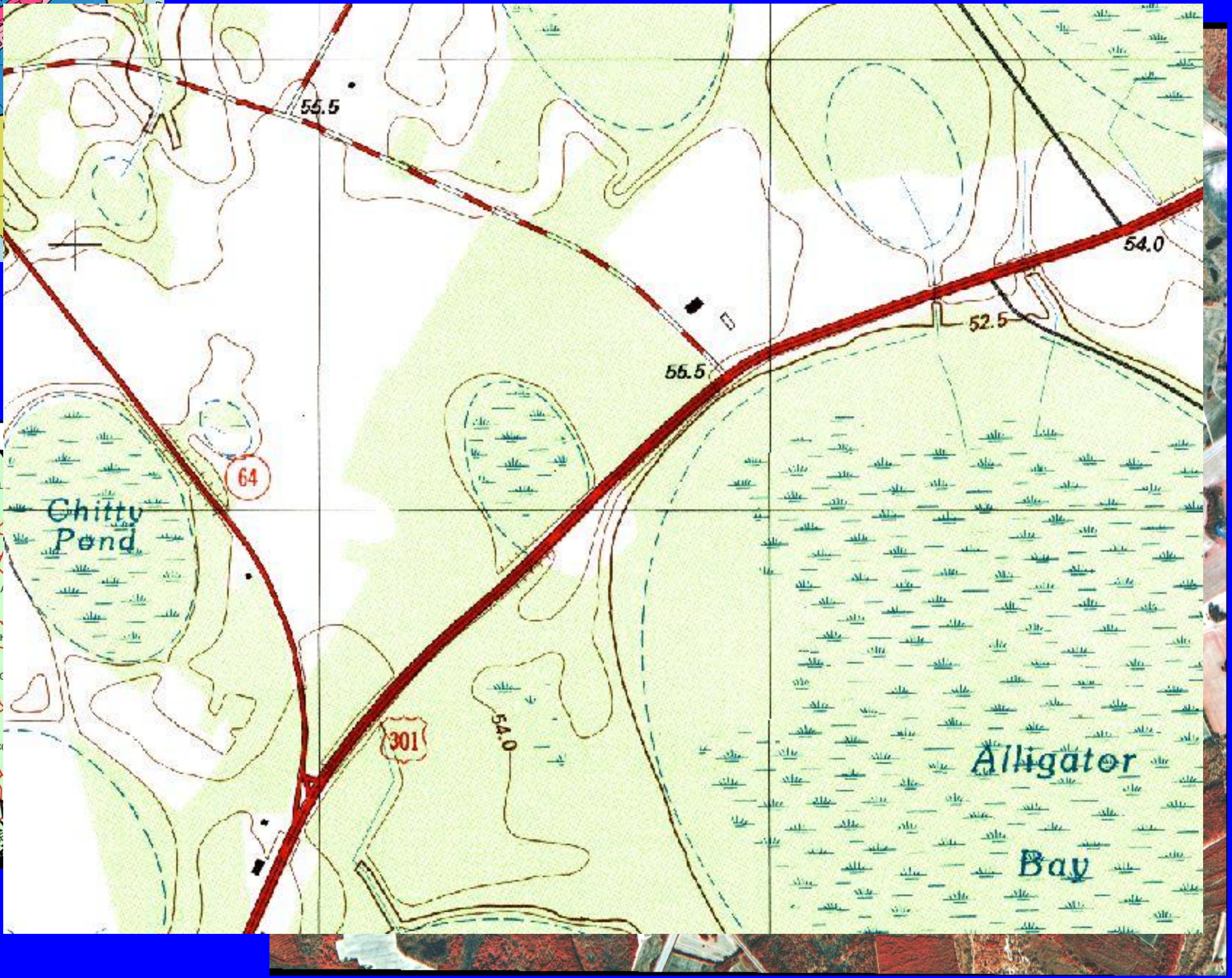


Key Findings

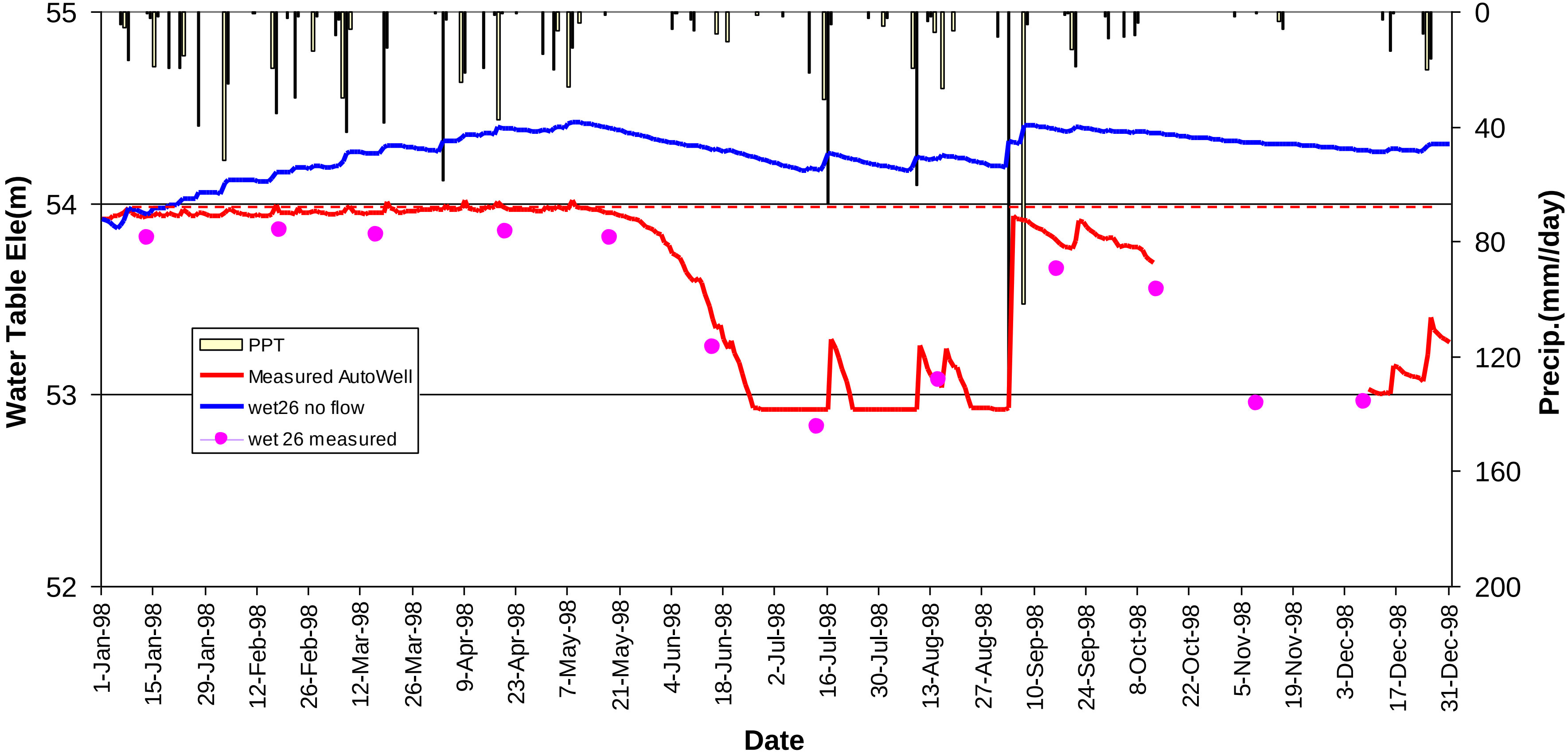
- ✓ Three types of flow pattern;
- ✓ Cypress ponds are NOT isolated;
- ✓ Similar ET between wetlands and uplands at annual scale

Carolina Bays, SC



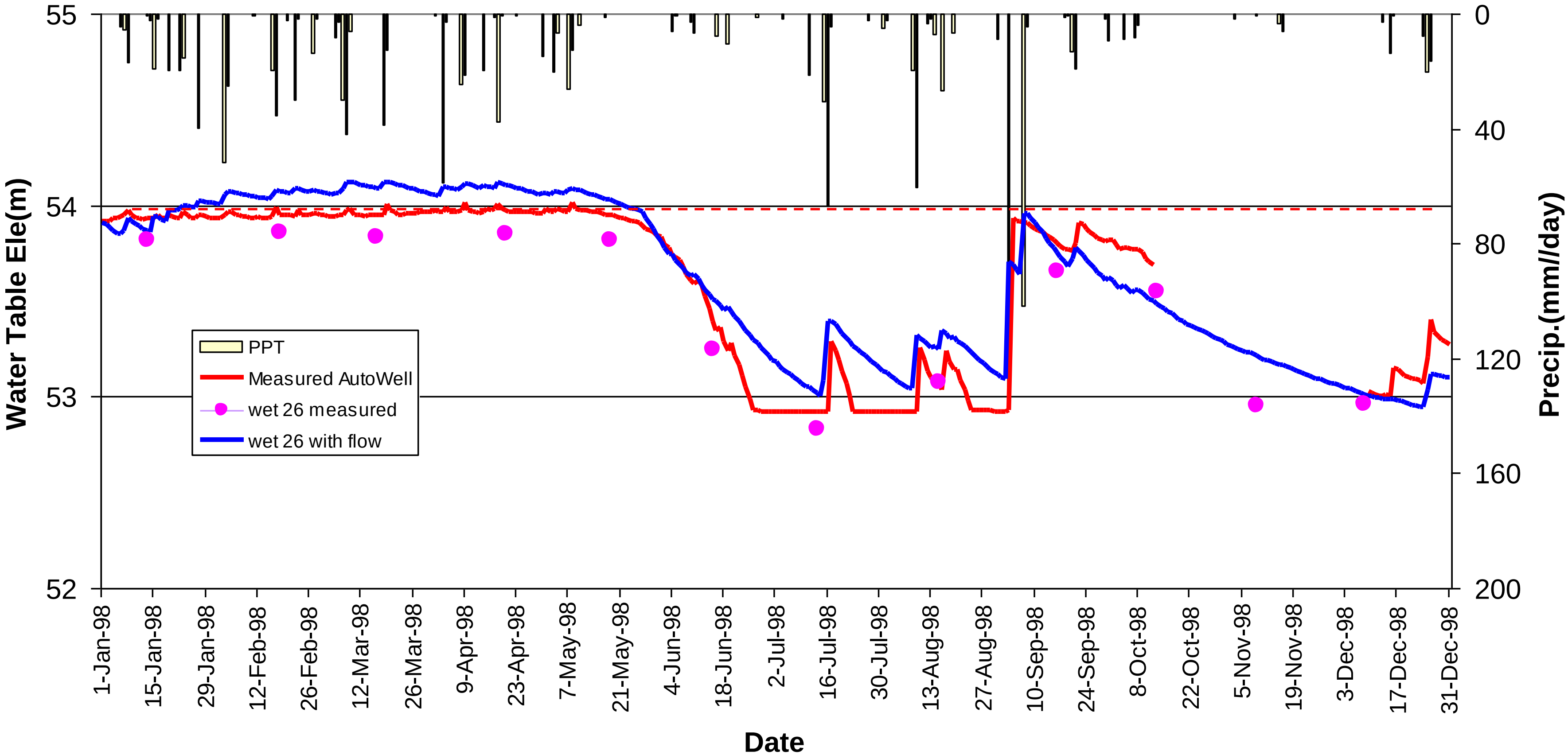


Wetland without Outflow Boundary



Sun et al., 2006. Wetlands, (26)2: 567-580

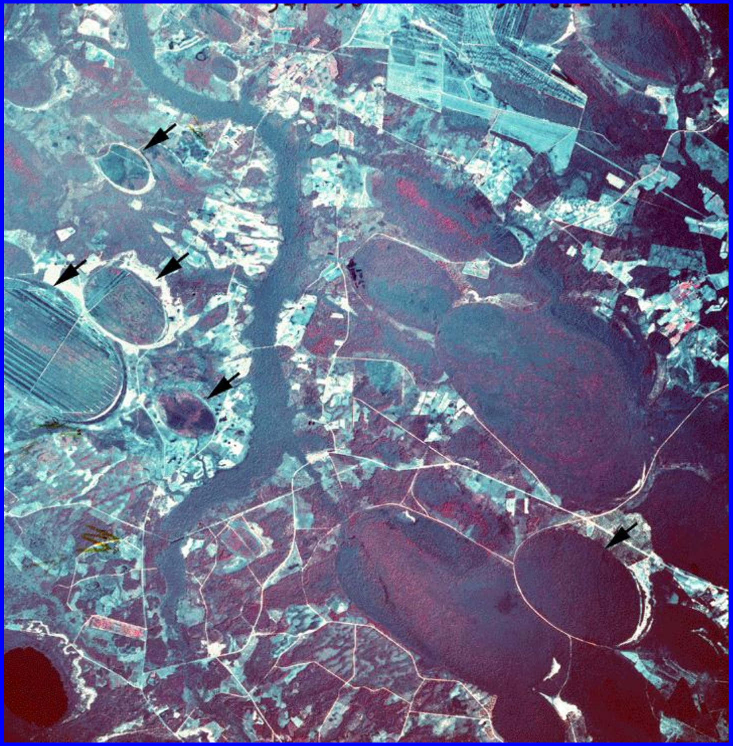
Wetland with Outflow Boundary



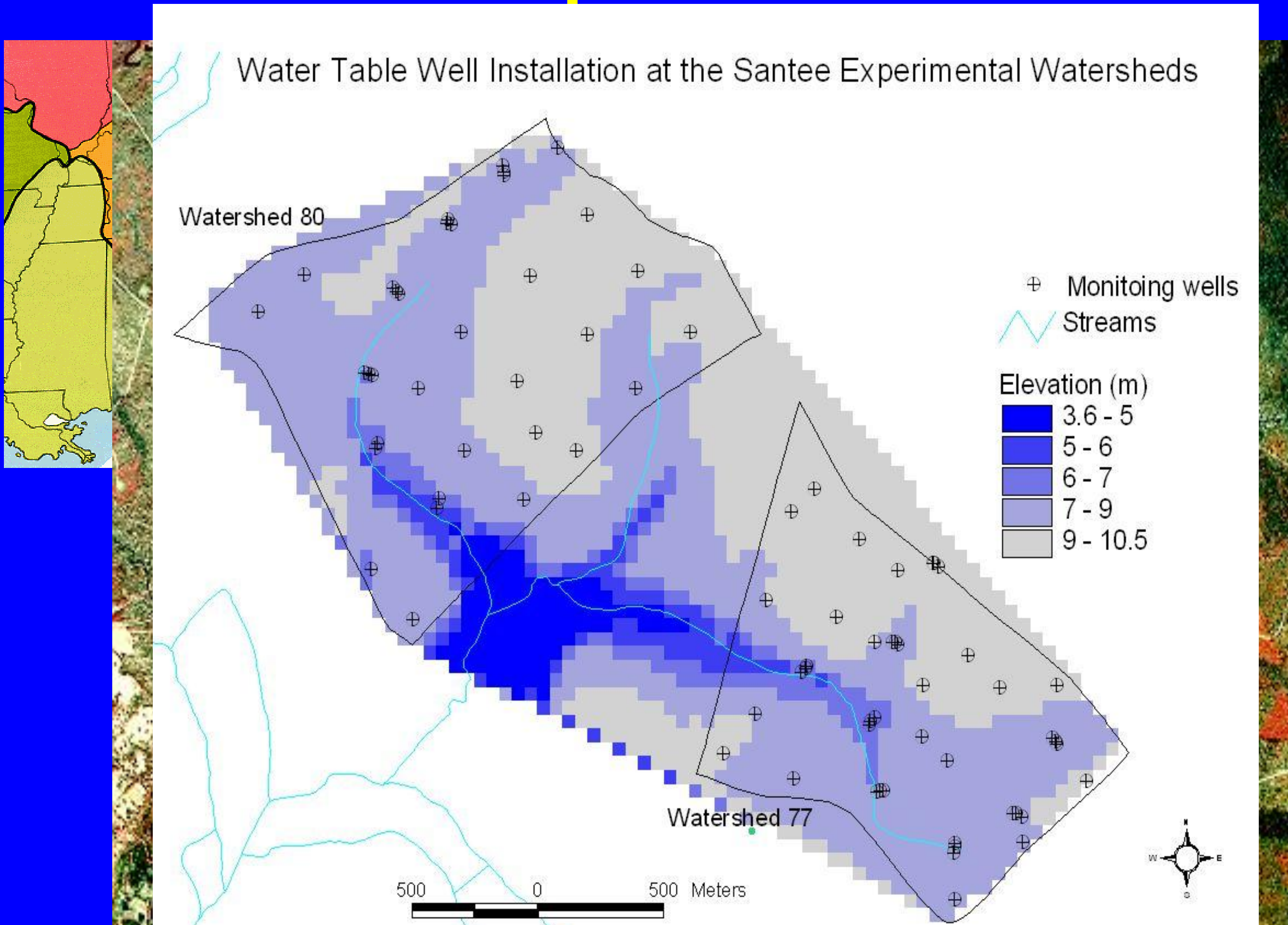
Sun et al., 2006. Wetlands, (26)2: 567-580

Key Findings

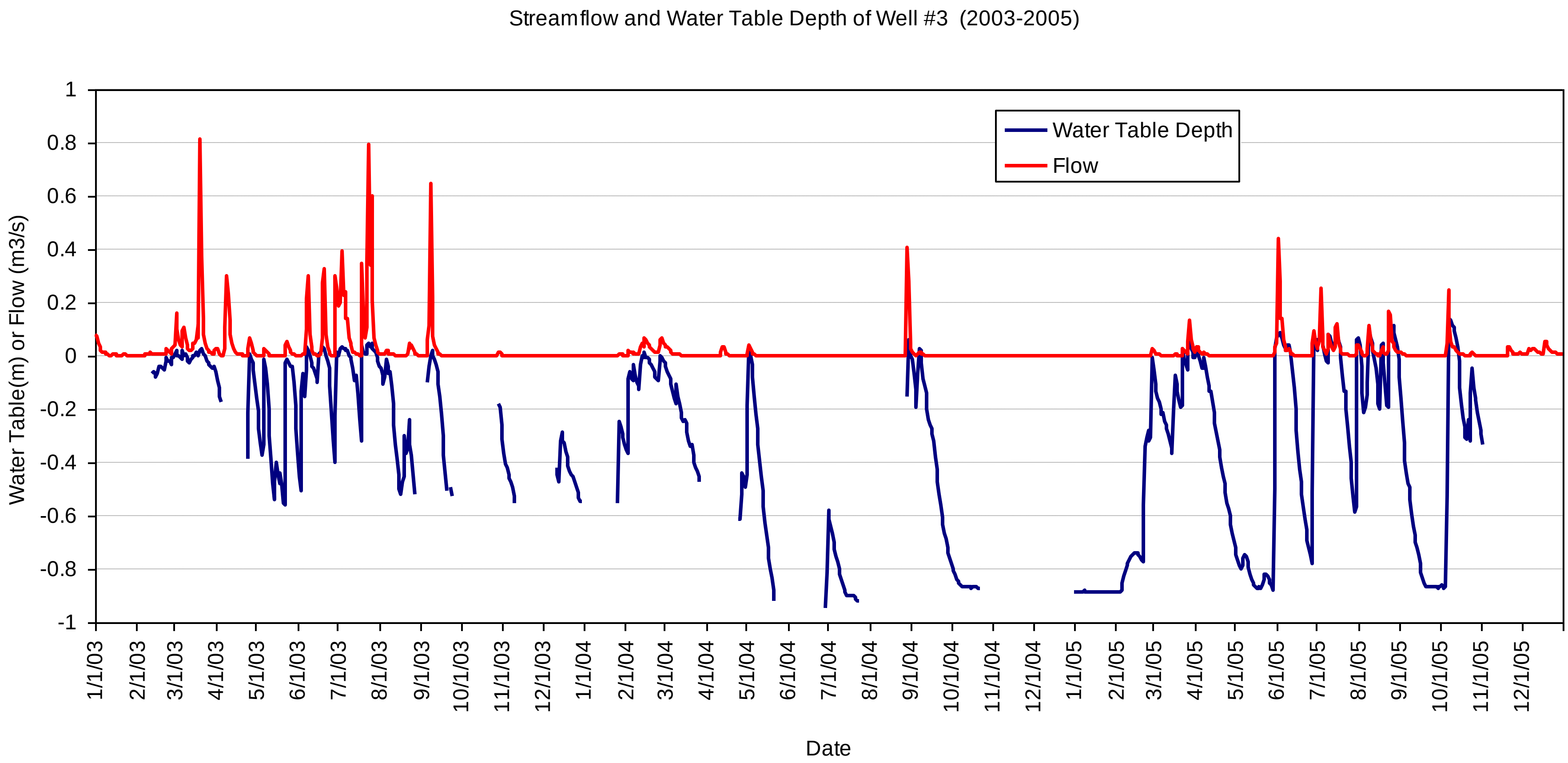
- ✓ Depressional wetlands are not isolated in groundwater flow/Surface flow with its surrounding uplands.
- ✓ Flow directions may be related to the subsurface restricting layer: the lower watershed boundary.
- ✓ Wet period critical to groundwater-surface water interactions



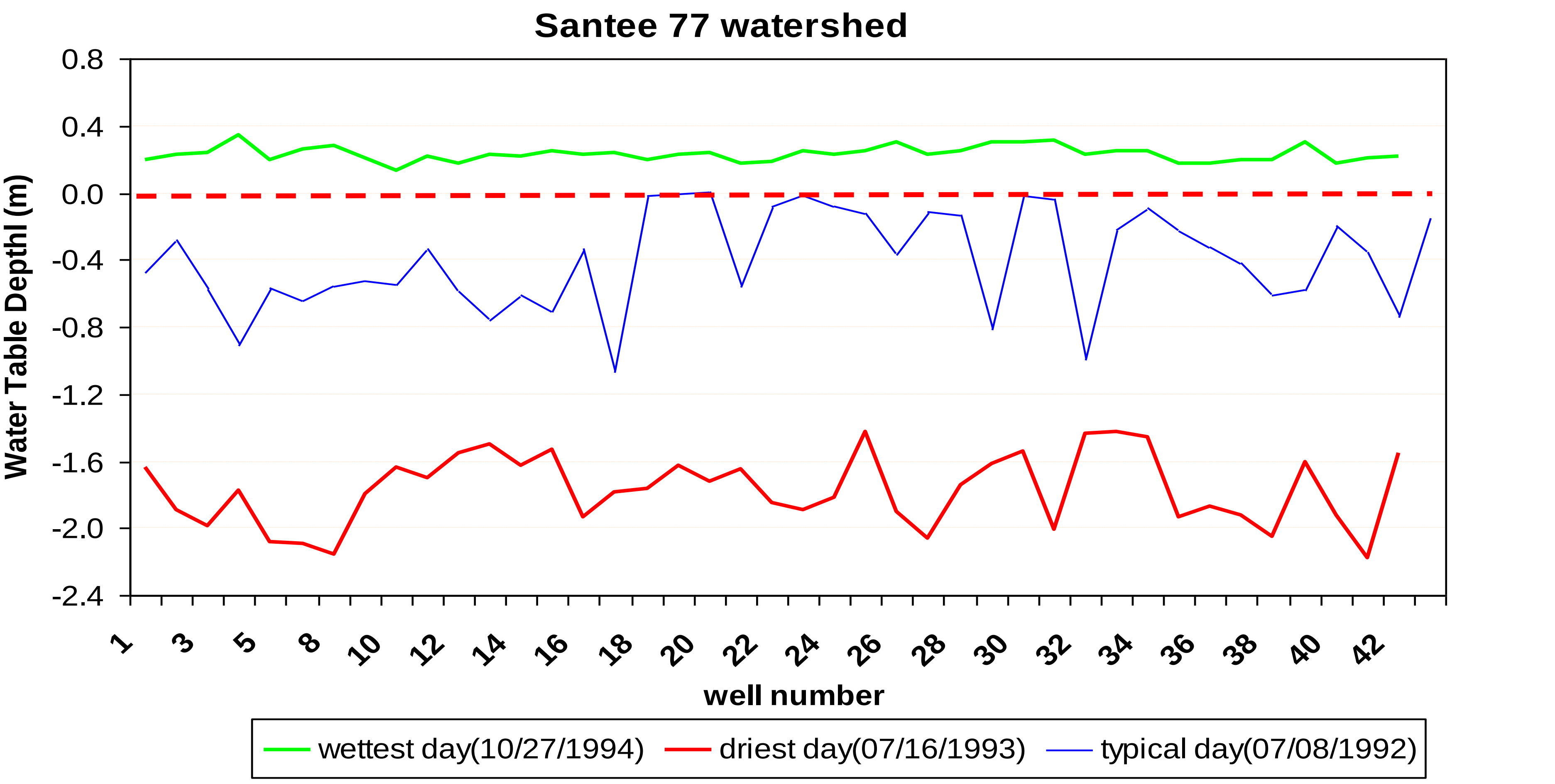
Santee Experimental Forest

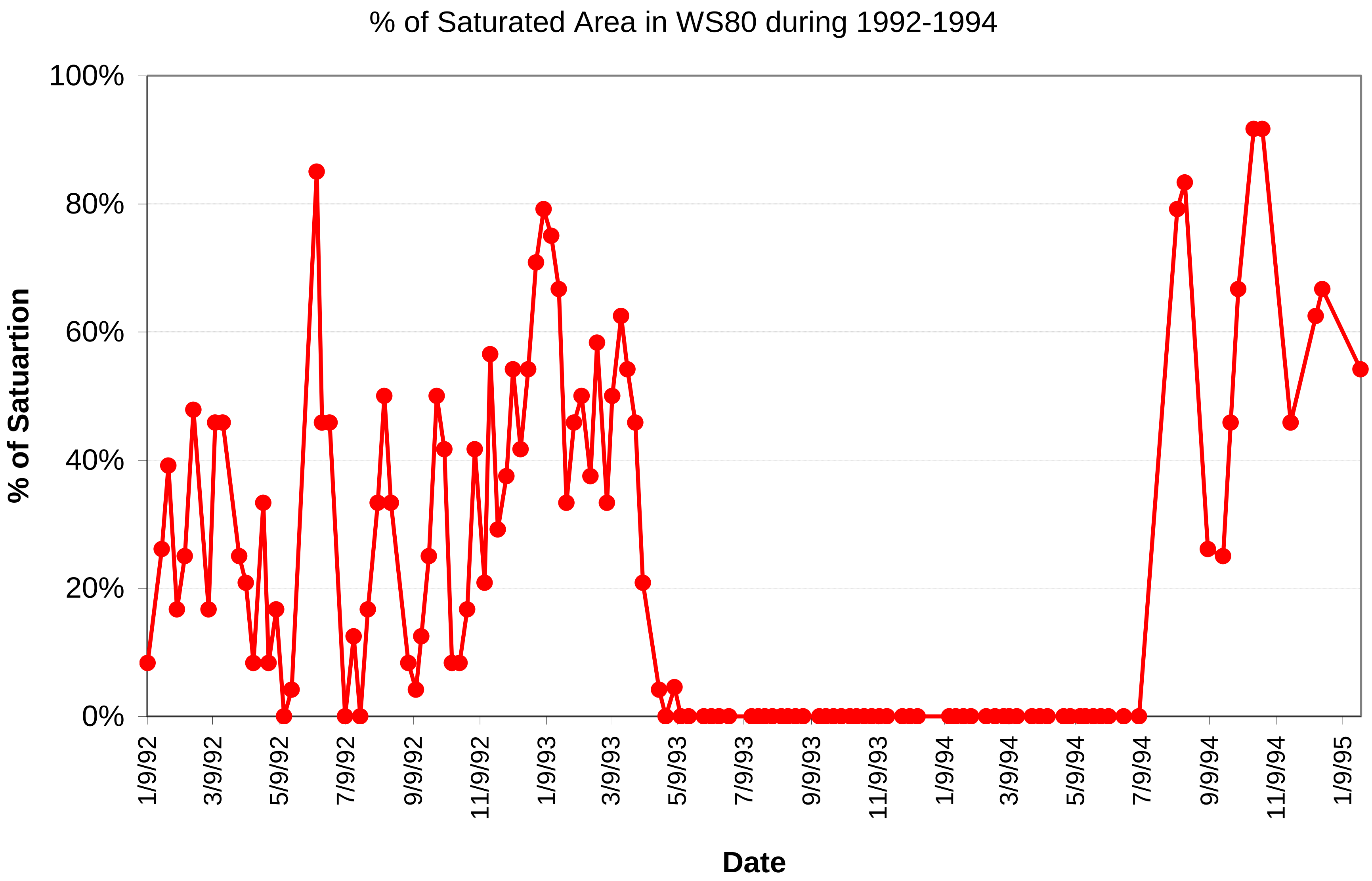


Santee Watershed (Control)



Spatial Distribution of Water Table Depth





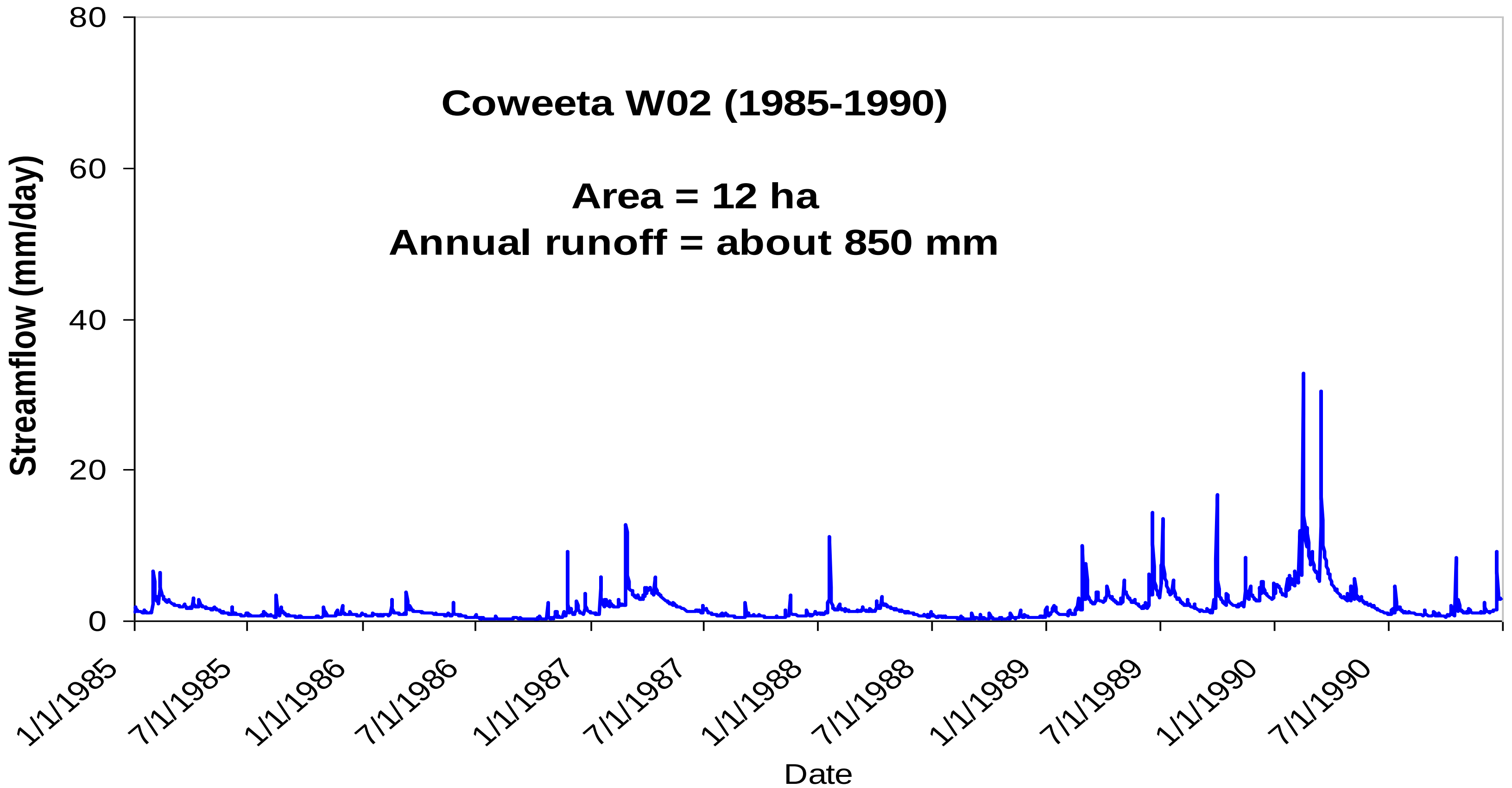
% of Saturated Area in WS80 during 1992-1994
100%
80%
60%
40%
20%
0%
% of Satuartion
1/9/92
3/9/92
5/9/92
7/9/92
9/9/92
11/9/92
1/9/93
3/9/93
5/9/93
7/9/93
9/9/93
11/9/93
1/9/94
3/9/94
5/9/94
7/9/94
9/9/94
11/9/94
1/9/95
Date

Key Findings

- 1^{st} order watershed: highly dynamic and large saturated area;
- Overland flow dominated the stream-upland connectivity;
- Shallow groundwater table controls hydrologic response to rainfall.

Research Sites

Coweeta Watershed



Key Findings

- Zero order watershed: saturation rarely occurs;
- 1^{st} order stream: very narrow saturated area;
- Subsurface flow dominated the stream-upland connectivity.

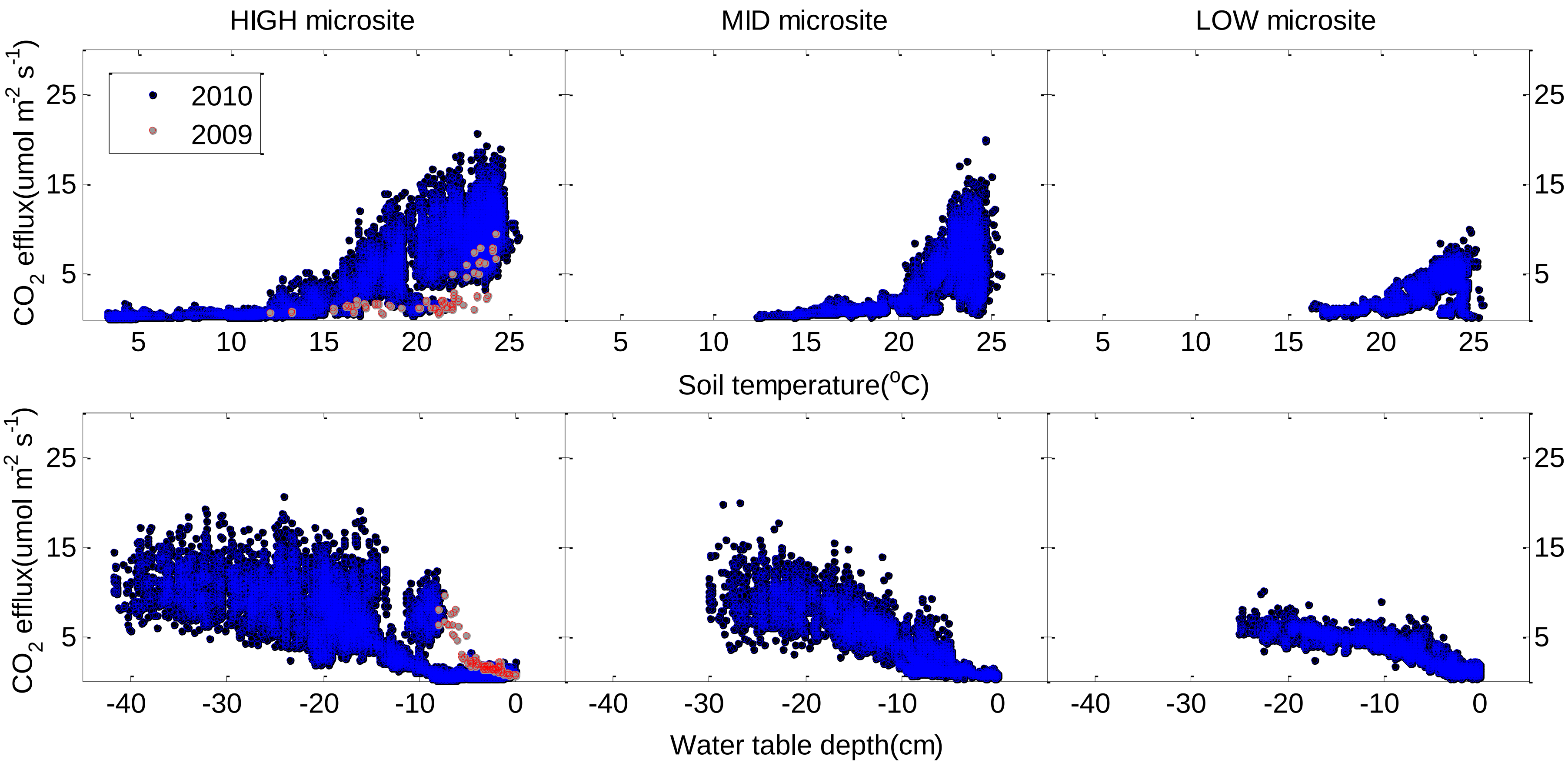
Implications:

Wetland are biogeochemical
Hot Spots

Sensitivity of Soil Respiration

Miao, Guofang (NCSU) unpublished data

Sensitivity of CO_2 Emission to WT and Temp



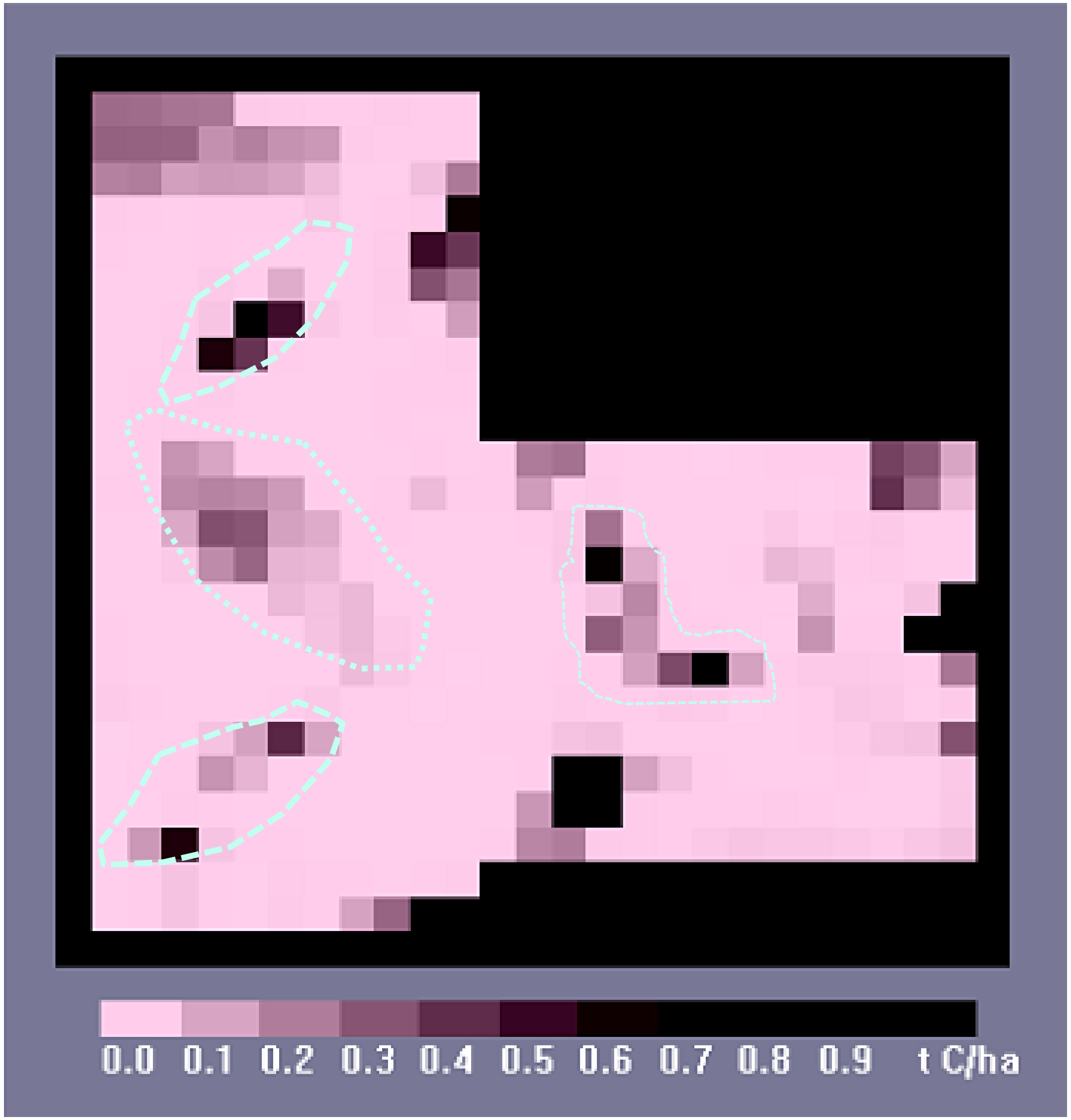
Miao, Guofang (NCSU) unpublished data

Modeled Spatial Distribution of CH_4

Slash pine Uplands:

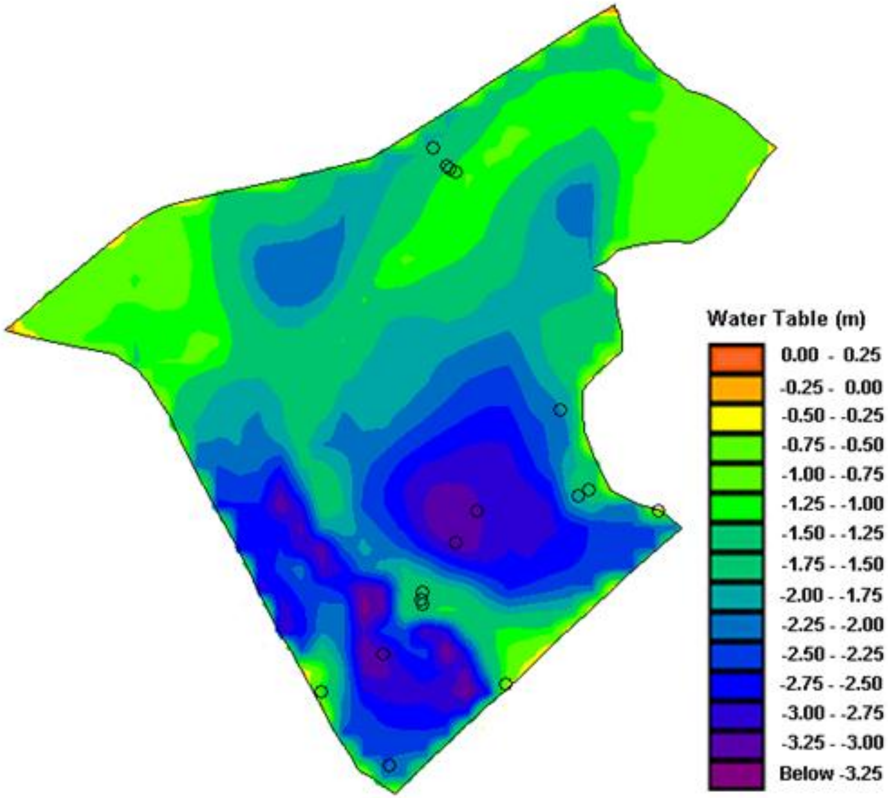
-5 kg/yr.

Cypress Wetlands:
2507 kg/yr.

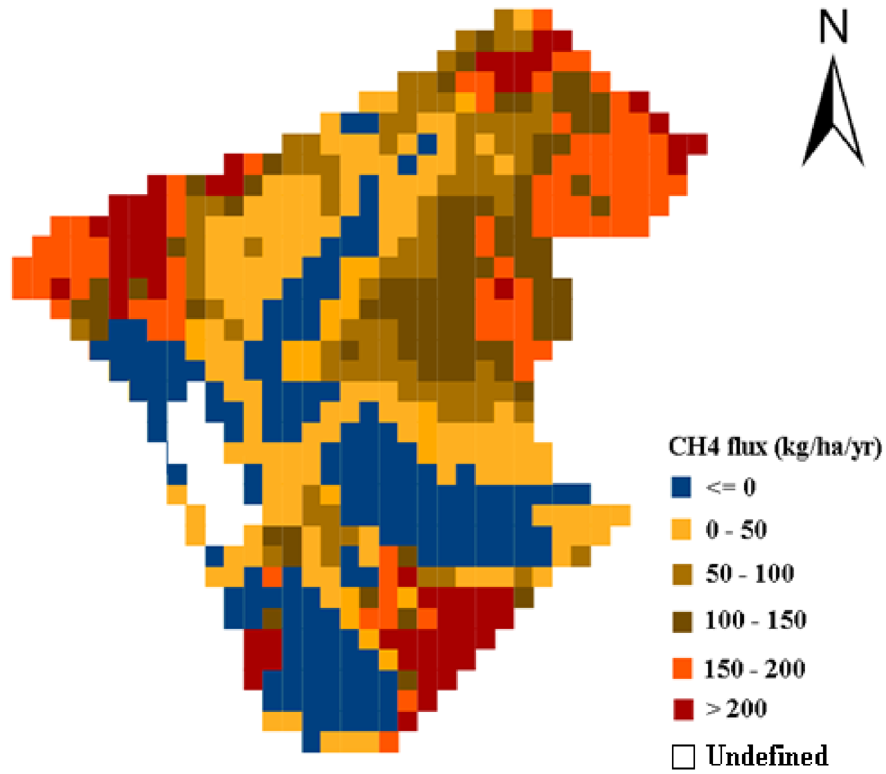


(Sun et al. ASABE Proceedings, 2006)

Water Table and CH4 Emission: Landscape Scale (Dai et al. Unpublished)



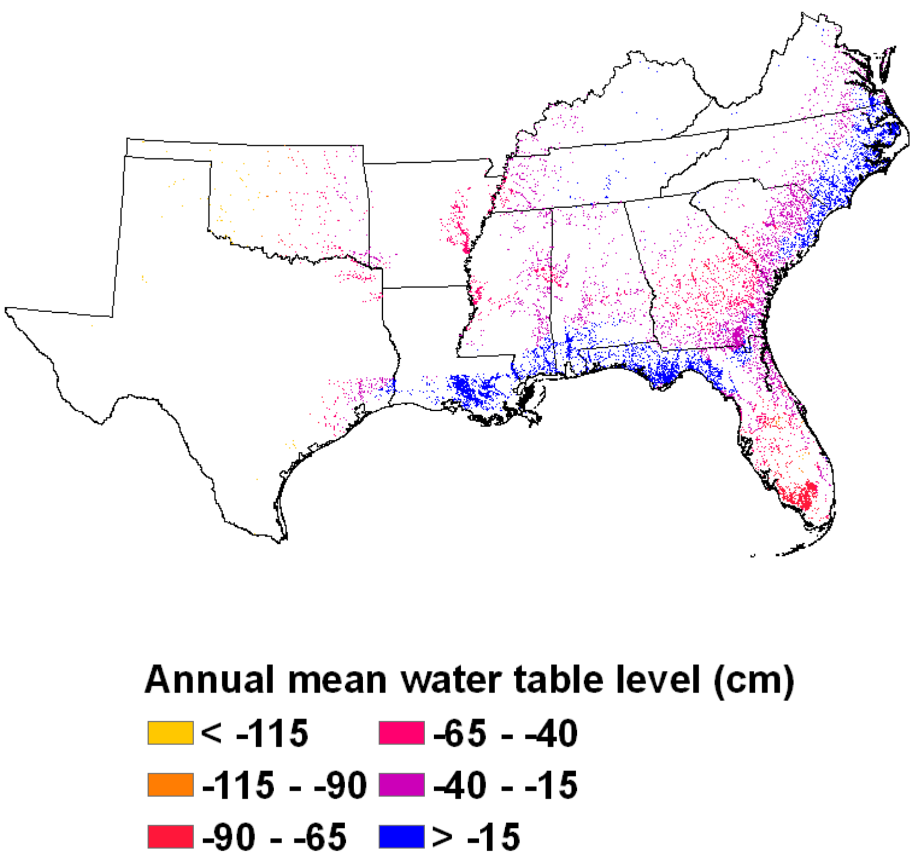
Water table depth (m) on WS80
(August 30th of 2007)



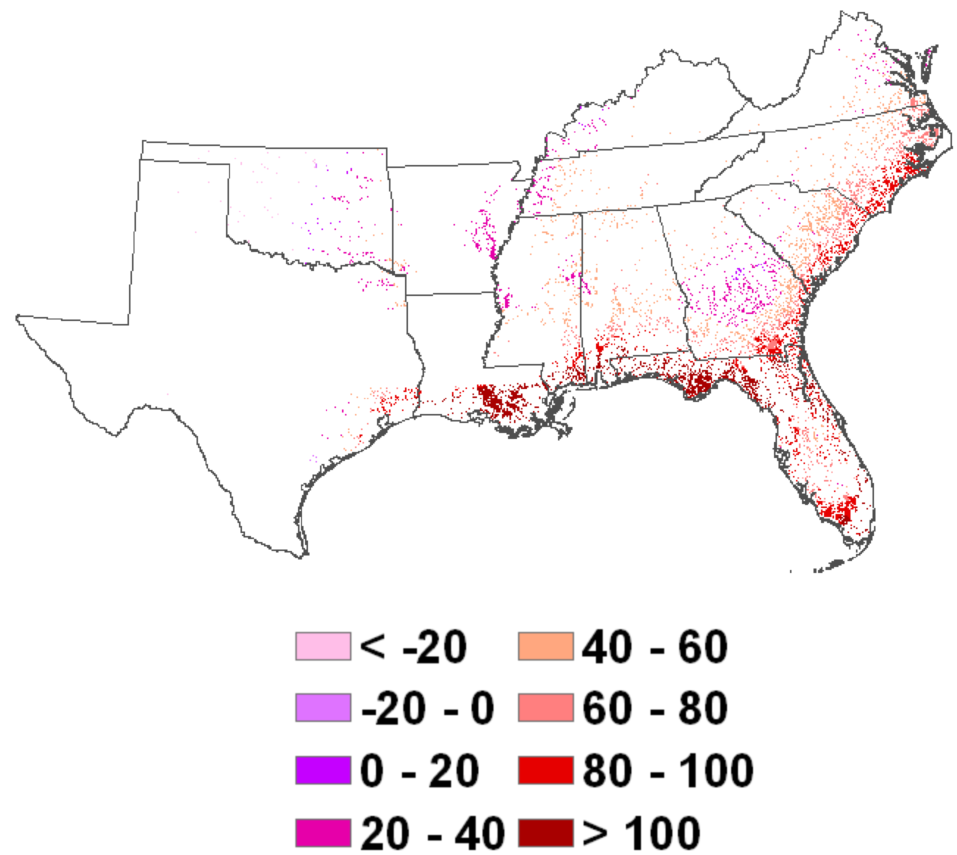
Mean CH4 flux WS80
(1965-2007)

Climate, Hydrology, and CH_4 Emission at Regional Scale (Dai et al. Unpublished)

Water table



Mean Net CH4 flux



Buffer Design and Flow Generation

- Large saturated areas of first-order watersheds;
- Overland flow forests;
- Wetlands are sources of stormflow.

The Variable Source Area Concept (Hewlett and Hibbert, 1967)