Process In and Services From Isolated Wetlands in Florida

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Background Information

Isolated wetlands are those that have no regular surface connection to the regional drainage network. They dominate the low-relief Florida landscape, particularly in head water areas where channelization is flow limited. They are critically important wetland resources, supporting more than 30% of the endangered fauna in Florida. Because they dry out regularly, and because they are hydrologically isolated, they represent a key component for supporting landscape biodiversity. They also represent distributed water storage that buffers variation in regional aquifer levels, and slows the passage of rainfall to the sea. As such, they have been easy and productive targets for drainage activities. Because they are small, they are often lost completely as part of development. In other cases, despite being left as wetlands, they are connected via complex networks of ditches, creating a new drainage system that alters both the wetlands and the landscape hydrology. Their ecological and hydrological value has been challenged in the US legal system since 2004. Two landmark Supreme Court decisions vacated the interpretation that these systems are legally protected waters under the Federal Clean Water Act. As such, they are critically imperiled landscape attributes. What is needed is a deeper understanding of how they work and what services they provide to the regional drainage system (water quantity and quality).

Fig. 1 – Current imagery of isolated wetland complexes in a) Big Cypress National Preserve, b) Osceola National Forest, c) Lake Okeechobee watershed, and d) west Florida development (where many of the isolated wetlands have been turned into open water systems).

Major Research and Management Problems

The main research questions pertain to the function of these wetlands as components of regional catchment systems. While they historically lacked surface connections, they still acted as buffers of the regional surficial aquifer system. In their current configuration, where ditches convey water between them and towards drainage conduits, their hydrologic services are more obvious. Moreover, as regional biogeochemical hot-spots and the location most proximate to agricultural and urban runoff, their potential to influence water quality is enormous. Currently, there are large and growing programs that pay farmers to enhance their isolated wetlands to provide regional services. There are also significant efforts underway to remove legal protections for these systems at the state level, facilitating their loss during urbanization and agricultural development.

Key technical questions include understanding their role in regional hydrology, their role in contaminant reduction (and how to optimize this), and how they respond ecologically to various types of disturbance (contamination, hydrologic modification, direct impacts via grazing).

In addition, there are two more fundamental questions that have received attention. The first involves refinement of methods for the estimation of wetland ET; isolated wetlands represent an ideal study site for this work (e.g., McLaughlin and Cohen, in review; Fig. 2). Second, these

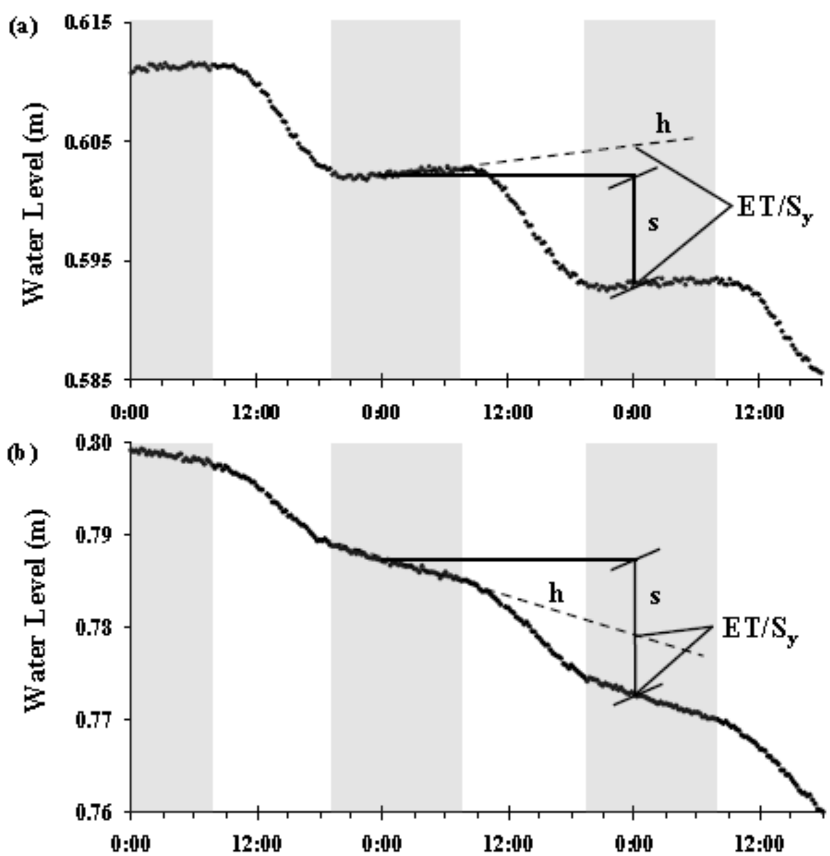

Fig. 2 – Selected water level data from one isolated wetland under two different ground water exchange regimes a) exfiltration, b) infiltration. The White method coupled with high resolution stage data can provide direct measures of both ET and net groundwater exchange, facilitating numerous new lines of ecohydrologic inquiry. Dark vertical bars denote nighttime periods.

wetlands likely play a significant role in the development of karst landscapes. Water infiltrating from these wetlands is highly undersaturated with respect to calcite (due to the indirect effects of aquatic respiration on the partial pressure of CO_2 and the direct effects of organic acids). As such, preferential dissolution of the subsurface limestone matrix is highly likely. This creates a millennial scale ecohydrologic feedback between the surface storage of water and the creation and augmentation of surface depressions (which form as the subsurface matrix is dissolved away and the overlying material collapses). Regular patterning evident in Fig. 1 strongly supports this mechanism, and is the subject of two major proposal efforts to the National Science Foundation.

Possible end-users

The protection of isolated wetlands at the national scale has fallen to the US Army Corps of Engineers, whose guidance regarding protection practices has changed dramatically in light of recent legal decisions. The US EPA, who is also charged with interpreting the new legal standards, has pursued several lines of research to better understand the hydrologic role these wetlands play at the landscape scale. As such, both agencies are important end-users, and potential supporters of research efforts. More locally, the burden of protecting isolated wetlands has fallen to Florida's Water Management Districts, as well as local county governments. Both are actively soliciting information to defend their permitting criteria, as would be users of this research. In South Florida, where programs that secure payments for ecosystem services to farmers that enhance their wetlands for water quantity and quality benefits, information about the role these isolated wetlands is also critical, and has been the source of ongoing funding.

Site conditions

Isolated wetlands vary widely in their hydrologic, edaphic and ecological characteristics. What they share, however, is a closed basin drainage morphology. They are typically round, comparatively small (1-10 ha) and have catchment areas typically 3-10 times larger than their surface area. Sandy soils generally preclude significant surface runoff, except during periods of high antecedent rainfall when the water table is at or near the land surface. Underlying most of these sites is a thick clay layer that slows (but does not stop) vertical seepage. As such, most hydrologic exchange occurs via shallow groundwater fluxes moving laterally. Variation in specific yield between the wetlands and their upland surroundings means that lateral groundwater flows are typically towards to wetland (exfiltration) for short periods following rain events, but out of the wetland (infiltration) most of the time. ET rates are generally high, though the breakdown between evaporative and transpiration losses is not well constrained.

Typical hydroperiod in these isolated wetlands ranges from 120 to 300 days, with significant interannual variation. Water levels are usually highest in the late fall, and stay high until the dry season and leaf-out consume the water during periods of low rainfall in April and May. Soils are typically quite organic rich, but generally are not true peats because of short hydroperiods.

One sentinel feature of forested isolated wetlands (and perhaps forested wetlands in general) is the emergence of microtopographic high points (hummocks). These hummocks are constructed of organic matter, and typically form around bases of trees where below ground production is highest. By virtue of shorter hydroperiod, which reduces inundation stress and remineralizes critical nutrients, they are the site of the vast majority of rooted plants. This creates an interesting local positive feedback (between productivity and soil elevation) that has hallmark attributes of self-organization. This ecological feedback on local hydrology is an area of active research.

Monitoring and Data

There is limited sustained data collection in these systems, principally because monitoring resources are typically dedicated to downstream settings and larger wetlands. However, we have (in North Florida - Cohen) 3 years of continuous stage data in 12 wetlands, and nearly as long in 4 study sites in South Florida – Jawitz). As part of a proposal to NSF, we have instrumented 4 wetlands in the Big Cypress National Preserve with level logging equipment from which we can obtain direct estimates of ET, net groundwater exchange and hydropattern information. Large catchment discharge information is relatively widely available, but low-relief and significant back-water effects have limited the number of small catchment sites that are monitored. The Bradford Experimental Forest in North Florida has ca. 30 years of daily flow, groundwater level and rainfall data for two small catchments that contain isolated wetlands.

Publications

Bond, B.J., J.A. Jones, G. Moore, N. Phillips, D. Post, and J.J. McDonnell (2002), The zone of vegetation influence on baseflow revealed by diel patterns of streamflow and vegetation water use in a headwater basin, Hydrol. Processes, 16, 1671-1677, doi:10.1002/hyp.5022.

Ewel, K.C., and J.E. Smith (1992), Evapotranspiration from Florida pondcypress swamps, Water Resour. Bull., 28(2), 299-304.

Hill, A.J., and V.S. Neary (2007), Estimating evapotranspiration and seepage for a sinkhole wetland from diel surface-water cycles,JAWRA, 43(6), 1373-1382.

Liebowitz, S.G. 2003. Isolated wetlands and their functions: an ecological perspective. Wetlands 23:517-531

Lindsay, J.B., I.F. Creed and F.D Beall. 2004. Drainage basin morphometrics for depressional landscapes. Water Resources Research 40: W09307, 9 PP., doi:10.1029/2004WR003322

Lu, J., G. Sun, S.G. McNulty, and Comerford, N.B. 2009. Sensitivity of pine flatwoods hydrology to climate change and forest management in Florida, USA. Wetlands (29): 826-836.

McLaughlin, D.L, M.T. Brown and M.J. Cohen. 2011. The Ecohydrology of a pioneer wetland species and a drastically altered landscape. Ecohydrology. doi: 10.1002/eco.253

McLaughlin, D.L. and M.J. Cohen. 2011. Thermal Artifacts in Measurements of Fine Scale Water Level Variation. Water Resources Research 47: 3 PP., 2011 doi:10.1029/2010WR010288

McLaughlin, D.L. and M.J. Cohen. In Press. Ecosystem Specific Yield for Estimating Evapotranspiration and Groundwater Exchange from Diel Surface Water Variation. Ecohydrology

Mould DL, Frahm E, Salzmann T, Miegel K, Acreman MC. 2010. Evaluating the use of diel groundwater fluctuations for estimating evapotranspiration in wetland environments: case studies in southeast England and northeast Germany. Ecohydrology 3: 294-305, doi: 10.1002/eco.108

Richardson, C.J. 2003. Pocosins: Hydrologically isolated or integrated wetlands on the landscape? Wetlands 23:563-576

Rosenberry DO, Winter TC. 1997. Dynamics of water-table fluctuations in an upland between two prairie-pothole wetlands in North Dakota. Journal of Hydrology. 191: 266-289.

Semlitsch, R.D. and J.R. Bodie. 1997. Are Small Isolated Wetlands Expendable? Conservation Biology 12:1129-1133

Sumner, D.M. (2007), Effects of capillarity and microtopography on wetland specific yield, Wetlands, 27(3), 693-701.

Tamea, S., Muneepeerakul, R., Laio, F., Ridolfi, L., Rodriguez-Iturbe, I. 2010. Stochastic description of water table fluctuations in wetlands. Geophysical Research Letters 37: L06403, doi: 10.1029/2009GL041633

Tiner, R.W. 2003. Geographically isolated wetlands of the United States. Wetlands 23:494-516