RELATIONSHIPS AMONG SOIL LITHOLOGY, TIMBER HARVEST AND THE HYDROLOGY OF COASTAL PLAIN DEPRESSIONAL WETLANDS

Melinda Mosner[1], C. Rhett Jackson[2] and Darold P. Batzer[3]

AUTHORS: [1]Graduate Student and [2]Assistant Professor, Warnell School of Forest Resources; and [3]Assistant Professor, Department of Entomology, University of Georgia, Athens, Georgia 30602.

REFERENCE: Proceedings of the 1999 Georgia Water Resources Conference, held March 30-31, 1999, at the University of Georgia. Kathryn J. Hatcher, editor, Institute of Ecology, University of Georgia, Athens, Georgia.

Abstract. Piezometric data and soil data are being collected within and around a group of Coastal Plain depressional wetlands located in commercial timber land in Effingham County, GA. The water level data is being used to determine how differences in soil lithology affect the hydroperiods, especially the start and end of dry periods. The data is also being used to compare the hydroperiods among wetlands with differing ages of adjacent tree stands. The pine forests around these wetlands are harvested on a 20-25 year cycle, and the chemistry and understory of these wetlands respond dramatically and immediately to adjacent timber harvest. The role of hydrologic change in these chemical and plant community responses is being investigated as part of this project.

INTRODUCTION

Ten isolated Coastal Plain wetlands, located on commercial forest property, have been instrumented to characterize their hydrology and to determine the extent that soil properties and timber management practices affect the hydrology of these wetlands. The area under investigation is a cypress dome/pine flatwoods ecosystem in which flat topography, soil porosity, and the vertical movement of water define its regional hydrology (Fares, 1996). Much of the Georgia Coastal Plain is covered by pine plantations, and forestry management practices have led to significant regional changes in the water regime (Reikirk, 1989).

Need for hydrologic data

While much research has been done on the vegetative and biogeochemical functioning of coastal wetlands there has been little concentrated work on the hydrologic aspects of these wetlands. As early as 1978 the lack of hydrologic information was a concern. Gosselink and Turner (1978) felt "solid quantitative information about the hydrodynamic characteristics of different wetlands is surprisingly difficult to find" (Reed, 1993). These concerns were echoed in the 1980's by many who felt that although hydrology was the driving force of wetland ecology, an understanding of the specific factors involved was lacking (Carter, 1986 and Labaugh, 1986). Because of this, the relationship between hydrologic processes and the structure and function of wetlands was poorly understood (Labaugh and Winter, 1987). Recognizing this lack of information, recent researchers have examined the hydrologic characteristics of wetlands, more importantly the relationship between wetlands and groundwater (Gerla, 1992; Doss, 1995; Doss, 1993; Fares et al., 1996; Reikirk, 1989; Richardson and McCarthy, 1994; and Richardson, 1994).

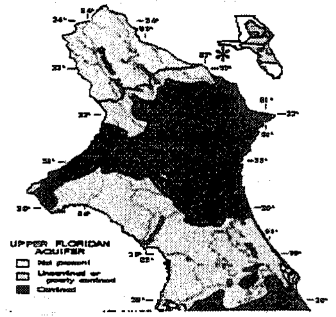

Figure 1. Floridan aquifer and the study area from Berndt et al., 1998.

Basic hydrologic descriptions of these wetlands are also relevant for understanding the relationship between groundwater pumping and surficial wetland hydrology. In the Savannah area, increased pumping from the Floridan aquifer has become a major environmental and political concern. Prior to development, coastal Georgia was a discharge area for the aquifer, and water from the aquifer flowed upwards into the surficial aquifer. With increased pumping, flow paths are now primarily downward and the surficial aquifer of the Georgia coast acts as a recharge area for the Floridan

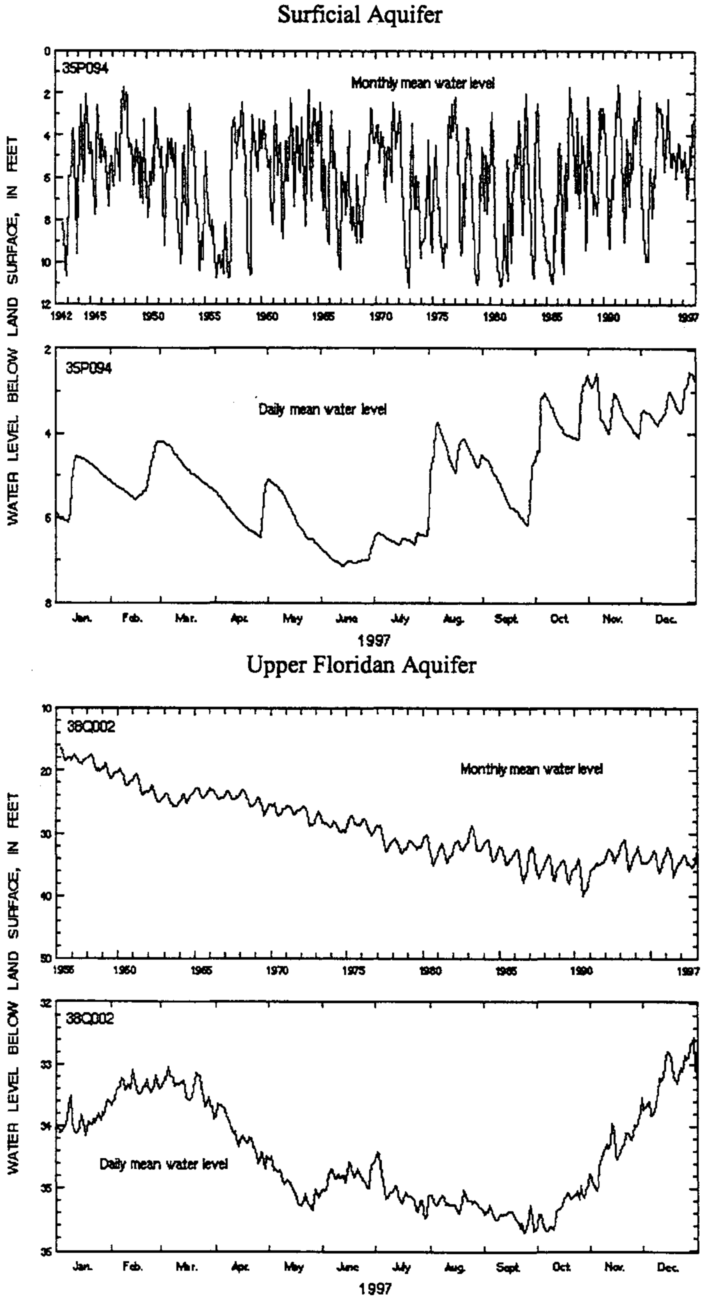

Figure 2. Historical and current fluctuations of surficial aquifer and Upper Floridan aquifer from Cressler, 1997.

aquifer (Garza and Krause, 1992) (Figure 2). As a result, saltwater intrusion and aquifer contamination are now serious environmental threats. It is unknown how changes in groundwater flow patterns influence wetland hydrology in the coastal plain, and how these changes affect the functioning of the ecosystem as a whole. By altering gradients in the surficial aquifer, groundwater pumping may affect wetland hydroperiods.

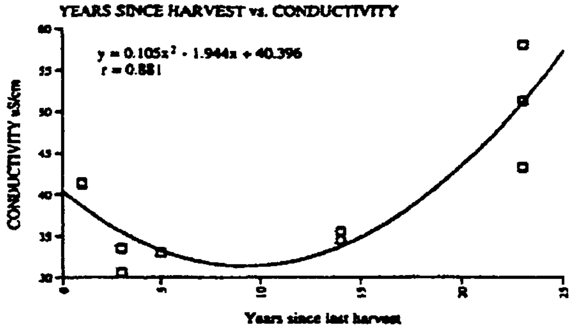

Figure 3. Wetland chemistry variation in 1998 among sites harvested over 23 years.

Preliminary surveys of the study wetlands have found strong gradients in chemical and herbaceous plant growth with respect to the age of the adjacent timber stand (Figure 3). We have hypothesized several factors driving these changes including alterations of hydroperiod, changes in incident light, nutrient release from clearcuts, and stand fertilization. Although this discussion is concerned with only the hydrologic aspects, investigations into the other factors are ongoing.

STUDY AREA

The study area is located 15 miles north of Savannah, GA on commercial forest lands. Wetlands used in the study range in size from 0.5 to 2 acres. The overstory is cypress, black gum, and/or pine, the understory consists of assorted shrub/scrub, and as mentioned above herbaceous cover is highly variable. The area is characterized by a flat topography, with elevational changes of less than 20 feet.

The region is well known for the productivity of its aquifer system. The surficial aquifer consists of Miocene and post-Miocene age sands, clays, and interbedded limestone. Water in the surficial aquifer is controlled by vertical influences and is recharged primarily by rainfall. The upper confining unit consists primarily of clays and other clastic sediments of low to moderate permeabilities. Its thickness ranges from 50 to 400 feet, increasing in depth as it nears the coast. The Floridan aquifer is the main water-bearing unit for the coastal plain. The Floridan is broken into two hydrologic units, upper and lower. Due to salt water leakage from below and depth, the lower unit is rarely used as a water source. The depth to the upper unit ranges from 100 to 450 feet, increasing southward and aquifer thickness ranges from 1 to 600 feet, again increasing towards the coast (Garza and Krause, 1992).

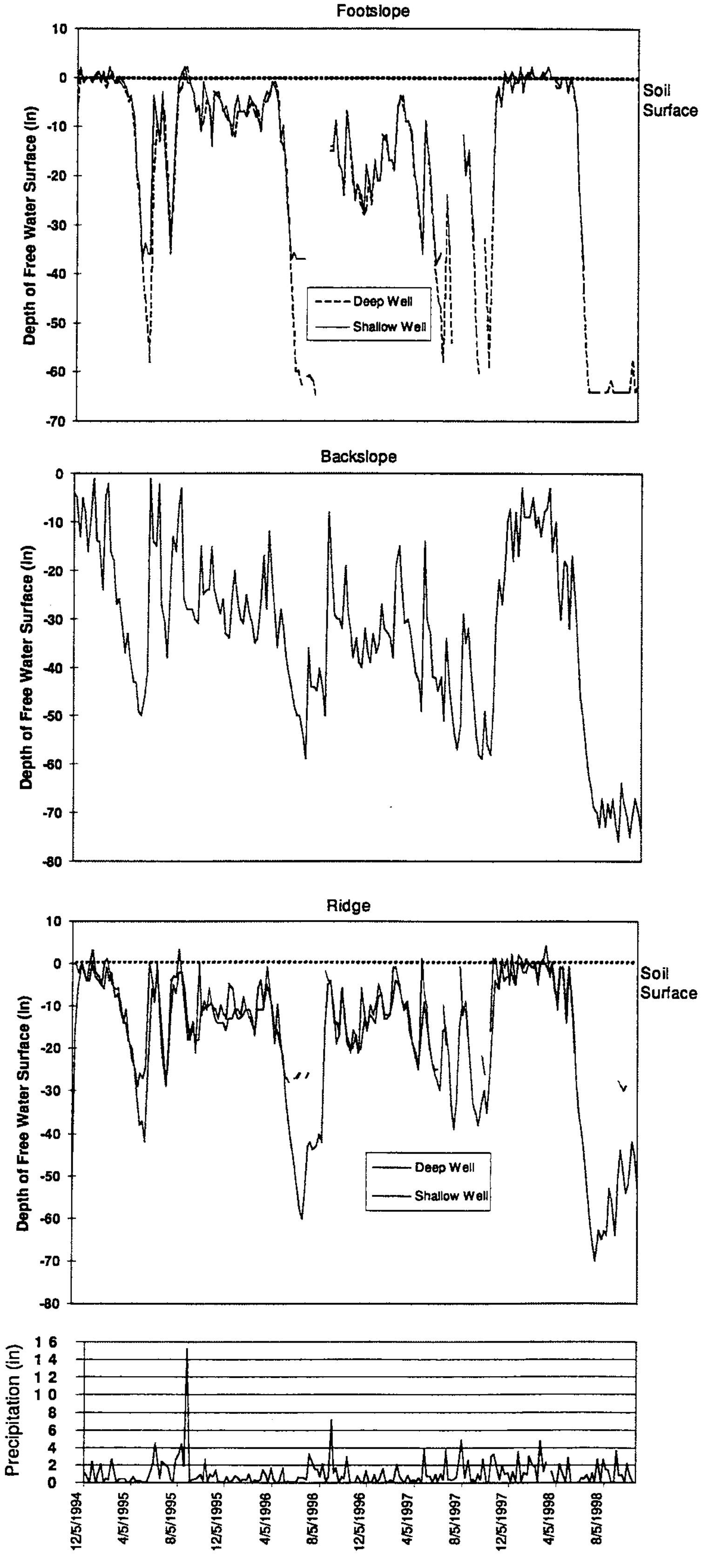

Figure 4. Water level and precipitation data from piezometric study begun in December 1994. Deep wells are generally 6 feet deep, shallow wells generally 2 feet deep.

METHODS

Surficial groundwater, wetland stage and precipitation will be measured biweekly through the summer of 1999. Nests of piezometers are installed at all sites to depths of 3 and 6 feet. In four of these wetlands the deep well is equipped with a continuous water level recorder. The stands surrounding these wetlands are also equipped with continuous water level recorders. Stand age varies from clearcut to 23 years. Wells of 2-inch PVC were installed using a 4-inch auger, backfilled with sand and sealed with bentonite. All wells are screened at the bottom and capped to prevent direct precipitation. Electronic water level finders and water indicating paste are used to measure current and high water levels. Soil samples were taken from wetlands during well installation. Upland soil samples will be taken this winter along several topographic transects. Precipitation is currently monitored on site with complete records dating to December 1994.

RESULTS

This project is in its initial stages. Instrumentation of the sites was completed in November and more work is scheduled for February. Drought conditions in the study area have postponed the seasonal wetting up pattern of these wetlands and little data is available for report at this time. However data from a concurrent study, being incorporated into this project, allows us to develop further hypotheses regarding the hydrology of the region. Figure 4 shows the water table fluctuation of three sites along a wetland catena. Each of these sites responds dramatically to rainfall events, and the hydroperiods appear to be seasonally driven. Wells at a lower topographic position show brief periods of water levels above the soil surface, while those on slopes respond similarly to climatic influence but water levels never reach the surface. From this data we have developed a conceptual flow net in an attempt to describe typical flow paths in the surficial aquifer (Figure 5). The lower boundary conditions of the flow net are unknown, so for the purposes of this project we assume that the upper confining unit of the Floridan aquifer is a no-flow boundary.

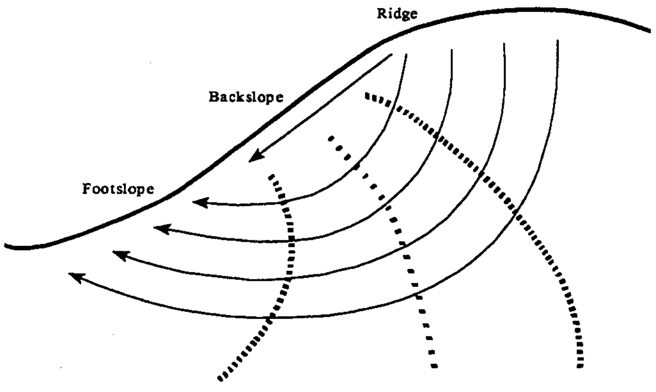

Figure 5. Schematic of hypothesized flow net for catena.

In the flow net, water is introduced at the top of the ridge via precipitation and lost by evapotranspiration and downward groundwater flow. Further down the ridge, near-surface groundwater flows nearly parallel to the surface. The wetlands and stream at the base of the catena receive water not only from precipitation but also groundwater discharge from the entire hillslope.

CONCLUSIONS AND FUTURE EMPHASIS

The sandy soils of the region allow for relatively rapid response to rainfall events, evidenced by the fluctuations of shallow wells. What has yet to be determined is how the interspersed lenses of clay and the lower boundary conditions specifically affect these flow paths. Seasonal evapotranspirative demands of the surrounding pine stands may influence groundwater flow, but the cumulative affect these factors have on wetland hydrology has yet to be quantified. Future work will focus on the degree of influence that timber harvest and stand age in adjacent uplands have on local wetland hydrology as well as the regional effect of aquifer drawdown and how it has altered groundwater flow paths within the coastal plain.

LITERATURE CITED

Berndt, M.P., Hatzell, H.H., Crandall, C.A., Turtora, M., Pittman, J.R., and Oaksford, E.T., 1998. Water Quality in the Georgia-Florida Coastal Plain, Georgia and Florida, 1992-96: U.S. Geological Survey Circular 1151, on line at<URL: http://water.usgs.gov/pubs/circ1151>, updated April 2, 1998.

Carter, V. 1986. An overview of the hydrologic concerns related to wetlands in the United States. Canadian Journal of Botany 64:364-374.

Cressler, A. 1997. Ground-Water Conditions in Georgia, 1997. U.S. Geological Survey Open-File Report 98-172, 104 pages.

Doss, P. 1993. The nature of a dynamic water table system of non-tidal, freshwater coastal wetlands. Journal of Hydrology 141:107-126.

Doss, P. 1995. Physical-hydrogeologic processes in wetlands. Natural Areas Journal 15:216-226.

Fares, A., R. S. Mansell, and N. B. Comerford. 1996. Hydrological aspects of cypress wetlands in coastal-region pine forests and impacts of management practices. Soil and Crop Science Society of Florida Proceedings. 55:52-58.

Garza, R. and R. Krause. 1992. Water supply potential of major streams and the upper Floridan aquifer in the vicinity of Savannah, Georgia. United States Geological Survey Open File report 92-629, 49 pages.

Gerla, P. 1992. The relationship of water-table changes to the capillary fringe, evapotranspiration, and precipitation in intermittent wetlands. Wetlands 12:91-98.

Labaugh, J.W. 1986. Wetland ecosystem dynamics from a hydrologic perspective. Water Resources Bulletin 22:1-10.

Labaugh, J.W. and T.C. Winter, V.A. Adomatis, and G.A. Swanson. 1987. Hydrology and chemistry of selected prairie wetlands in the Cottonwood Lake area, Stutsman County, North Dakota. Professional Paper 1431, U.S. Geological Survey, Denver, Colo. 26 pages.

Reikirk, H. 1989. Influence of silvicultural practices on the hydrology of pine flatwoods in Florida. Water Resources Research. 25:713-719.

Reed, D.J. 1993. Hydrology of temperate wetlands. Progress in Physical Geography 17, 1: 20-31.

Richardson, C. 1994. Ecological functions and human values in wetlands: A framework for assessing forestry impacts. Wetlands 14:1-9.

Richardson, C. and E. McCarthy. 1994. Effect of land development and forest management practices on hydrologic response in southeastern coastal wetlands: a review. Wetlands 14:56-71.