OKEFENOKEE SWAMP HYDROLOGY

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Abstract. The Okefenokee Swamp is one of North America's largest freshwater wetlands. Swamp hydrology is largely controlled by precipitation and evapotranspiration; regional topographic features of the swamp control surface water movements. Manipulations to the swamp topography and vegetation communities during this century have affected water movement and variability in parts of the swamp. Changes in swamp hydrology since the construction of the Suwannee River Sill are generally restricted to the West Central area bounded by the Pocket, Billy's Island, Craven's Island, Minnie's Island, and Minnie's Lake; changes in precipitation patterns during the "with-sill" interval may have contributed to reduced flow variability and increased volume exiting the swamp via the St. Mary's River. We are currently examining the spatial effects of the Suwannee River sill on the swamp hydrology with a grid-cell based model.

AREA DESCRIPTION

The Okefenokee Swamp is a complex of forested uplands and freshwater wetlands covering 3826 km^2 of lower Atlantic Coastal Plain in Southeast Georgia and Northeast Florida. The swamp's geologic origins are 200,000 years ago, and its current character as a peat-based wetland began with peat accumulation 6,500 years ago (Cohen 1973). The swamp's watershed (approximately 3700 km^2) includes 3 drainage basins. The Suwannee River carries roughly 85% the exiting flow; the St. Mary's River (11%) and Cypress Creek (4%) account for the remainder (Rykiel 1977). Water enters the swamp as precipitation (70%) and surface drainage of uplands along the northwestern edge and leaves through evapotranspiration (80%) and river and stream flow (Rykiel 1977). Water inflow and outflow via groundwater exchange are believed to be minimal. Water levels are lowest during June when evapotranspiration demands are highest, and December, the normal dry season. Most rainfall occurs during June-September. The swamp topographic relief is minimal. The swamp is a bowl-like depression in the landscape with the trend in ground surface elevation from 38.4 m at Kingfisher Landing in the Northeast to 33.0 m in the area where the Suwannee River exits the swamp in the West to 34.75 m at Ellicott's Mound in the Southeast near the St. Mary's River outflow. Within the swamp are regional topographic highs on large sand-based islands and lows in large prairies. The prairies also contain local topographic highs on peat-based islands that may rise a meter above the surrounding inundated peat surface. This local topographic variation results in gradients of vegetation community distributions within the prairies; the forest matrix between the prairies has less local topographic variation and a less diverse vegetation composition. Peat thickness is also greatest in the prairies, most likely due to the pooling of water in these topographic lows which decreases decomposition of the accumulated peat. The peat surface is occasionally exposed during periods of extremely low rainfall. Drought conditions occur every 20-30 years and may last for a few weeks to months. The swamp responds quickly to a return to average seasonal rainfall; most areas that have experienced drawdown will return to seasonal water levels with 2-3 weeks of the return of normal rainfall. During this century the swamp hydrology has been directly and indirectly modified by human influence. An attempt to drain the swamp during the late 1890's and removal of marketable timber and peat during the early 1900's altered local and possibly regional flow patterns. During 1954-1955 extensive fires burned 80% of the swamp and damaged much of the surrounding commercially managed timber land (Hamilton 1984). To prevent this destruction to the surrounding lands from re-occurring, and to decrease additional peat loss in the swamp near the Billy's Lake outflow point, a dam (the Suwannee River sill) was constructed during 1960-1962 across the Suwannee River at its exit from the swamp. Its purpose was 1) to retain water in the swamp, particularly during seasonal low water level periods when wildfire frequency is greatest, to prevent wildfires from initiating in and spreading away from the swamp, and 2) to accelerate peat accumulation in the Billy's Lake "natural sill" area to create a "plug" and impound water from this point throughout the swamp (Roelle and Hamilton 1990). Although the dam has 2 maneuverable outfall gates, these gates are not manipulated and remain closed. Drawdowns which have occurred since the sill's construction have been due to temporary breaks in the gate structures and periods of low rainfall. Additional local and regional hydrologic manipulation is probably continuing as recreational boat trails are used and annually maintained throughout the swamp.

SWAMP HYDROLOGY

The hydrologic environment is not uniform throughout the swamp. There are 5 major "basins" within the swamp which show some connectivity but also behave independently. The basins are 1) the northwestern quarter from Sapling Prairie to Billy's Island and the Pocket; 2) the northeastern area from Double Lakes to southern Durdin Prairie; 3) the central region from Chase Prairie to Blackjack Island; 4) the southeast corner from south of Blackjack Island to the St. Mary's River; and, 5) the southwest corner from Blackjack Island west to Cypress Creek. Each of these areas follows the overall seasonal trends in water surface elevation (Figure 1). However, the magnitude of these trends varies among the regions. Greatest seasonal and annual variability in water surface elevation occurs in the northwestern region, which includes the Suwannee River. Annual variation may be $\pm$0.75 m, and all of this change may occur over a 3-4 week interval during a concentrated period of low rainfall and high evaporative demands. Water surface elevation in this area is probably controlled by seasonal rainfall, primarily because much of the water is contributed by streams in the watershed to the west of the swamp. In contrast the least seasonal and annual variability in water surface elevation occurs in the northeast, where annual variation averages $<\pm$0.06 m. This may be due to groundwater inflows or restricted outflow creating a perched water surface. The central region has intermediate annual variability of $<\pm$0.15 m. Most of the water in this area is contributed by precipitation, and water surface elevation declines rapidly during periods of high evaporative demand; there is also some groundwater flow into this area, although this contribution is probably minor. The Southeast and Southwest regions are somewhat isolated from the remainder of the swamp by large islands (Blackjack, Mitchell, Soldiers Camp, Honey, Pocket) and are probably not hydrologically influenced by the Suwannee River. These areas show intermediate fluctuations like the central region, and variability like the northwestern region at the basin low points (the St. Mary's River outflow in the Southeast and Cypress Creek outflow in the Southwest).

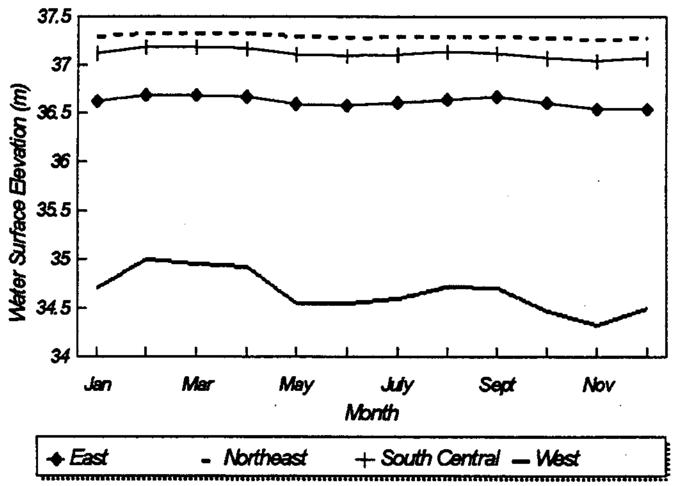

Figure 1. Average monthly water surface elevation above mean sea level measured during 1980-1993 in regions of the Okefenokee Swamp, GA.

EFFECTS OF THE SUWANNEE RIVER SILL

The Suwannee River sill has altered the swamp hydrology, although its affects vary with distance from the structure (Figure 2). Most of the effect has been in increased water levels, primarily in the west central region near the sill. Discharge from the Suwannee River and variability of flow into the St. Mary's River have decreased since the Suwannee River Sill was constructed (Yin 1990). The impounded water probably has also affected draining at the western extreme of the Suwannee Canal (horizontally bisecting the swamp at its center) by slightly slowing the exiting flow to the West. Flow into the St. Mary's River has increased since the sill's construction; it is uncertain whether this is a function of the sill's effects or reflective of a change in rainfall patterns (Yin 1990). Although average monthly rainfall has decreased during the growing season (March-October) since the sill's construction, there has been an increase in the non-growing season rainfall during this period. This is probably accounting for some of the increase in flow volume from the St. Mary's River and in increased water levels measured at the Suwannee Canal Recreation Area (SCRA, located in the extreme east-central region) and Stephen C. Foster State Park (SCFSP, located

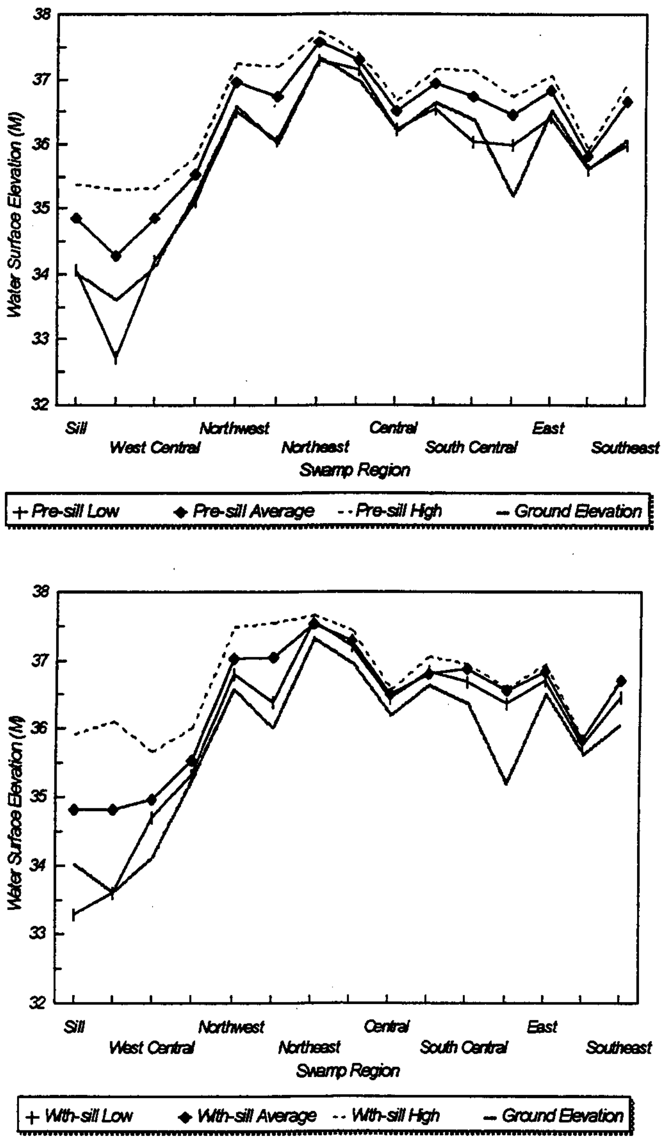

Figure 2. Pre-sill (top graph) and post-sill (bottom graph) water surface elevations across the Okefenokee Swamp, GA, during average, high, and low water conditions.

in the west-central region, approximately 5000 m from the sill) gauges. Since the sill was constructed during 1960-62, the mean daily water surface elevations measured at SCFSP and SCRA have increased. This increase has been uniform between growing (gs) and non-growing (ng) seasons at SCFSP (gs +0.21 m, ng +0.22 m) and SCRA (gs +0.07 m, ng +0.06 m). In general prior to the sill's construction (1941-1959), 40% of the recorded water elevations in the swamp (represented by SCFSP and SCRA recording stations) were lower than the pre-sill average, and 17% were higher than average. Following the sill construction (1960-1995), water elevations were low at both stations for 16% of the interval and high for 43%.

MODELING THE SILL'S EFFECTS

Determining the sensitivity of the swamp hydrologic environment to the presence and manipulation of the sill has been the focus of a grid-cell based hydrology model developed at the USGS-DBR Florida Cooperative Fish and Wildlife Research Unit. The model predicts 2-week average water surface elevation and depth using estimates of 2-week inflow, outflow, precipitation, and evapotranspiration volumes and water movement direction determined by the swamp surface topography. There are spatial differences in the swamp sensitivity to the model parameters. The western region is tightly controlled by water flow rates in the streams and river channels and inflow and outflow volumes. Manipulations of these parameters cause changes in water surface elevations throughout this region. The remainder of the swamp is less influenced by flow rates in the streams and Suwannee Canal, and more affected by variations in evapotranspiration and rainfall volumes. The model represents swamp hydrology fairly well throughout the swamp; poorest performance is in sites susceptible to flash flows, such as streams receiving water from storm events. Groundwater exchange is not a component in the model, and probably accounts for only a minor amount of model error. The extent of the sill's effects are being examined with the model by removing the sill from the topographic surface to approximate pre-sill topography. The extent of the sill's effects appear to be limited by the structure's size and the amount of available water from rainfall; the sill berm would have to be several meters higher and extend several kilometers further to the north, with an increase in precipitation, to have a spatial effect throughout the swamp. Long-term effects of the sill on swamp hydrologic environments and potential changes in vegetation distributions are the focus of current research.

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