SETTING WETLAND REHYDRATION LEVELS USING BIOLOGICAL INDICATORS IN BENNETT SWAMP, VOLUSIA COUNTY, FL.

David Stites¹, William Dunn², and Robert Epting³

ABSTRACT: The St. Johns River Water Management District (SJRWMD) is evaluating the benefits of augmenting surface water in wetlands for rehydration and aquifer recharge. The goal is to avoid or mitigate impacts from groundwater withdrawals. Bennett Swamp was selected as a pilot project site after biological indicators of altered hydrology were observed. The first step in the project was an evaluation of current and historic hydrologic regimes in the swamp. Field measurements of vegetative and soil indicators of hydrology were compared to modeled stage-duration curves for recent and historic conditions. Biological indicators of current water levels are well below historic levels. Historic impacts from surface water alterations and groundwater withdrawal have shifted the stage-duration curve, with the greatest impact in the range of the frequent low to average portions of the curve. Comparison of modeled and field estimated curves provides an useful tool for hydrologic projects. In Bennett Swamp, a 1 ft increase in the stage-exceedance behavior was recommended as an initial rehydration target.

KEY TERMS: wetland rehydration, biological impact, biological indicator, stage-exceedance

INTRODUCTION

The St. Johns River Water Management District is evaluating the benefits of augmenting surface water in wetlands for rehydration and recharge to avoid or mitigate impacts from groundwater withdrawals. Bennett Swamp is a 2,200-acre swamp located in Volusia County, FL (Figure 1) was selected as the pilot project site after biological indicators of altered hydrology were observed there.

The swamp and the surrounding area have been affected by human activity for many years. Thayer Canal, currently the primary outlet for the swamp, was one of many canals in the area constructed for drainage prior to 1960. Groundwater pumping for potable water began in the early 1980s and the level of pumping has increased as local and regional wellfields have expanded. There are no historic measurements of water elevations inside Bennett Swamp. Available measurements begin with this project. Beginning in 1982, however, there are records of Thayer Canal elevations and flows for a point downstream of Bennett Swamp, and those data were included in development of the hydrologic model for the system. The canal has had some impact on the hydrology of the swamp, as the main function of the canal is drainage (SJRWMD 1999).

¹Senior Water Resources Scientist, CH2M HILL, 3011 SW Williston Rd, Gainesville, FL, 32608-3928 Tel: 352-3357991. Fax 352-335-2959. bdunn@ch2m.com. ²Senior Water Resources Scientist, CH2M HILL, Gainesville, FL, ³Senior Scientist, Department of Resource Management, St. Johns River Water Management District, Palatka, FL.

Figure 1. Location of study site in Volusia County, FL
Groundwater models were used in conjunction with available surface hydrology models (CDM 1995, SJRWMD 1999) to project pre-wellfield (pre-1982), and current and future (2010) surface water conditions in Bennett Swamp (Freeman, 2001). Stage-exceedance curves were developed for three locations within the swamp associated with biological sampling transects.

**BIOLOGICAL DATA COLLECTION AND ANALYSIS**

Elevations of soil and vegetation parameters were collected at each of three transects. Biological parameters were collected, when available, from mature trees of the dominant canopy species, cypress (Taxodium distichum) or black gum (Nyssa sylvatica) present at each site. Parameters were divided into short-term indicators (elevation of lower edge of epiphytic mosses and lichens), moderate-term indicators (root crown of fetterbush (Lyonia lucida)), and long-term indicators (lower and upper tree buttress points). Epiphytic lichens and mosses and live on the trunks of trees. Lichens live above the seasonal high water line (SHWL), while mosses lie below the SHWL. Fetterbush is a shrub whose root crown elevation is also an indicator of SHWL. Median quartile and range statistics were calculated for each set of vegetation parameter data for each transect. Median values for the biological parameters were compared to one another and to modeled stage-exceedance curves provided by Freeman (2001).

Elevation and thickness of the surficial organic horizon along a gradient of water depth was measured at each transect. A mean water elevation no lower than 0.25 ft below the mean surface elevation of histosol soils has been used to protect muck soils in south Florida (Stephens, 1974; SJRWMD unpublished data). This same depth below the muck surface has been found to correspond to the water elevation exceeded about 50 to 60% of the time (Clayton and Neller, 1943; Brooks and Lowe, 1984; Hall, 1987). Furthermore, the mean organic soil elevation described above minus 1.67 ft is estimated to be the minimum dry season water level necessary to maintain the organic soil profile and other wetland functions and structures (Mace, 2001) and generally corresponds to the 80 to 90% stage-exceedance range (Clayton and Neller, 1943; Stephens, 1974; Sonny Hall, Personal Communication, 2001).

The soil elevation data for each transect were regressed against depth. Elevation values for 8 and 16 inches of soil depth were interpolated using the regression equations. The mean histosol soil elevation was estimated as the average of organic soil horizon elevations at 8 inches thick (considered the histic epipedon) and 16 inches thick (the minimum organic horizon of a true histosol). Soil and vegetative indicator elevations were placed on the stage-exceedance curves and compared to the expected stage-exceedances from the literature. Differences were related to changes in the hydrologic regime in the swamp.

**RESULTS AND INTERPRETATION**

The collective indicator data suggest a range of possible impacts to the hydrology of Bennett Swamp. The vegetative indicators behaved consistently within a site (Figure 2). Mosses were found at the lowest elevations, followed by lichens and fetterbush. Lichen lines were very close to the minimum elevation of fetterbush root crown tops. Not all indicators were found at each of the three sites. For example, no buttress measurements were made at the Thayer Canal transect location (due to logistic constraints). The Lower Bennett Swamp transect is downslope of the other two sites, lying approximately one foot lower, and so the indicator elevations were offset by about that amount (Figure 2).

Soil and vegetation data were overlaid on the modeled stage-exceedance curve to provide an estimate of the range of the change in hydrological regime at the 50% to 60% and 10% to 20% stage-exceedance ranges (Figure 3). We chose the 50% point on the curves for comparison as a measure of average conditions. We used percent exceedance ranges of 45% - 65% for the Minimum Average (MA) stage-exceedance value, and about 75% - 90% for the Minimum Frequent Low (MFL) as the expected values. The histic epipedon and histosol elevations were then projected onto those percent exceedance values to assess where the historic curve might fall (Figure 3: Expected Minimum Average and Expected Minimum Frequent Low).
Figure 2. Box and whisker plots for elevation of vegetative indicators for three transect locations in Bennett Swamp. Line within boxes indicate median; top and bottom of boxes indicate first and third quartiles; bars on top and bottom of boxes indicate maximum and minimum.

Once the soil indicators for MA and MFL were plotted in the expected positions on the stage-exceedance diagram an approximation of the historic condition provided by these data was sketched (Figure 3: soil-estimated historic curve). Comparison of the simulated historic and 1988 stage curves show that 0.75 ft or more of stage has been lost from the system at the midrange of exceedance percentages (Figure 3: at 50% exceedance, point B minus point C). The invert elevation of Thayer Canal at the eastern side of Bennett Swamp (24 ft NGVD 1929: Freeman, 2001) likely contributes to this result.

Analysis of organic soil horizon data also indicates that the modeled historic stage-exceedance curve is lower than the soil-predicted elevations (Figure 3). Overlaying the modeled historic stage curve with the estimated MA value of 28.1 ft (NGVD 1929) yields a 28.4 percent stage-exceedance rather than the 50 percent to 60 percent point expected. Likewise the MFL estimate, 26.7 ft (NGVD 1929), is at the 51.6 percent level rather than near the expected 75 to 90 percent points. This indicates that the Freeman’s (2001) simulated historic condition is actually an already impacted condition, and that the soil oxidation has lagged behind the reduction in stage. The soil based stage-exceedance estimates suggest an historic elevation different from the modeled 1988 data by about 1.75 feet (Figure 3: at 50% exceedance, point A minus point C). Furthermore, the moss lines suggest that the current condition is impacted beyond the modeled 1988 condition, or a possible impact of about 2 ft relative to a pre-disturbance condition (Figure 3: at 50% exceedance, point A minus point D).

Tree buttress elevation ranges are in line with both historic and 1988 simulations. Buttress information suggests that historically, low-frequency events (less than 0.5 percent) typically occur at water elevation in the range of 32 to 33 ft (NGVD 1929) for the Hammock Field site, and about 1.5 feet below that at the lower Bennett Swamp site (Figure 3).
1946-1996 SIMULATED SURFACE WATER STAGE-DURATION CURVES FOR BENNETT SWAMP TRANSECT / THAYER (600' UPSTREAM OF THAYER CANAL OUTLET)

Figure 3. Estimation of possible elevation changes between about 15 and 60% stage-exceedance values in Bennett Swamp. Shaded area shows the minimum average elevation zone for each curve (estimated from soil transect, and model simulations for historic, 1988, and 2010). Dotted lines on the curves are projected, not calculated, ranges of a curve.
Elevation data for tree buttresses and fetterbush root crowns were in the region of the curves (historic, 1988, 2010) where the stage-exceedance curves are quite similar. The data plotted approximately where they might be expected to be observed in terms of percentage exceedance, but we recognize that the curves are simulations; thus these results must be carefully interpreted.

Moss and lichen lines are expected to lay around the 10 to 15 percent and 1 percent to 5 percent stage-exceedances respectively, with fetterbush at a slightly higher elevation than the moss line. The expected elevations are more than 1 foot higher than the data for those indicators plotted on the simulated 1988 hydrograph. Further, the mosses and lichens were shifted relative to the fetterbush, indicating that at least in the short term there has been a further reduction in stage-exceedance elevations toward the upper end of the scale.

CONCLUSIONS

Despite the variability in the data, there is a sufficiently consistent pattern in the information to draw preliminary conclusions and make a recommendation concerning a rehydration target. The hydrologic simulations, vegetation, and soil indicators demonstrate that the hydrology of Bennett Swamp has been adversely affected. Causal factors likely include surface water drainage alterations and ground water withdrawal and changes may have begun prior to the operation of water supply wells.

The hydrologic simulations provided by Freeman (2001) showed a reduction of between 0.5 and 1 ft at the middle portion of the stage curve for the modeled historic and 1988 conditions. The modeled conditions, however, represent conditions already affected by the presence of Thayer Canal. Thus the current condition is more adversely affected than suggested by the 1988 simulation. The soil data, suggest a stage reduction of 1.75 ft in the 50 to 60 percent stage-exceedance elevation measured as the difference between pre-disturbance, or at least pre-well field, and current conditions. Furthermore, biological data suggest an additional stage reduction of about 5% -10% between the modeled 1988 and current conditions, indicated from moss lines. This further suggests that the 2010 stage duration curve is a better model for the current conditions.

The results suggest an appropriate initial rehydration target is to increase the stage 1 foot at duration frequencies of 20 percent and greater. This will bring the hydrology toward the historic condition without affecting adjacent land uses, such as managed pine plantations, located at the edge of the swamp. Interestingly, the invert of Thayer Canal at the eastern side of Bennett Swamp is about one foot below the estimated average elevation of the swamp's soil surface (Freeman, 2001).

A weir is now being designed for placement at the origin of Thayer Canal in Bennett Swamp. A final decision concerning the weir elevation will involve SJRWMD, the Florida Division of Forestry (which manages plantations at the edges of the swamp) and other interested parties. Ongoing monitoring will continue and in the next stage of the project the effect of the weir in reducing biological impacts will be evaluated.

REFERENCES


Hall, Sonny, Ph.D. 2001. Numerous discussions regarding long and short term biological stage indicators during the course of this and other projects.


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