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Determining Changes in Hydrologic Behaviors in the Florida Everglades

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Introduction

The ecological community structure of the Florida Everglades is an expression of present and historic hydrologic conditions. The restoration of the Everglades is dependent on understanding how the ecological communities respond to temporal and spatial changes in hydrology. Small changes in seasonal and annual water levels in the Florida Everglades can cause substantial changes to the ecology of the area including vegetation and water quality. The Everglades were originally a precipitation driven hydrologic system. Current (2012) water levels in the Everglades respond to precipitation and the regulated flow of water through canals and marshes. There is a need by ecologists to determine changes in hydrologic behaviors and quantify generalized differences in water levels between periods of different regulation and climate conditions. Cumulative water-level frequency curves were generated for different periods determined by break-point analysis for five long-term water-level sites in the Florida Everglades (fig. 1). The long-term water-level sites are near Aquatic Cycling of Mercury (ACME) sampling sites and alligator survey transects.

Approach

Cumulative Z-scores are a useful technique to find subtle changes, or break points, in time-series data (Briceño and others, 2010). For a given set of data, a Z-score is the measured value minus the mean value divided by the standard deviation and defines how many standard deviations the measured value is above or below the mean (Iman and Conover, 1983). Changes in the slope of the cumulative Z-scores indicate a change in the behavior, or dynamics, of the time-series data. Cumulative water-level frequency plots for periods between the breaks in the slopes can then be generated to evaluate the water-level distribution for the periods.

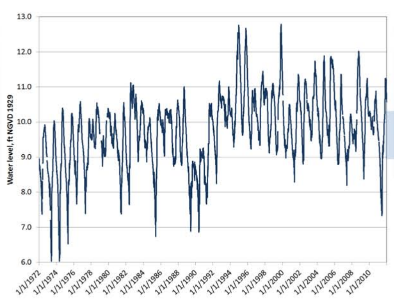


Figure 2. Daily water-level data at Site 64 in Water Conservation Area 3A for the period January 1, 1972 to December 31, 2011.

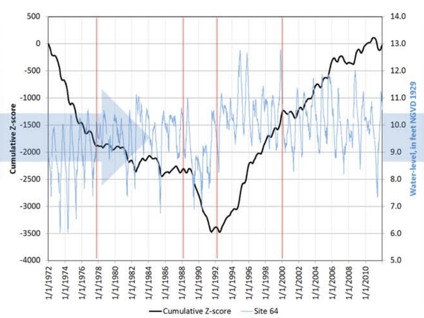


Figure 3. Cumulative Z-score and daily water-level data at Site 64 in Water Conservation Area 3A for the period January 1, 1972 to December 31, 2011.

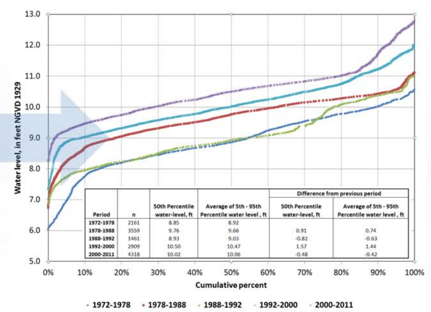


Figure 4. Cumulative water-level frequency curves for Site 64 in Water Conservation Area 3A for five periods between January 1, 1972 to December 31, 2011.

For example, a 40-year daily water-level time series for Site 64 is shown in figure 2. One can see that there is a difference in the hydrologic behavior before and after 1990 but changes within these periods are more difficult to discern. The Z-score for each day was computed and the cumulative Z-score plotted (fig. 3). The plot of the cumulative Z-score shows five substantial breaks, or changes, in the slope of the line: 1972 to1978, 1978 to 1988, 1988 to 1992, 1992 to 2000, and 2000 to 2011. (The small annual changes are due to wet- and dry-season water-level differences.) Figure 4 shows cumulative water-level frequency curves for the five periods determined by the breakpoint analysis of the cumulative Z-score plots. The 50th percentile and average of the 5th to 95th percentiles are listed in Table 1 along with the change in the values from the previous period. Differences in the 50th and the average of the 5th to 95th percentiles usually occur when the high and low frequencies cross between break-point periods. The approach was applied to five long-term water level datasets for sites from Water Conservation Area 1 to the Everglades National Park for the period 1991 to 2011(figs. 5-14 and tables 2-6).

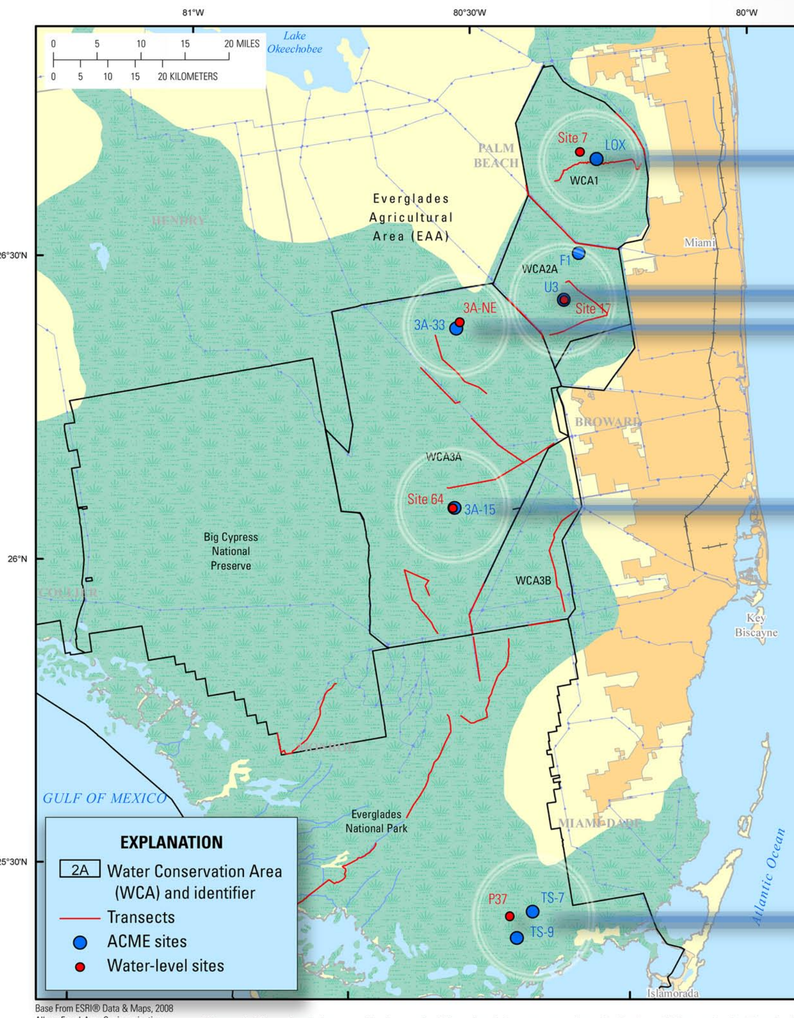
Period	n	50th Percentile water-level, ft	Average of 5th - 95th Percentile water level , ft	Difference from previous period: 50th Percentile water-level, ft	Difference from previous period: Average of 5th - 95th Percentile water level , ft
1972-1978	2161	8.85	8.92		
1978-1988	3559	9.76	9.66	0.91	0.74
1988-1992	1461	8.93	9.03	-0.82	-0.63
1992-2000	2909	10.50	10.47	1.57	1.44
2000-2011	4318	10.02	10.06	-0.48	-0.42

Table 1. The 50th percentile value, average of the 5th to 95th percentile and difference between the subsequent time periods for Site 64 in Water Conservation Area 3A. [n, count; ft, feet]

References

Briceño, H. O., Boyer, J.N., and Harlem, P.W., 2010, Proposed Methodology for the Assessment of Numeric Nutrient Criteria for South Florida Estuaries and Coastal Waters, Report to the National Park Service, Everglades National Park, Cooperative Agreement Number: H5000-06-0104, 44 p.

Imam, R. L. and Conover, W. J., 1983, A Modern Approach to Statistics, John Wiley and Son, 497 p.



Base From ESRI® Data & Maps, 2008
Albers Equal-Area Conic projection;
Standard parallels 29 30 N and 45 30 N;
Central meridian -96 00 00

Figure 1. Water-level sites used in the study. Water-level sites are near Aquatic Cycling of Mercury in the Everglades (ACME) sites and transects where alligator surveys are performed.

Results and Discussion

For Site 64 over the 40-year period, 1972 -2011, water levels were lowest during the 1972 -1978 period and highest during the 1992-2000 period (fig. 3). The largest shift in water levels between subsequent periods occurred between the lower water of 1988-1992 and higher water during 1992-1999 (table 1). Comparing the water level distributions for the past twenty years (1991-2011) at all five sites (figs. 6, 8, 10, 12, and 14) and based on the average of the 5th and 95th percentiles; water levels were highest during the period 1994-1996. The periods of lowest water frequency distribution, as measured by the average of the 5th to 95th percentiles varies between the sites. The period for lowest water for 3A-NE was during the period 2006-2011whereas the period for the lowest water for Site 64, in the same conservation area, was for the period 2000-2001. Site 64 had the largest total range of 1.84 ft between periods of high and low water level and Site 7 and P37 had the lowest range of 0.91 and 0.90 ft, respectively.

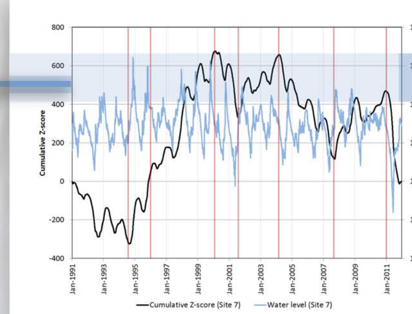


Figure 5. Cumulative Z-score and daily water-level data at Site 7 in Water Conservation Area 1 for the period January 1, 1991 to December 31, 2011.

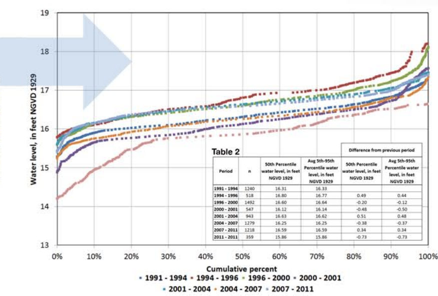


Figure 6. Cumulative water-level frequency curves for Site 7 in Water Conservation Area 1 for eight periods between January 1, 1991 to December 31, 2011 and table 2 listing the 50th percentile value, average of the 5th to 95th percentile and difference between the subsequent time periods.

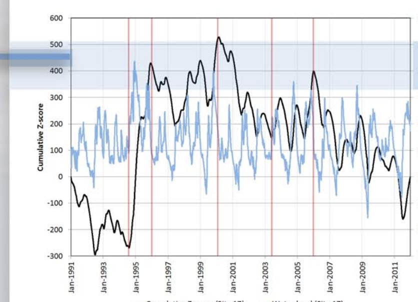


Figure 7. Cumulative Z-score and daily water-level data at Site 17 in Water Conservation Area 2A for the period January 1, 1991 to December 31, 2011.

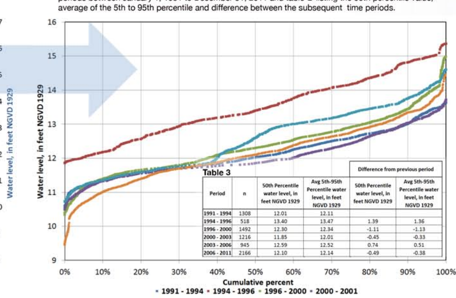


Figure 8. . Cumulative water-level frequency curves for Site 17 in Water Conservation Area 2A for six periods between January 1, 1991 to December 31, 2011 and table 3 listing the 50th percentile value, average of the 5th to 95th percentile and difference between the subsequent time periods.

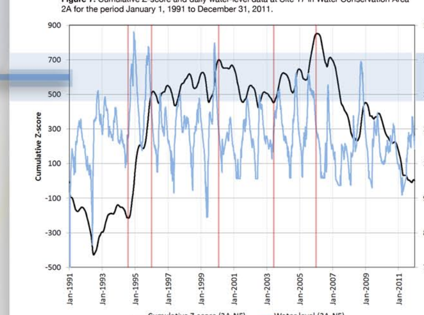


Figure 9. Cumulative Z-score and daily water-level data at 3A-NE in Water Conservation Area 3A for the period January 1, 1991 to December 31, 2011.

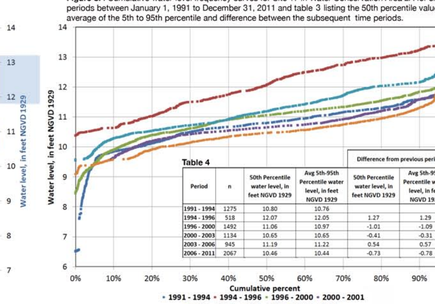


Figure 10. Cumulative water-level frequency curves for 3A-NE in Water Conservation Area 3A for six periods between January 1, 1991 to December 31, 2011 and table 4 listing the 50th percentile value, average of the 5th to 95th percentile and difference between the subsequent time periods.

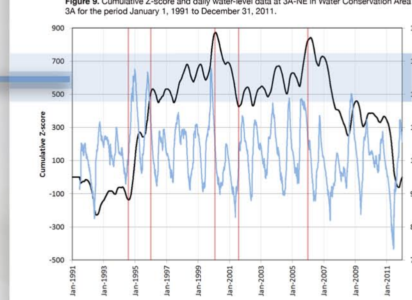


Figure 11. Cumulative Z-score and daily water-level data at Site 64 in Water Conservation Area 3A for the period January 1, 1991 to December 31, 2011.

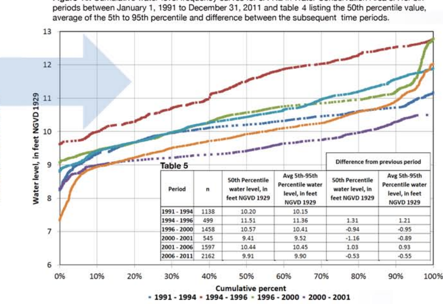


Figure 12. Cumulative water-level frequency curves for Site 64 in Water Conservation Area 3A for six periods between January 1, 1991 to December 31, 2011 and table 5 listing the 50th percentile value, average of the 5th to 95th percentile and difference between the subsequent time periods.

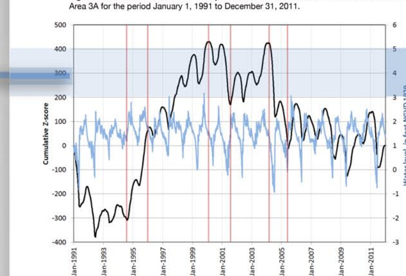


Figure 13. Cumulative Z-score and daily water-level data at P37 in Everglades National Park for the period January 1, 1991 to December 31, 2011.

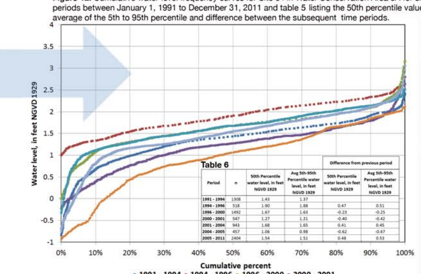


Figure 14. Cumulative water-level frequency curves for P37 in Everglades National Park for seven periods between January 1, 1991 to December 31, 2011 and table 6 listing the 50th percentile value, average of the 5th to 95th percentile and difference between the subsequent time periods.