Response of the Everglades Ecosystem to Changes in Hydroperiod

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Restoration of the Everglades depends on first identifying the links between human activities and key functions of the ecosystem. These links determine the opportunities for effective action to improve and maintain the health of the ecosystem. In addition, managers need quantitative information on how the ecosystem responds to changes in the human activities that affect it. This will determine the magnitude of planned actions required to achieve goals set for the improvement of ecosystem function. Generally, this information cannot be known with certainty before action is required. In this situation, management actions must be viewed as experiments conducted to learn about the ecosystem, as well as to help it, and the paradigm of adaptive management applies.

A wealth of historical data exists on hydrology, water management and ecosystem function in and around Everglades National Park. These data, in effect, record the results of an experimental, i.e. trial and error, approach to managing water resources in South Florida during the last 50 years. The information now needed by ecosystem managers about the linkages between human activities and functions of the ecosystem is contained in these data. However, the data have not yet been employed to their full potential. In part, this is because the objectives and methods for ecosystem restoration have only recently become clear. Also, there has not been a concerted effort to query the historical data directly for relationships between ecosystem function and the driving processes of climate, sea level and the influence of human activities on the hydrology of the region.

Results of this preliminary investigation of historical data demonstrate how information needed for ecosystem restoration can be obtained. In this case, analysis of the data established a functional relationship between variations in annual hydroperiod in Shark Slough and nesting success by wood storks in Everglades Park, Figure 1. Hydroperiod was also found to depend on the pattern of water releases into Everglades Park through the water control structures along Tamiami Trail. The reproductive success of a top predator, like the wood stork, serves as a measure of the functioning of

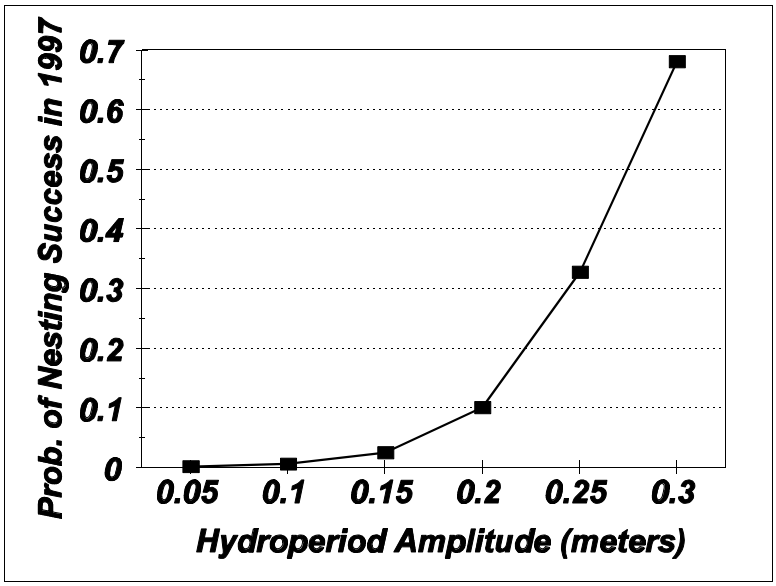

Figure 1: Ecosystem functional response to hydroperiod, from analysis of historical data

the entire food web in the ecosystem. The connection of nesting success with the operation of the water control structures provides managers with an effective tool to improve the ecosystem's overall function. This brief report summarizes the approach taken, and it demonstrates that information of practical value to the restoration of the Everglades ecosystem can be obtained directly from an examination of the historical data.

The history of the Everglades in this century is one of uninterrupted decline in ecosystem function. Decimation of wading bird populations is perhaps the most visible sign of this decline. For example, between 5,000 to 8,000 wood storks (*Mycteria americana*) annually nested in the southern Everglades during the period 1931 to 1946. These numbers declined to an estimated 2,650 birds in the period 1974 to 1981 and again to 750 birds for the period 1982 to 1989 (Ogden 1994). The same period saw the construction of massive water-control works for flood control and water supply in South Florida. The subtropical climate of South Florida is characterized by distinct wet and dry seasons during the year, and this is reflected as a strong seasonal fluctuation in the water levels and flows in the Everglades, i.e. the hydroperiod. It is hypothesized that water-management activities have changed the hydroperiod in the wetland feeding grounds used by wood storks, and this has adversely affected the timing of nesting and reproductive success (Walters et al. 1992, Ogden 1994).

This study makes use of the overall success or failure of the annual nesting effort by the wood stork for the period 1953 to 1988, as summarized by Ogden (1994). The data on wood storks are the most complete of all the major species of wading birds in the Everglades, and there is the added advantage that each year wood storks nest at the same locations in the headwaters of the mangrove estuaries. The initiation of nesting coincides with the drawdown of water levels towards the end of the dry season. Declining water levels concentrate prey fish in contracting pools within easy reach of the nesting sites. Hydroperiod is linked to nesting success through its influence on prey availability.

Examination of the data makes innovative use of harmonic analysis to characterize annual hydroperiod in Shark Slough. Harmonic analysis represents a series of data as the mean of the data plus the sum of a finite number of time-varying, sinusoidal functions. Each sinusoid, or harmonic component, corresponds to a distinct period of oscillation and is parameterized by an amplitude and a phase angle, Figure 2. Applied to hydroperiod, harmonic analysis is used to obtain the amplitude and phase angle, i.e. the timing, of the annual harmonic component that determines the overall pattern of the water-level fluctuations (Nuttle 1997). By separately analysing the record of water level in successive years, the pattern occurring within each year is described by the mean water level, the amplitude, and the phase angle of the annual harmonic component. Using these parameters as measures of hydroperiod, one can then apply

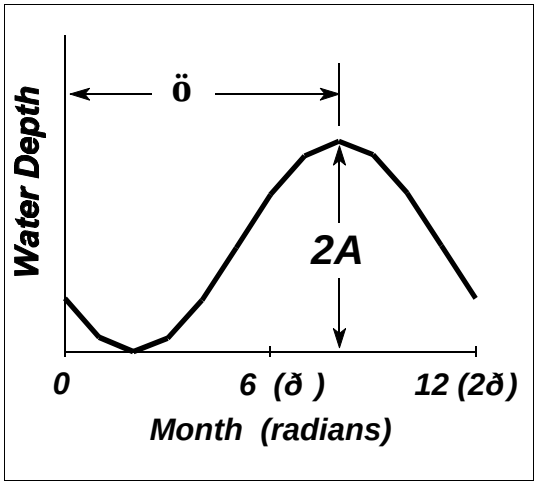

Figure 2: Hydroperiod measured by amplitude, A, and phase angle, ö

statistical techniques to investigate sources of variation in hydroperiod and its ecological consequences.

The relationship between the probability of nesting failure and hydroperiod was investigated by using stepwise multiple logistic regression. The probability of nesting failure is strongly related to hydroperiod amplitude, Table 1. Failure is more likely in years with lower hydroperiod amplitudes. The probability of failure is also affected by Year (i.e., there is a higher probability of failure in later years independent of the effect of hydroperiod amplitude). However, nesting failure is most highly affected by hydroperiod amplitude, as indicated by the chi-square values reported. The logistic model shown in Table 1 is the basis for the relationship between hydroperiod amplitude and probability of nesting success plotted in Figure 1. Linear regression was applied in a similar fashion to investigate, and demonstrate, a relation between hydroperiod and managed water flows into the Park.

These are the results of a limited examination of an extensive data set. Therefore, the form of the relationships must be treated as preliminary pending analysis of a larger portion of the relevant data. However, these results succeed in demonstrating how essential information needed to guide ecosystem restoration can be obtained by analysis of routine monitoring data. In the case of the Everglades, a wealth of historical data exist to guide on-going restoration efforts. In other ecosystems, these data will accumulate as part of an adaptive management approach to restoration.

Table 1: Stepwise logistic regression analysis of nesting failure on hydroperiod parameters (amplitude A, phase angle ö, and annual mean M) and Year. Final model is:

$$\ln\left(\frac{P\,[failure]}{P\,[success]}\right) = -1.7025 - 29.5 * A + 0.101 * Year$$

Source	Wald Chi-Square	Prob > Chi-Square
intercept	0.243	0.6222
A	5.52	0.0188
Year	4.21	0.0401

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