Comparison of the South Florida Natural System Model with Pre-canal Everglades Hydrology Estimated from Historical Sources

U.S. Department of the Interior—U.S. Geological Survey

Preservation and restoration of the remaining Everglades ecosystem is focussed on two aspects: improving upstream water quality and improving "hydropatterns" - the timing, depth and flow of surface water. Restoration of hydropatterns requires knowledge of the original pre-canal drainage conditions as well as an understanding of the soil, topographic, and vegetation changes that have taken place since canal drainage began in the 1880's.

The Natural System Model (NSM), developed by the South Florida Water Management District (SFWMD) and Everglades National Park, uses estimates of pre-drainage vegetation and topography to estimate the pre-drainage hydrologic response of the Everglades. Sources of model uncertainty include: (1) the algorithms, (2) the parameters (particularly those relating to vegetation roughness and evapotranspiration), and (3) errors in the assumed pre-drainage vegetation distribution and pre-drainage topography. Other studies are concentrating on algorithmic and parameter sources of uncertainty.

In this study we focus on the NSM output -- predicted hydropattern -- and evaluate this by comparison with all available direct and indirect information on pre-drainage hydropatterns. The unpublished and published literature is being searched exhaustively for observations of water depth, flow direction, flow velocity and hydroperiod, during the period prior and just after drainage (1840-1920).

Additionally, a comprehensive map of soils in the Everglades region, prepared in the 1940's by personnel from the University of Florida Agricultural Experiment Station, the U.S. Soil Conservation Service, the U.S. Geological Survey, and the Everglades Drainage District, is being used to identify wetland soils and to infer the spatial distribution of pre-drainage hydrologic conditions. Detailed study of this map and other early soil and vegetation maps in light of the history of drainage activities will reveal patterns of change and possible errors in the input to the NSM. Changes in the wetland soils are important because of their effects on topography (soil subsidence) and in their role as indicators of hydropattern.

Project Goals

The objectives of this study are: (1) to produce a data base of direct hydrologic observations, localized to specific NSM 2 x 2 mile grid cell and to date of observation; (2) to compile indirect soil and vegetation information from which pre-drainage hydropatterns can be inferred; (3) to evaluate the NSM output using the data base, the indirect information, and contemporaneous weather data; (4) wherever possible, to cross check and document inconsistencies between independent historical sources; and (5) to document drainage-induced soil and vegetation changes within the original Everglades.

Background

Aldo Leopold wrote that "the first step in intelligent tinkering is to save the pieces." For the Everglades, saving the ecosystem pieces would have meant making synoptic stage and flow measurements over multiple years and over an area larger than the State of Connecticut, *prior* to launching even the first canal dredge. Unfortunately, but understandably, this was not done. For the first 40 to 60 years of drainage very few standard hydrologic measurements exist. Evaluation of a hydrologic "hindcasting" model such as the NSM must, therefore, rely on more than the traditional sources of information. There are numerous sources of hydrological information which merit full exploitation, but they are often in unusual locations, may be unpublished, and sometimes require further interpretation and analysis. Examples of historical sources include early maps, government surveys, botanical explorations, road and canal profiles, cross-Everglades expeditions, military accounts, and early scientific investigations.

Source Materials

Government surveys. Many townships on the edge and extending into the Everglades were surveyed under Federal or State of Florida contracts during the 1840's, 1870's, 1880's, and 1910's. All but the last of these periods precede any canal drainage. As the surveys are dated to month and usually day, and as they are accurate to within 10's to at most 100's of feet, the observations included in the survey field notes on soil type and depth, vegetation cover, and water depths are an invaluable source. Water depth observations will be compared directly with appropriate NSM output. Soil information will be used to assist in hindcasting the 1948 soil map, and the vegetation observations as a way of determining pre-drainage extent and scales of vegetation patterns.

Tree islands. Comparison of 1917 surveys with 1948 and 1995 images of the whole Everglades suggests that the larger, directional tree islands are stable in position. As such, they are reliable indicators of long term average flow direction. The presence of 100+ year old trees suggests that the islands generally do not flood for extended periods, providing an upper bound for surrounding water levels.

Fire. Although written fire records appear to be insufficient to serve as a detailed source, ash observations from soil cores, as well as known sawgrass and peat soil response to fire, will be used to infer minimum water depths and durations. Fire history will aid in reconstructing soil changes.

Expeditions. Military expeditions, Indian crossings, surveying expeditions and naturalists' explorations provide transects of observations across various parts of the Everglades. A number of the early expeditions give sufficient detail to locate the transects to within 1 or 2 NSM grid cells, permitting the vegetation, soil, and hydrological observations to be compared directly with NSM output. Comparison of expedition routes with soil maps and government survey notes helps

identify regions that have been affected by soil and hydrologic change.

Edge elevations. To the extent that the pre-drainage edge of the Everglades can be located and related to reliable points, the elevation of this edge can be determined. This in turn gives information on water levels to some distance out into the Everglades. Elevations of former rapids and falls on the east coast rivers will supplement this information.

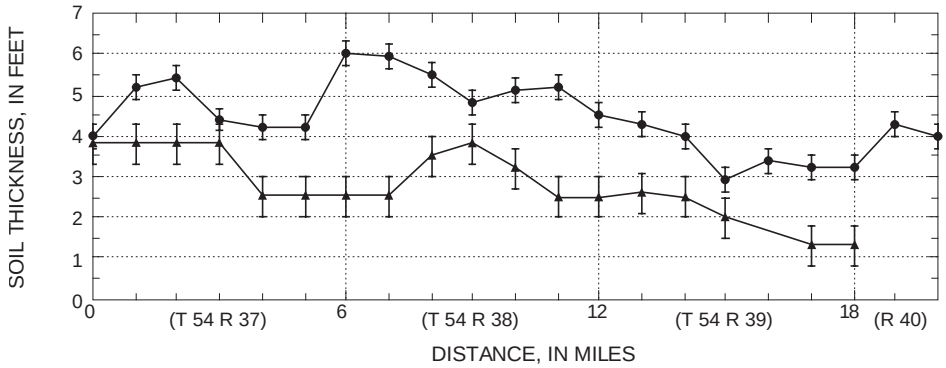
Scientific and engineering reports. A number of early technical texts provide qualitative and quantitative information concerning the pre-drainage and early post-drainage Everglades. These include texts accompanying soil and vegetation surveys, published scientific articles, reports accompanying private land surveys, engineering reports to the Internal Improvement Fund, the Everglades Drainage District and the Okeechobee Drainage District, and State and Federal Geological Survey reports.

Results To Date

Water depths. Extensive information is available in pre-1920 government surveys; the data are almost always quantitative and include dates. Several expedition accounts also include water depths. Rainfall information is available back to 1880; prior to 1880, rainfall data are qualitative only. Preliminary findings suggest that prior to drainage, water depths were sufficient to prevent all but localized peat burns. Tree islands were probably flooded occasionally, but not for long enough to kill upland trees.

Ft. Lauderdale-Davie area. This area has been studied in detail, with the investigators cross-checking the 1845 and 1870 government surveys with a 1915 soil map and the 1948 soil map. The patterns of soil and hydrological change, likely to be typical for the eastern and part of the western edge of the Everglades, have been documented. Soil losses of 3 feet are common.

East Everglades area. Sufficient sources exist to permit cross-checking of pre-drainage hydropatterns. The pattern of soil change in this area, from soil-covered to exposed pinnacle rock, has been deduced and related to hydrologic changes. Previously undocumented soil subsidence of two feet (average) has occurred south of Tamiami Trail (see figure).



Soil thicknesses along Tamiami Trail, south side (Township 54, Ranges 37-40) in 1918 and in 1996. (1918 thicknesses from pre-construction profiles; 1996 thicknesses from Soil Survey of Dade County.)

Vegetation. Sufficient references to vegetation have been found to permit annotations and improvements to a 1943 vegetation map. Estimation of characteristic sizes of components of the pre-drainage vegetation mosaics will be possible.

Soil change. In addition to soil subsidence in known areas as well as in previously undocumented ones, it appears that, prior to 1946, the nature of the soil profile changed measurably throughout vast areas of the sawgrass plains. This sheds further light on pre-drainage hydropatterns.

Planned Work Products

Products will include:

- Maps of estimated average annual high and low water depths and of approximately 1-in-10-year water depth extremes; cell by cell statistical comparison with NSM output.
- Comparison of NSM output with data base of water depth observations.
- Annotations to 1943 vegetation map.
- Estimates of scales of vegetation patterns (to use in estimating effective roughness coefficients).

Collaborators

This ongoing effort was initiated by the South Florida Water Managment District, Hydrologic Systems Modeling Division, and was expanded into a cooperative project with the Environmental Defense Fund (EDF) in 1995. The SFWMD contributes an environmental scientist, computing and library resources, and hosts an EDF soil scientist. Current funding in support of the EDF scientist is being provided by the U.S. Army Corps of Engineers through a contract with the U.S. Geological Survey and the EDF.

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