SL 311

UF | UNIVERSITY of FLORIDA
IFAS Extension

Soil Subsidence in the Everglades Agricultural Area[1]

Alan L. Wright and George H. Snyder[2]

Introduction

This document describes the soils in the Everglades Agricultural Area (EAA), an agricultural region in Florida south of Lake Okeechobee growing primarily sugarcane and winter vegetables, and addresses how the soils are changing with time. The objective is to describe soil loss in the EAA since this region was converted from wetlands to agricultural use, and to illustrate how these changes affect future sustainability.

The organic soils (Histosols) of the EAA formed over a period of several thousand years when organic matter production exceeded decomposition in the flooded sawgrass prairies that flourished in the area south of Lake Okeechobee. Since the onset of drainage of the EAA soils in the early 1900s for crop production, organic matter decomposition has exceeded accretion, resulting in a loss of soil and lowering of the surface elevation, a process referred to as *subsidence*. These Histosols are underlain by hard limestone bedrock, making subsidence all the more important since cultivation of the bedrock and water management would be difficult.

These Histosols formed because the land was flooded for much of the year, resulting in insufficient oxygen in the soil to maintain active populations of aerobic microorganisms that decompose organic matter. Oxygen penetration into the soil increases upon drainage, stimulating the activity of aerobic microorganisms. These microorganisms then decompose the soil organic matter at a much higher rate compared to the anaerobic microorganisms that dominate in flooded soil. As such, microbial activity as affected by drainage is considered the main factor influencing subsidence.

However, other factors also influence soil subsidence, including a loss of buoyancy following drainage, shrinkage and compaction caused by vehicular traffic, and soil loss by wind erosion and burning. It is likely that all of these factors have been partly responsible for subsidence in the EAA.

Soil Subsidence

Subsidence was observed as soon as the Everglades were drained in the early 1900s to remove water from soil to better support crop production. In 1924, a graduated concrete post was driven to the underlying bedrock at the University of Florida/IFAS

1. This document is SL 311, one of a series of the Soil and Water Science Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Original publication date November 2009. Visit the EDIS Web Site at http://edis.ifas.ufl.edu.
2. Alan L. Wright, assistant professor, Department of Soil and Water Science, Everglades Research and Education Center (REC)--Belle Glade FL; George H. Snyder, distinguished professor emeritus, Everglades REC--Belle Glade, FL; Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL 32611.

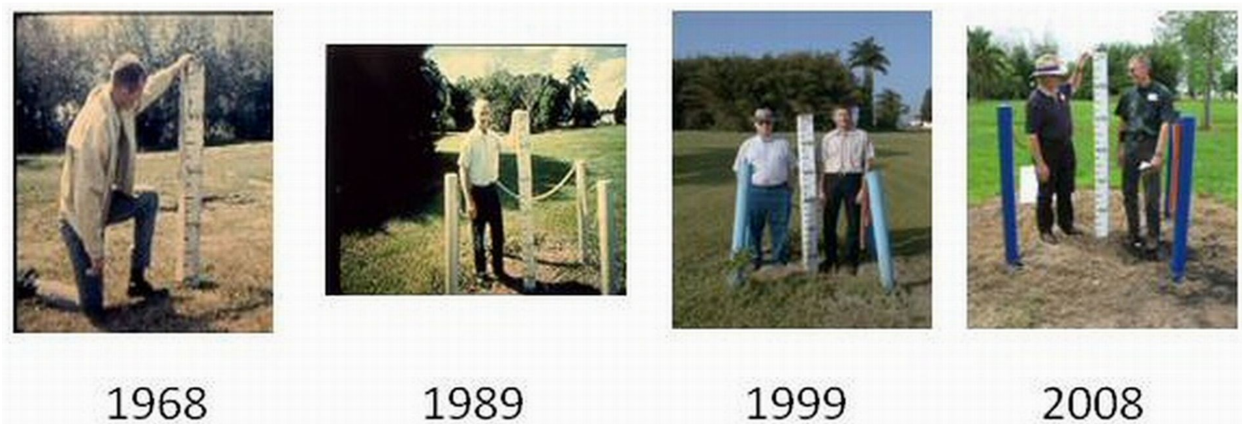

Figure 1. Decreases in soil depth since 1924 can be observed using the EREC subsidence post near Belle Glade, FL.

Everglades Research and Education Center (EREC) near Belle Glade. The soil surface was level with the top of the post, which is 9 feet in length (Figure 1). During a 43-year period from 1924 to 1967, there was a 48 inch decline in soil depth at the subsidence post, resulting in a subsidence rate of 1.12 inches/year. As of 2009, the soil depth at the site was 37 inches. From 1967 to 2009, the elevation reduction was 71 inches, for an average subsidence rate of 0.55 inches/year. At this site, it is apparent that the soil subsidence rate has not remained constant through time, and in fact has decreased by 50% from 1924-1967 to 1968-2009.

The rate of subsidence throughout the EAA has been investigated and documented in several other ways. The subsidence rate estimate at the EREC subsidence post coincides favorably with estimates obtained from transect lines monitored across the EAA (Shih et al., 1998). Starting in 1913, and further augmented in the 1930s, a series of transects (termed subsidence lines) were established in which the surface elevation relative to mean sea level was measured at 25 to 50-foot intervals for a distance of several thousand feet every 5 to 20 years. Two east-west elevation transects were made in 1912, and a much more detailed measurement of surface elevation was made throughout the entire Everglades in 1939-1940.

In the 1930s, a study was conducted at EREC to relate the rate of subsidence to the depth to water table (Neller, 1944). Based on all of these studies, Stephens and Johnson (1951) concluded that the subsidence rate would be one foot per decade assuming that the water table is maintained at an 18-24 inch depth. The resulting subsidence rate was calculated to be 1.2 inches/year, and this estimate was later substantiated by Shih et al., 1978 by monitoring the transect lines. Shih et al. (1998) measured surface elevation along the subsidence lines following a 19-year lapse in measurement, and concluded that the subsidence rate during this period averaged 0.57 inches/year. This rate was significantly lower than the 1.2 inches/year calculated by Stephens and Johnson (1951), and Shih et al. (1998) speculated that maintenance of higher water tables after 1978 was one of the major reasons for the observed reduction in the subsidence rate.

It thus appears that the subsidence rate has shown a declining trend through time. There are several potential mechanisms that can explain this decline, including increased mineral content in soil (Figure 2), humification, and water management (maintenance of higher water tables).

One argument for a decrease in subsidence is that mineral matter within the organic soil profile has become a major component of the soil matrix. As the organic matter is decomposed, the mineral content, such as calcium carbonate, sand, or clay, does not change and in fact its proportion to the total soil increases as subsidence continues.

As Histosols decompose, the easily degradable components are lost first, but the more resistant components persist longer, leading to decreases in the subsidence rate. The organic soils should become less easily oxidized with time as they become more humified and as the organic particles more resistant to decomposition accumulate. In addition to accumulation of mineral matter, such a theory could predict or account for a reduced subsidence rate as soils become very thin over bedrock.

A major factor influencing the decline in the subsidence rate through time has been improved water management. It has been well documented that the subsidence rate is closely aligned with water table depth, as organic matter decomposition is impaired by flooded conditions (Stephens and Johnson, 1951; Snyder et al., 1978). Implementation of best management practices (BMPs) in the mid 1990s has led to more water storage on EAA fields, which helps to retard organic matter decomposition and decrease the subsidence rate.

Current Trends

During the 1930s and 1940s, vegetables were the primary crops in the EAA and required good water control and did not tolerate flooded or waterlogged soils. Widespread adoption of sugarcane in the early 1960s led to changes in crop and land management practices, which increased water storage in EAA fields since sugarcane is more tolerant of flooded conditions. Shih et al. (1982) also observed that temperature reduction in sugarcane fields decreased the subsidence rate by 16%. These two mechanisms suggest that widespread cultivation of sugarcane contributed to a decrease in the rate of soil subsidence in recent years. Growers have also modified field operations in response to shallower soils by tilling less deeply and making fewer passes over the fields, which minimizes soil disturbance. Thus, growers have contributed to the reduction of the soil subsidence rate through their management practices. Continuation of BMP implementation by growers, development of crop cultivars more tolerant of flooded conditions, reduced tillage, and potential adoption of green manure crop rotations, will likely further minimize subsidence in the future and increase the longevity of these soils for agricultural use.

Figure 2. Increase in mineral content of shallow Histosols.

For more information:

Neller, J.R. 1944. Oxidation loss of Lowmoor peat in fields with different water tables. Soil Sci. 58:195-204.

Shih, S.F., G.S. Rahi, H.Y. Ozaki, and A.G. Smajstrla. 1982. Effect of water table and crops on soil temperature. Soil Crop Sci. Soc. Fl. Proc. 41:47-54.

Shih, S.F., B. Glaz, and R.E. Barnes, Jr. 1998. Subsidence of organic soils in the Everglades Agricultural Area during the past 19 years. Soil Crop Soc. Fl. Proc. 57:20-29.

Snyder, G.H., H.W. Burdine, J.R. Crockett, G J. Gascho, D.S. Harrison, G. Kidder, J.W. Mishoe, D.L. Meyer, F.M. Pate, and S.F. Shih. 1978. Water table management for organic soil conservation and crop production in the Florida Everglades. Bull. 801, University of Florida/IFAS Agric. Exper. Stn., Gainesville, Fl.

Stevens, J.C., and L. Johnson. 1951. Subsidence of organic soils in the upper Everglades region of Florida. Soil Sci. Soc. Fl. Proc. 11:191-237.