Peat and Carbon Loss in the Everglades Using Historical Data and Geospatial Techniques

Thomas W. Dreschel

1Everglades Systems Assessment,
South Florida Water Management District,
West Palm Beach, Florida

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Water, Energy and Carbon Cycling Within the Greater Everglades Ecosystem Workshop

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The Everglades Protection Area (EPA) and Everglades Agricultural Area (EAA)

Project 1. Evaluating Peat Loss From the Entire Everglades System

Project 2. Evaluating Peat Loss From the Everglades Agricultural Area

Project 3. Evaluating Peat Loss From a Tree Island in WCA-2A
Evaluating Everglades Peat Carbon Loss Using Geospatial Techniques

Sources for the South Florida Topography Project

<table>
<thead>
<tr>
<th>Data Source</th>
<th>Type of Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. Army Corps of Engineers (USACE)</td>
<td>Terrestrial Light Detection and Ranging (LIDAR) Surveys</td>
</tr>
<tr>
<td></td>
<td>Hydrographic, Structural and Channel Cross-section Surveys of the Okoocobee and the Atlantic Intercoastal Waterways</td>
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<tr>
<td></td>
<td>Hydrographic Surveys of the St. Lucie Estuary, the Caloosahatchee Estuary and the Lake Okeechobee</td>
</tr>
<tr>
<td>Collier County</td>
<td>LIDAR Survey</td>
</tr>
<tr>
<td>International Hurricane Research Center (IHRS), Florida International University</td>
<td>LIDAR Survey</td>
</tr>
<tr>
<td>National Ocean Service (NOS), National Oceanic and Atmospheric Administration (NOAA)</td>
<td>Bathymetric Surveys of the Loxahatchee Estuary, the St. Lucie Estuary and the Lake Okeechobee</td>
</tr>
<tr>
<td></td>
<td>Coastal Relief Model (CRM) Bathymetry of the Collier Shore, and the Charlotte Harbor to the Key West</td>
</tr>
<tr>
<td>Lee County</td>
<td>Photogrammetry</td>
</tr>
<tr>
<td>U.S. Geological Survey (USGS)</td>
<td>Measured Spot Elevations</td>
</tr>
<tr>
<td></td>
<td>High Accuracy Elevation Dataset (HAED)</td>
</tr>
</tbody>
</table>
Uncertainties

- The predrainage surface is a reconstruction using the best available information from predrainage and early post-drainage land surveys and canal construction surveys.

- The current surface is a mosaic of data from various sources having varying degrees of accuracy.

- The Parker bedrock map is referenced to earlier work of Jones et al. (1948) who describes the sampling (probing) to be to a 0.1 foot accuracy at intervals of 660 feet.

- We used current EPA peat soils characteristics for both the current and predrainage calculations.

- For the predrainage calculations, we screened the data and restricted it to values that were reasonable for predrainage peat, using the most unimpacted peat in the region (from WCA-1) as a proxy for predrainage.
Predrainage and Current Everglades Surfaces (freshwater)

Visualization of the contours of the peat surfaces used in the peat loss and carbon flux calculations for the Greater Everglades. The upper surface represents the pre-drainage peat surface (NSRSM) and the lower surface the current condition (USACE). As an example, the distance between the pre-drainage surface and the current surface of the WCAs is approximately three to five feet (0.4 m to 0.9 m). Acronyms: WCA = Water Conservation Area, EAA = Everglades Agricultural Area and ENP = Everglades National Park.
Everglades Peat and Carbon Loss Results (Method 1)

- The difference between the reconstructed peat surfaces provided an estimate of the degree of soil loss and carbon dioxide released that occurred during the period following the construction of the early drainage canals.

- Specifically, for the EAA: 2.3 billion metric tons; for WCA-1, 2A and 3B: 0.1 billion metric tons; for WCA-3A: 0.6 billion metric tons; and for WCA-2B and ENP: 50 and 60 million metric tons of carbon dioxide respectively.
Predrainage vs. Current (Method 2)
Predrainage Everglades

Predrainage Everglades Peat Surface Elevation

Predrainage Everglades Bedrock

Bedrock Predrain
Feet NGVD
11 - 12
10 - 11
9 - 10
8 - 9
7 - 8
6 - 7
5 - 6
4 - 5
3 - 4
2 - 3
1 - 2

Peat Surface
Feet NGVD
> 20
15 - 20
10 - 15
5 - 10
< 5

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
Everglades Peat Depths

Predrainage Everglades Peat Depth

Current Everglades Protection Area Peat Depth

Peat Depth
Feet
- 16 - 18
- 11 - 15
- 6 - 10
- 0 - 5

Peat Depth
Feet
- 16 - 22
- 11 - 15
- 6 - 10
- 0 - 5
Everglades Bulk Density

Predrainage Everglades Regions Bulk Density

Bulk Density Mg/m³
- 0.71 - 0.79
- 0.61 - 0.70
- 0.51 - 0.60
- 0.41 - 0.50
- 0.31 - 0.40
- 0.21 - 0.30
- 0.11 - 0.20
- 0.04 - 0.10

Mass Metric Tons
- 70,001 - 76,726
- 60,001 - 70,000
- 50,001 - 60,000
- 40,001 - 50,000
- 30,001 - 40,000
- 20,001 - 30,000
- 10,001 - 20,000
- 0 - 10,000

Current Everglades Protection Area Regions Bulk Density

Bulk Density Mg/m³
- 0.71 - 0.79
- 0.61 - 0.70
- 0.51 - 0.60
- 0.41 - 0.50
- 0.31 - 0.40
- 0.21 - 0.30
- 0.11 - 0.20
- 0.04 - 0.10

Mass Metric Tons
- 70,001 - 99,159
- 60,001 - 70,000
- 50,001 - 60,000
- 40,001 - 50,000
- 30,001 - 40,000
- 20,001 - 30,000
- 10,001 - 20,000
- 0 - 10,000
## Changes in Volumes and Masses (Method 2)

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Total Area (m²)</th>
<th>Peat Volume (m³)</th>
<th>Mass (MT)</th>
<th>Carbon (MT)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Predrainage Everglades Totals</strong></td>
<td>1.1 x 10¹⁰</td>
<td>2.0 x 10¹⁰</td>
<td>2.6 x 10⁹</td>
<td>9.4 x 10⁸</td>
</tr>
<tr>
<td><strong>Current EPA Totals</strong></td>
<td>5.6 x 10⁹</td>
<td>4.7 x 10⁹</td>
<td>4.5 x 10⁸</td>
<td>1.8 x 10⁸</td>
</tr>
<tr>
<td><strong>Change (Loss)</strong></td>
<td>5.4 x 10⁹</td>
<td>1.5 x 10¹⁰</td>
<td>2.2 x 10⁹</td>
<td>7.6 x 10⁸</td>
</tr>
</tbody>
</table>
USEPA R-EMAP Data Comparison
(Scheidt, Johnson, Scinto and Kalla, GEER 2015)

Current Soil Volume

- Soil Volume = Area x Median Thickness ~ method A
- EPA soil volume $4.69 \times 10^9$ m$^3$ (n= 977)
- Soil Thickness: median = 2.3 feet

<table>
<thead>
<tr>
<th>Sub-Area</th>
<th>Area (km$^2$)</th>
<th>n</th>
<th>Median Soil Thickness (m)</th>
<th>Volume (m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LNWR</td>
<td>567</td>
<td>105</td>
<td>2.62</td>
<td>$1.49 \times 10^9$</td>
</tr>
<tr>
<td>WCA2</td>
<td>539</td>
<td>104</td>
<td>1.28</td>
<td>$0.69 \times 10^9$</td>
</tr>
<tr>
<td>WCA 3AN</td>
<td>715.8</td>
<td>129</td>
<td>0.49</td>
<td>$0.35 \times 10^9$</td>
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<tr>
<td>WCA 3AS</td>
<td>1288</td>
<td>224</td>
<td>0.88</td>
<td>$1.14 \times 10^9$</td>
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<tr>
<td>WCA 3B</td>
<td>401.4</td>
<td>78</td>
<td>1.01</td>
<td>$0.40 \times 10^9$</td>
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<tr>
<td>ENP SRS</td>
<td>357.6</td>
<td>67</td>
<td>0.46</td>
<td>$0.16 \times 10^9$</td>
</tr>
<tr>
<td>ENP NESS</td>
<td>251.1</td>
<td>44</td>
<td>0.49</td>
<td>$0.12 \times 10^9$</td>
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<tr>
<td>ENP OM</td>
<td>437.6</td>
<td>79</td>
<td>0.24</td>
<td>$0.11 \times 10^9$</td>
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<tr>
<td>ENP EMW</td>
<td>693.4</td>
<td>115</td>
<td>0.21</td>
<td>$0.15 \times 10^9$</td>
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<tr>
<td>ENP EME</td>
<td>137.1</td>
<td>19</td>
<td>0.21</td>
<td>$0.03 \times 10^9$</td>
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<tr>
<td>ENP TS</td>
<td>59.1</td>
<td>13</td>
<td>0.91</td>
<td>$0.05 \times 10^9$</td>
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<tr>
<td>TOTAL</td>
<td>5447.1</td>
<td>977</td>
<td></td>
<td>$4.69 \times 10^9$</td>
</tr>
</tbody>
</table>

Hohner & Dreschel 2015 ~ method B GIS based approach:
surface elevation – bedrock elevation

$4.7 \times 10^9$
This study estimated the volume and mass of peat that had been lost over the last 125 years within the EAA.

To offset limitations in the historical as well as current data sets, we used two independent methods and sets of data to estimate the volumes of peat lost. The first method was based on historical and current estimates of peat thickness. The second method was based on estimates of the historical and current surface topography.

We used a GIS to organize the historical data, to interpolate, and to calculate volume differences.

The volumes were used, in combination with soil characteristics to determine peat subsidence, peat carbon loss and carbon dioxide emissions.
Contour maps were created and analyzed to estimate peat loss (ft) in the EAA:

**Approach 1**
Peat Thickness 1915;
Peat Thickness 2003

**Approach 2**
Bedrock (1955);
Peat Surface 1880;
Peat Surface 2000
Estimated values of soil parameters for predrainage and current soil profiles in the EAA
EAA Analysis Results

- Approximately two-thirds of the peat volume from the EAA has been lost during the last century, decreasing from about $7 \times 10^9$ m$^3$ to about $2.5 \times 10^9$ m$^3$.

- This corresponds to a loss of about $2.5 \times 10^8$ metric tons of peat and a release of about $5 \times 10^8$ metric tons of CO$_2$.

- This CO$_2$ is similar to the annual carbon emissions of approximately $1 \times 10^5$ American households, assuming emissions of 48 metric tons per year per household.
3. Geospatial Quantification of Peat Loss from an Everglades Tree Island

- This study estimates changes on a tree island in Water Conservation Area-2A over a 36-year period.

- The data sources used were land surveys of the surface of the island conducted in 1973 and 2009. The more recent survey included the collection of soil/sediment cores for analysis.
Ghost Tree Islands and Dineen Island
1973 Survey of Dineen Island

Map courtesy of Kenneth Rutchey
1973 and 2009 Peat Surface Transects

(b) Comparison between historic and recent peat surface elevation along the survey transects in Dineen’s Island.
Topographic Interpolations
Core Analysis Results
Tree Island Change Results

- The average peat subsidence on the island in 36 years was about 0.14 m, which is equivalent to 0.40 cm yr$^{-1}$. This compares well with our result from Project 1 that the average peat subsidence calculated for the entire landscape of WCA-2A of approximately 0.42 cm yr$^{-1}$ over 130 years.

- The changes in the island resulted in a net loss of roughly 8,000 metric tons of peat, 3,600 metric tons of carbon, 2.5 metric tons of total phosphorus and 230 metric tons of total nitrogen.
Overall Summary

- Using GIS and a variety of spatial data sources, we calculated the volume of peat loss from various regions of the historical Everglades.

- In addition, from analyses performed on collected peat cores and values found in the literature, we were able to estimate the masses of peat, carbon and other mineral constituents lost.

- Although many uncertainties exist with the data and the techniques, we believe that this approach can provide insight into the amount of change that the Everglades has experienced over more than a century.
Sources:


Sources (continued):


Everglades Peat Loss

THE PLAYERS:

- Christopher McVoy, Winnifred Park Said, Jayantha Obeysekera, Joel VanArman
- Sumanjit Aich
- Susan Hohner
- Fabiola Santamaria
- Ben Gu
- Sharon Ewe and team from Ecology & Environment, Inc
- Dan Scheidt, Diana Johnson, Len Scinto, Pete Kalla
Questions or Comments?

Fig. 2. Concrete post driven into the organic soil at the University of Florida Everglades Research and Education Center, Belle Glade, in 1924, when the soil surface was even with the top of the post. Photographed in 2003.