Utilizing EDEN Data and Tools—An Example

The EDEN surface-water model and its applications are valuable tools for characterizing current and historic hydrologic conditions in the Everglades and for assessing the potential impacts of restoration. EDEN allows scientists to make limited measurements in the field, and then tie those data into the network of data available from EDEN to gain extensive hydrologic information. For example, during a 2007 study of 245 tree islands in Water Conservation Area 3 (Volin and others, 2008), researchers measured water level relative to the top of each island and near each island. Using an auger, they measured the depth to water from the top, and also measured the depth of the water surrounding the islands. Then, using the EDEN xyLocator program, they input the UTM coordinates of the measurement sites to obtain the EDEN water-surface elevations at these islands on the date they made their measurements. Using these surface-water elevations, they were able to determine the elevation of the top of each tree island and the elevation of the land surrounding the island. Using this approach, they developed not only the elevation profiles of the tree islands, but they utilized the long-term EDEN database to look at changes in the tree islands with respect to water level over time. Periods of flooding, or inundation, for each tree island are generated for the period from January 2000 to present, by plotting the elevation of the top of the tree island and the ground surface surrounding the tree island with the EDEN time series water-level data (fig. 7).

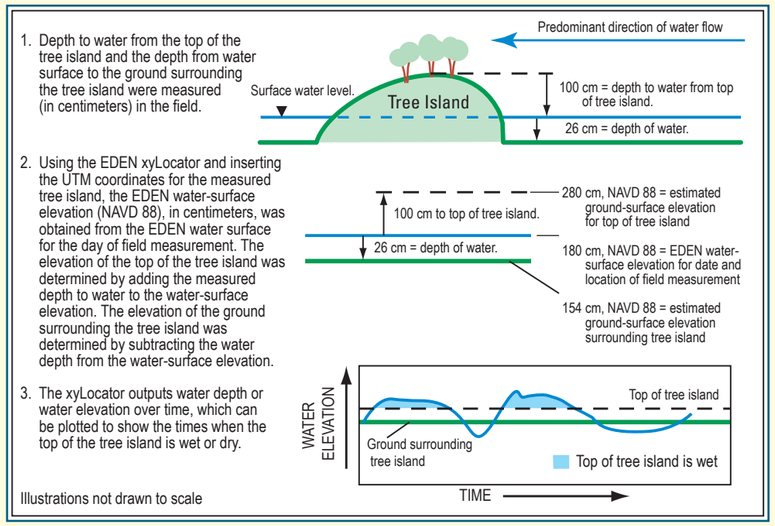

Figure 7. Schematic of the process used in applying the EDEN data and xyLocator application to a study of tree islands.

Summary

An important goal of Everglades restoration is to restore the volume, timing, and distribution of sheetflow. Five EDEN applications (tools) were developed for EDEN users to view, extract, plot, and manipulate EDEN data in a variety of ways. These tools provide information which will help hydrologists and resource managers monitor sheetflow changes and other changes to the natural system. The EDEN tools will also provide biologists and ecologists with the information necessary to examine trophic-level responses to the hydrodynamic changes in the Everglades.

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[1] All EDEN publications are available at *http://sofia.usgs.gov/eden/publications.php*

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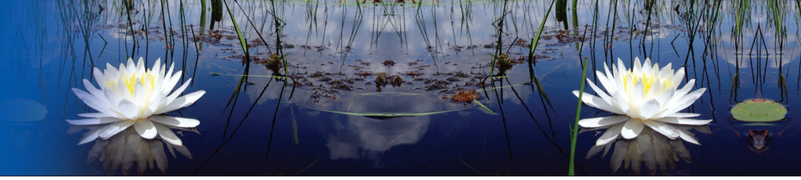


Florida Integrated Science Center

Everglades Depth Estimation Network (EDEN) Applications:
Tools to View, Extract, Plot, and Manipulate EDEN Data

The Everglades Depth Estimation Network (EDEN) is an integrated system of real-time water-level monitoring, ground-elevation data, and water-surface elevation modeling to provide scientists and water managers with current on-line water-depth information for the entire freshwater part of the greater Everglades. To assist users in applying the EDEN data to their particular needs, a series of five EDEN tools, or applications (EDENapps), were developed. Using EDEN's tools, scientists can view the EDEN datasets of daily water-level and ground elevations, compute and view daily water depth and hydroperiod surfaces, extract data for user-specified locations, plot transects of water level, and animate water-level transects over time. Also, users can retrieve data from the EDEN datasets for analysis and display in other analysis software programs. As scientists and managers attempt to restore the natural volume, timing, and distribution of sheetflow in the wetlands, such information is invaluable. Information analyzed and presented with these tools is used to advise policy makers, planners, and decision makers of the potential effects of water management and restoration scenarios on the natural resources of the Everglades.

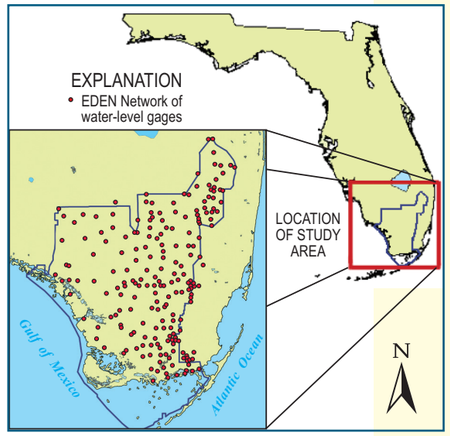


Figure 1. Location of EDEN domain and water-level gages.

Background—The Everglades Depth Estimation Network

EDEN is a primary product of the hydrology module of the Restoration Coordination and VERification (RECOVER) Monitoring and Assessment Plan (MAP), and provides much of the hydrologic data that underpins many of the MAP's restoration hypotheses (RECOVER, 2004; Telis, 2006). EDEN offers a consistent and documented dataset of ground-elevation measurements and continuous water-level data for the greater Everglades. The dataset can be used by scientists and managers to: (1) guide large-scale field operations, (2) integrate hydrologic and ecological responses, and (3) support biological and ecological assessments that measure the way the ecosystem responds to the implementation of the Comprehensive Everglades Restoration Plan (CERP) (U.S. Army Corps of Engineers, 1999).

Surface water-level data have been collected daily since 1999 at up to 253 wetland and canal gaging stations operated by the Big Cypress National Preserve, Everglades National Park, the South Florida Water Management District, and the U.S. Geological Survey (USGS) (fig. 1). Data are entered into the USGS National Water Information System (NWIS) database daily, with a 1-day delay from the date of collection. Once in NWIS, the data are available at *http://sofia.usgs.gov/eden/stationlist.php*. EDEN water-level data are accessed through an interactive map showing the location of gaging stations in the network, which provides "clickable" access to gage data on a near real-time basis.

Ground-elevation data for the greater Everglades and the digital ground-elevation models (DEM) derived from them form the foundation for all EDEN water depth and associated ecological/hydrologic modeling. Ground-surface elevation data were collected by the USGS (Desmond, 2003) at more than 50,000 sites with an approximate spacing of 400 meters and covering almost the entire greater Everglades. Using the North American Vertical Datum of 1988 (NAVD 88) allows for comparing of water-level data and for computing of accurate water depths across the greater Everglades.

A water-surface elevation model uses the daily median values of up to 240 of the EDEN network water-level gages in the freshwater Everglades to create spatially continuous interpolations of the water-surface elevation. EDEN's daily water-level surfaces are georeferenced gridded surfaces that can be viewed with the EDEN Data Viewer and most georeferencing programs, such as ArcGIS. More information regarding EDEN is provided in Telis (2006) and on the EDEN website, *http://sofia.usgs.gov/eden*. These water-level surfaces are posted on the website daily, with the following specifications:

- Daily water surfaces are generated from daily median water-level gage data from January 1, 2000 to current (Pearlstine and others, 2007; Palaseanu and Pearlstine, 2008);
- Surfaces are created on a 400 × 400 meter grid (Jones and Price, 2007a);
- Water-level surfaces are in centimeters;
- Vertical datum is North American Vertical Datum of 1988 (NAVD 88);
- Surfaces are available as NetCDF and GeoTiff files;
- There is a 4-day delay to allow the collecting agencies to address initial quality control issues with provisional real-time data.

EDEN Applications (EDENapps)

Three EDEN applications were developed to make the data more accessible, by allowing users to view, extract, plot, and manipulate the data in a variety of ways. Two additional applications were developed to create data files formatted in netCDF file format for further manipulation by ArcGIS and other georeferencing programs. By combining the daily water-level surfaces with the ground-elevation model (Jones and Price, 2007b) and using the EDEN applications, a full suite of hydrologic data is made available to scientists and others, including:

- Water depth,
- Hydroperiod (computation of days since last dry),
- Water-surface slope,
- Surface animations of water elevation and water depth over time, and
- Transects of water depth animated over time

EDEN uses the NetCDF data format, which more efficiently supports large array-oriented datasets than the commonly used ESRI Grid format. The EDEN applications are programmed to read the netCDF format (.nc). Users with ESRI ArcGIS installations (version 9.2 or higher) can import the netCDF file into ESRI ArcMap and easily animate daily EDEN files. EDEN daily files of water level are also created in the standard GeoTiff file format for use with multiple geospatial programs. EDEN tools, installation instructions, and user manuals are available for download at *http://sofia.usgs.gov/eden/edenapps/index.php*. Each of the tools is briefly described below.

The **EDEN Data Viewer** displays daily EDEN surfaces of water level, ground elevation, water depth, and days since last dry (hydroperiod) (fig. 2). The entire EDEN domain can be viewed, or the user can query the layers for data values at user-specified locations by zooming in using the cursor or by entering UTM coordinates. Additionally, the user can view changes through time with animation; by selecting a starting date, the displays can travel backward or forward in time, at the user-specified animation speed.

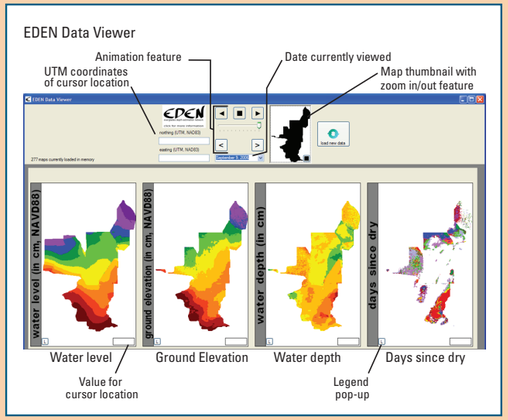


Figure 2. Image of the EDEN Data Viewer, showing the daily surfaces of water level, ground elevation, water depth, and days since dry, along with the tools used to pan, zoom, and animate the surfaces.

The **EDEN xyLocator** is a program for extracting data for user-specified locations from spatial hydrologic time-series, such as water surface, water depth and days since last dry, and the EDEN ground-surface DEM. The user specifies the locations needed by identifying the UTM position coordinates. The output is a text file which can be opened in a text editor or opened and plotted in a spreadsheet program such as Excel (fig. 3*A,B,C*).

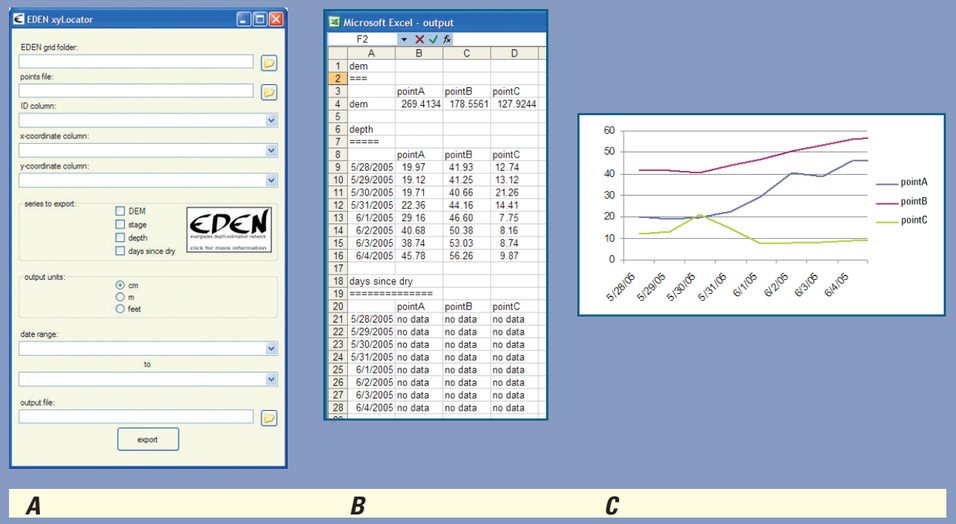
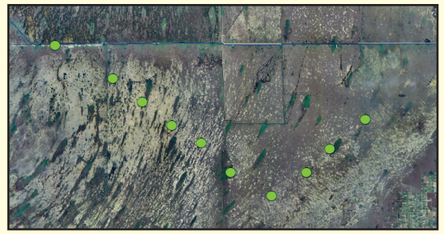


Figure 3. EDEN xyLocator program views including: *A,* online form on which the user can select locations and outputs of interest; *B,* sample output file, opened in Excel; and *C,* graph produced in Excel to show the daily changes in water depth at three specified points over time.

The **EDEN Transect Plotter** is a program for plotting daily water-level surfaces and ground-elevation profiles for user-specified transects across the Everglades (fig. 4). The water-surface slope is calculated and displayed along the transect for user-specified distances (fig. 5), and the water surface can be animated over a user-specified time period. Observations of water depth and water level along the transect and within a user-specified distance perpendicular to the transect can be input for comparison and plotting of the profile. Likewise, the user can specify that the locations of nearby water-level gages be plotted.

Transect ID	UTMeasting	UTMnorthing
T1-1	519153	2849187
T1-2	523879	2846507
T1-3	526262	2844600
T1-4	528645	2842694
T1-5	531028	2841263
T1-6	533412	2838880
T1-7	536748	2836973
T1-8	539608	2838880
T1-9	541515	2840787
T1-10	544375	2843170

A



B

Figure 4. EDEN Transect Plotter images including: *A,* sample list of UTM easting and northing coordinates for selected points along a transect, and *B,* satellite image showing the locations of the selected transect points.

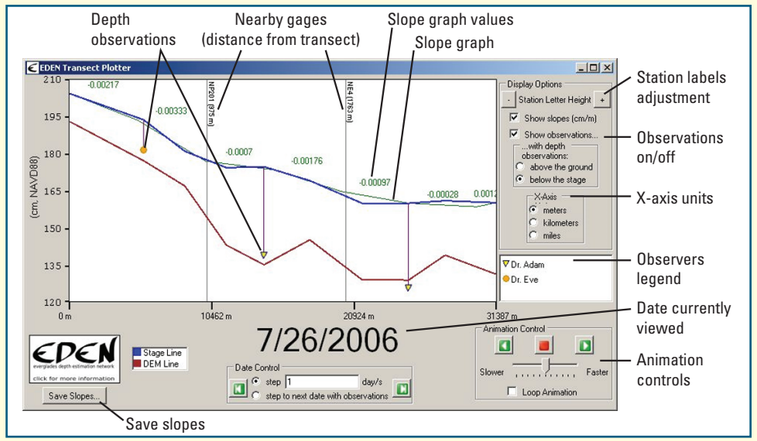


Figure 5. Sample EDEN Transect Plotter display showing the slope of water level along the specified transect, values at each slope interval, locations of nearby gages included by the user, and estimates of ground elevation based on water-depth observations input by the user, for July 26, 2006.

The EDEN Depth&DaysSinceDry tool creates daily surfaces (in netCDF file format, .nc) of water depth and days since last dry. For each 400×400 meter grid cell in the EDEN database, the daily water-level surface is subtracted from the ground-elevation model to obtain the water depth for the grid. The daily water-depth surfaces are bundled in quarter-year periods (Jan.-Mar. 2004, Apr.-June 2004, and so forth.); the user can specify which quarters to include. The days since last dry (hydroperiod) indicates the number of consecutive days that an EDEN grid cell surface has had a water-depth value greater then zero (fig. 6). NetCDF files of daily surfaces of water depths and days since dry, bundled by quarter year, are produced for use in georeferencing programs.

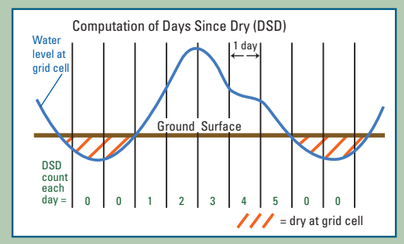


Figure 6. Schematic showing how the days since dry (DSD) is determined. In this example, the ground surface was wet for a total of 5 days before it again became dry.

NetCDFtoGrid is a program for converting EDEN water level, water depth, and days since dry gridded surfaces from NetCDF (.nc) format to ESRI Grid format. Users who wish to use ESRI ArcGIS (version earlier than 9.2) must use Grid file format to view and manipulate the EDEN surfaces.

Also, some users are more familiar with the Grid format than NetCDF format and may wish to convert to Grid before using a georeferencing program.