Conceptual design of the Everglades Depth Estimation Network (EDEN) grid

By John W. Jones and Susan D. Price

Open File Report 2007–1200

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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
Length		
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
mile, nautical (nmi)	1.852	kilometer (km)
yard (yd)	0.9144	meter (m)
Area		
acre	4,047	square meter (m^2)
acre	0.4047	hectare (ha)
acre	0.4047	square hectometer (hm^2)
acre	0.004047	square kilometer (km^2)
square foot (ft^2)	929.0	square centimeter (cm^2)
square foot (ft^2)	0.09290	square meter (m^2)
square inch (in^2)	6.452	square centimeter (cm^2)
section (640 acres or 1 square mile)	259.0	square hectometer (hm^2)
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
Volume		
barrel (bbl), (petroleum, 1 barrel=42 gal)	0.1590	cubic meter (m^3)
ounce, fluid (fl. oz)	0.02957	liter (L)
pint (pt)	0.4732	liter (L)
quart (qt)	0.9464	liter (L)
gallon (gal)	3.785	liter (L)
gallon (gal)	0.003785	cubic meter (m^3)
gallon (gal)	3.785	cubic decimeter (dm^3)
million gallons (Mgal)	3,785	cubic meter (m^3)
cubic inch (in^3)	16.39	cubic centimeter (cm^3)
cubic inch (in^3)	0.01639	cubic decimeter (dm^3)
cubic inch (in^3)	0.01639	liter (L)
cubic foot (ft^3)	28.32	cubic decimeter (dm^3)

cubic foot (ft^3)	0.02832	cubic meter (m^3)
cubic yard (yd^3)	0.7646	cubic meter (m^3)
cubic mile (mi^3)	4.168	cubic kilometer (km^3)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
acre-foot (acre-ft)	0.001233	cubic hectometer (hm^3)
Flow rate		
acre-foot per day (acre-ft/d)	0.01427	cubic meter per second (m^3/s)
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year (m^3/yr)
acre-foot per year (acre-ft/yr)	0.001233	cubic hectometer per year (hm^3/yr)
foot per second (ft/s)	0.3048	meter per second (m/s)
foot per minute (ft/min)	0.3048	meter per minute (m/min)
foot per hour (ft/hr)	0.3048	meter per hour (m/hr)
foot per day (ft/d)	0.3048	meter per day (m/d)
foot per year (ft/yr)	0.3048	meter per year (m/yr)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic foot per second per square mile [(ft^3/s)/mi^2]	0.01093	cubic meter per second per square kilometer [(m^3/s)/km^2]
cubic foot per day (ft^3/d)	0.02832	cubic meter per day (m^3/d)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
gallon per day (gal/d)	0.003785	cubic meter per day (m^3/d)
gallon per day per square mile [(gal/d)/mi^2]	0.001461	cubic meter per day per square kilometer [(m^3/d)/km^2]
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
million gallons per day per square mile [(Mgal/d)/mi^2]	1,461	cubic meter per day per square kilometer [(m^3/d)/km^2]
inch per hour (in/h)	0 .0254	meter per hour (m/h)
inch per year (in/yr)	25.4	millimeter per year (mm/yr)
mile per hour (mi/h)	1.609	kilometer per hour (km/h)
Mass		
ounce, avoirdupois (oz)	28.35	gram (g)
pound, avoirdupois (lb)	0.4536	kilogram (kg)
ton, short (2,000 lb)	0.9072	megagram (Mg)
ton, long (2,240 lb)	1.016	megagram (Mg)
ton per day (ton/d)	0.9072	metric ton per day
ton per day (ton/d)	0.9072	megagram per day (Mg/d)
ton per day per square mile [(ton/d)/mi^2]	0.3503	megagram per day per square kilometer [(Mg/d)/km^2]

ton per year (ton/yr)	0.9072	megagram per year (Mg/yr)
ton per year (ton/yr)	0.9072	metric ton per year
Pressure		
atmosphere, standard (atm)	101.3	kilopascal (kPa)
bar	100	kilopascal (kPa)
inch of mercury at 60ºF (in Hg)	3.377	kilopascal (kPa)
pound-force per square inch (lbf/in^2)	6.895	kilopascal (kPa)
pound per square foot (lb/ft^2)	0.04788	kilopascal (kPa)
pound per square inch (lb/in^2)	6.895	kilopascal (kPa)
Density		
pound per cubic foot (lb/ft^3)	16.02	kilogram per cubic meter (kg/m^3)
pound per cubic foot (lb/ft^3)	0.01602	gram per cubic centimeter (g/cm^3)
Energy		
kilowatthour (kWh)	3,600,000	joule (J)
Radioactivity		
picocurie per liter (pCi/L)	0.037	becquerel per liter (Bq/L)
Specific capacity		
gallon per minute per foot [(gal/min)/ft)]	0.2070	liter per second per meter [(L/s)/m]
Hydraulic conductivity		
foot per day (ft/d)	0.3048	meter per day (m/d)
Hydraulic gradient		
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
Transmissivity*		
foot squared per day (ft^2/d)	0.09290	meter squared per day (m^2/d)
Application rate		
pounds per acre per year [(lb/acre)/yr]	1.121	kilograms per hectare per year [(kg/ha)/yr]
Leakance		
foot per day per foot [(ft/d)/ft]	1	meter per day per meter
inch per year per foot [(in/yr)/ft]	83.33	millimeter per year per meter [(mm/yr)/m]

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:
°F=(1.8×°C)+32

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:
°C=(°F-32)/1.8
Vertical coordinate information is referenced to the insert datum name (and abbreviation) here for instance, "North American Vertical Datum of 1988 (NAVD 88)."
Horizontal coordinate information is referenced to the insert datum name (and abbreviation) here for instance, "North American Datum of 1983 (NAD 83)."
Altitude, as used in this report, refers to distance above the vertical datum.
*Transmissivity: The standard unit for transmissivity is cubic foot per day per square foot times foot of aquifer thickness [$(ft^3/d)/ft^2$]ft. In this report, the mathematically reduced form, foot squared per day (ft^2/d), is used for convenience.
Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).
Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).
NOTE TO USGS USERS: Use of hectare (ha) as an alternative name for square hectometer (hm^2) is restricted to the measurement of small land or water areas. Use of liter (L) as a special name for cubic decimeter (dm^3) is restricted to the measurement of liquids and gases. No prefix other than milli should be used with liter. Metric ton (t) as a name for megagram (Mg) should be restricted to commercial usage, and no prefixes should be used with it.

SI to Inch/Pound

Multiply	By	To obtain
Length		
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
kilometer (km)	0.5400	mile, nautical (nmi)
meter (m)	1.094	yard (yd)
Area		
square meter (m^2)	0.0002471	acre
hectare (ha)	2.471	acre
square hectometer (hm^2)	2.471	acre
square kilometer (km^2)	247.1	acre
square centimeter (cm^2)	0.001076	square foot (ft^2)
square meter (m^2)	10.76	square foot (ft^2)
square centimeter (cm^2)	0.1550	square inch (ft^2)
square hectometer (hm^2)	0.003861	section (640 acres or 1 square mile)
hectare (ha)	0.003861	square mile (mi^2)
square kilometer (km^2)	0.3861	square mile (mi^2)
Volume		
cubic meter (m^3)	6.290	barrel (petroleum, 1 barrel = 42 gal)
liter (L)	33.82	ounce, fluid (fl. oz)
liter (L)	2.113	pint (pt)
liter (L)	1.057	quart (qt)
liter (L)	0.2642	gallon (gal)
cubic meter (m^3)	264.2	gallon (gal)
cubic decimeter (dm^3)	0.2642	gallon (gal)
cubic meter (m^3)	0.0002642	million gallons (Mgal)
cubic centimeter (cm^3)	0.06102	cubic inch (in^3)
cubic decimeter (dm^3)	61.02	cubic inch (in^3)
liter (L)	61.02	cubic inch (in^3)
cubic decimeter (dm^3)	0.03531	cubic foot (ft^3)
cubic meter (m^3)	35.31	cubic foot (ft^3)
cubic meter (m^3)	1.308	cubic yard (yd^3)

cubic kilometer (km^3)	0.2399	cubic mile (mi^3)
cubic meter (m^3)	0.0008107	acre-foot (acre-ft)
cubic hectometer (hm^3)	810.7	acre-foot (acre-ft)
Flow rate		
cubic meter per second (m^3/s)	70.07	acre-foot per day (acre-ft/d)
cubic meter per year (m^3/yr)	0.000811	acre-foot per year (acre-ft/yr)
cubic hectometer per year (hm^3/yr)	811.03	acre-foot per year (acre-ft/yr)
meter per second (m/s)	3.281	foot per second (ft/s)
meter per minute (m/min)	3.281	foot per minute (ft/min)
meter per hour (m/hr)	3.281	foot per hour (ft/hr)
meter per day (m/d)	3.281	foot per day (ft/d)
meter per year (m/yr)	3.281	foot per year ft/yr)
cubic meter per second (m^3/s)	35.31	cubic foot per second (ft^3/s)
cubic meter per second per square kilometer [(m^3/s)/km^2]	91.49	cubic foot per second per square mile [(ft^3/s)/mi^2]
cubic meter per day (m^3/d)	35.31	cubic foot per day (ft^3/d)
liter per second (L/s)	15.85	gallon per minute (gal/min)
cubic meter per day (m^3/d)	264.2	gallon per day (gal/d)
cubic meter per day per square kilometer [(m^3/d)/km^2]	684.28	gallon per day per square mile [(gal/d)/mi^2]
cubic meter per second (m^3/s)	22.83	million gallons per day (Mgal/d)
cubic meter per day per square kilometer [(m^3/d)/km^2]	0.0006844	million gallons per day per square mile [(Mgal/d)/mi^2]
cubic meter per hour (m^3/h)	39.37	inch per hour (in/h)
millimeter per year (mm/yr)	0.03937	inch per year (in/yr)
kilometer per hour (km/h)	0.6214	mile per hour (mi/h)
Mass		
gram (g)	0.03527	ounce, avoirdupois (oz)
kilogram (kg)	2.205	pound avoirdupois (lb)
megagram (Mg)	1.102	ton, short (2,000 lb)
megagram (Mg)	0.9842	ton, long (2,240 lb)
metric ton per day	1.102	ton per day (ton/d)
megagram per day (Mg/d)	1.102	ton per day (ton/d)
megagram per day per square kilometer [(Mg/d)/km^2]	2.8547	ton per day per square mile [(ton/d)/mi^2]
megagram per year (Mg/yr)	1.102	ton per year (ton/yr)
metric ton per year	1.102	ton per year (ton/yr)
Pressure		

kilopascal (kPa)	0.009869	atmosphere, standard (atm)
kilopascal (kPa)	0.01	bar
kilopascal (kPa)	0.2961	inch of mercury at 60°F (in Hg)
kilopascal (kPa)	0.1450	pound-force per inch (lbf/in)
kilopascal (kPa)	20.88	pound per square foot (lb/ft^2)
kilopascal (kPa)	0.1450	pound per square inch (lb/ft^2)
Density		
kilogram per cubic meter (kg/m^3)	0.06242	pound per cubic foot (lb/ft^3)
gram per cubic centimeter (g/cm^3)	62.4220	pound per cubic foot (lb/ft^3)
Energy		
joule (J)	0.0000002	kilowatthour (kWh)
Radioactivity		
becquerel per liter (Bq/L)	27.027	picocurie per liter (pCi/L)
Specific capacity		
liter per second per meter [(L/s)/m]	4.831	gallon per minute per foot [(gal/min)/ft]
Hydraulic conductivity		
meter per day (m/d)	3.281	foot per day (ft/d)
Hydraulic gradient		
meter per kilometer (m/km)	5.27983	foot per mile (ft/mi)
Transmissivity*		
meter squared per day (m^2/d)	10.76	foot squared per day (ft^2/d)
Application rate		
kilograms per hectare per year [(kg/ha)/yr]	0.8921	pounds per acre per year [(lb/acre)/yr]
Leakance		
meter per day per meter [(m/d)/m]	1	foot per day per foot [(ft/d)/ft]
millimeter per year per meter [(mm/yr)/m]	0.012	inch per year per foot [(in/yr)/ft]

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°F=(1.8×°C)+32
Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:
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The Everglades Depth Estimation Network (EDEN) Grid conceptual design

By John W. Jones and Susan D. Price

Introduction

The Everglades Depth Estimation Network (EDEN) offers a consistent and documented dataset that can be used to guide large-scale field operations, to integrate hydrologic and ecological responses, and to support biological and ecological assessments that measure ecosystem responses to the Comprehensive Everglades Restoration Plan (Telis, 2006). Ground elevation data for the greater Everglades and the digital ground elevation models derived from them form the foundation for all EDEN water depth and associated ecologic/hydrologic modeling (Jones, 2004, Jones and Price, 2007). To use EDEN water depth and duration information most effectively, it is important to be able to view and manipulate information on elevation data quality and other land cover and habitat characteristics across the Everglades region. These requirements led to the development of the geographic data layer described in this techniques and methods report. Relying on extensive experience in GIS data development, distribution, and analysis, a great deal of forethought went into the design of the geographic data layer used to index elevation and other surface characteristics for the Greater Everglades region. To allow for simplicity of design and use, the EDEN area was broken into a large number of equal-sized rectangles ("cells") that in total are referred to here as the "grid". Some characteristics of this grid, such as the size of its cells, its origin, the area of Florida it is designed to represent, and individual grid cell identifiers, could not be changed once the grid database was developed. Therefore, these characteristics were selected to design as robust a grid as possible and to ensure the grid's long-term utility. It is desirable to include all pertinent information known about elevation and elevation data collection as grid attributes. Also, it is very important to allow for efficient grid post-processing, sub-setting, analysis, and distribution. This document details the conceptual design of the EDEN grid spatial parameters and cell attribute-table content.

Map projection and coordinate system

The Universal Transverse Mercator (UTM) projection, using the North American Datum of 1983 (NAD83) was selected as the EDEN grid map projection and coordinate system. Originally developed to facilitate allied military operations, the UTM provides a metric-based coordinate system that is simple to use, precludes negative coordinate values (a potential source of error during data transfer and analysis), and is commonly employed in environmental and other geographic analysis. Use of the NAD83 ensures both compatibility with modern surveying systems and the highest degree of accuracy currently possible for South Florida regional geographic analysis.

Spatial resolution

To match the Airborne Height Finder (AHF) system sample spacing, the spatial resolution or the dimensions (in ground distance) of each grid cell is 400m on each side. The AHF is the helicopter-based high accuracy elevation data (HAED) measuring system that has been used over the past several years to collect Everglades ground surface elevations to an accuracy specification of +/- 15cm (Desmond, 2003). These data constitute the foundation for the EDEN grid as nearly 50,000 AHF points will be used to initially assign elevation values to each cell. The 400m spacing for AHF data collection was selected so that ground elevation data were collected at closer intervals than the spatial resolution planned for developing high-resolution hydrodynamic models for sub-regions of the Everglades (Schaffranek, 2001).

Spatial location and extent

The origin and extent of the EDEN grid were selected to cover not only existing AHF data and current regions of interest for Everglades restoration, but to cover a rectangular area that includes all landscape units (USACE, 2004) and conservation areas in place at the time of its development (Figure 1). This will allow for future expansion of analyses throughout the Greater Everglades region should resources allow and scientific or management questions require it. Combined with the chosen extent, the 400m cell resolution produces a grid that is 675 rows and 375 columns (253,125 cells total).

Cell identifier assignment

The assignment of a unique identifier to each EDEN cell is a difficult, but critical task. Unique identifiers allow for continual, long-term management and analysis of the data within the grid as it is a sub-set for analysis, data distribution, or editing during continued improvement. Cells are uniquely identified by two different processes. First, by definition each cell has a unique coordinate pair for its center. However, the use of X/Y coordinate pairs as a unique identifier is cumbersome. Therefore, a "master id" number has been assigned to each cell. Maintained as a separate attribute item, this ID is not altered by software processing (as internally assigned and maintained cell ID values can be).

Geographic data formats

To make the EDEN grid as easy to use as possible for a wide variety of researchers and analysts, the EDEN grid has been created in 3 different formats[1]: Microsoft ACCESS Geodatabase, ARC/INFO coverage, and ARC/INFO shapefile. Because of the grid's resolution, area of coverage, and extensive attribute information, these files can easily reach sizes of over 60 megabytes in compressed form.

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[1] Use of commercial products and trade names does not constitute an endorsement by the Federal Government.

Grid cell attribution

Through various GIS operations, grid cells can be attributed with a variety of information using data of different spatial resolutions. For example, based on EDEN applications modeling of daily water depths, each grid cell can be assigned a hydroperiod (average length of time per year that the cell has water above the ground surface). As another example, a satellite-derived land cover map (with 30m spatial resolution) was overlain on the 250,000+, 400m-resolution grid cells to calculate the percentage of each grid cell covered by each land cover type. The results were appended to the grid attribute table. (This represents a significant processing challenge that would not be practical "on-the-fly"). Figures 2 through 5 show the percentages of grid cells covered by one of four land cover classes derived from the early 1990's Landsat satellite data (Florida Cooperative Fish and Wildlife Research Unit, 2007) for the entire EDEN domain. How might these pieces of information be used? To identify areas with diverse wetland habitat content, a biologist might query the grid for all cells with a hydroperiod greater than 6-months and equal percentages of each land cover type. Or, managers might estimate areas likely to undergo significant changes in vegetation cover given changed water flow management by identifying cells with "marginal" land cover of one class (e.g., sawgrass) or another (e.g., open water). Following years of managed flow, new satellite-based maps of land cover might be developed and the operation repeated to asses impacts of water management actions on vegetation. Such continued development and attribution of the grid can facilitate adaptive management of the Everglades restoration.

Data distribution

The EDEN grid is freely distributed through the South Florida Information Access website (***http://sofia.usgs.gov***/eden/models/edengrid.php) data exchange pages. Attribute data associated with the EDEN grid are considered preliminary and will undergo further development and evaluation prior to release.

Acknowledgements

Funding for EDEN DEM development was provided by the USGS's Greater Everglades Priority Ecosystems Science Program and the Land Remote Sensing Program.

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Figures

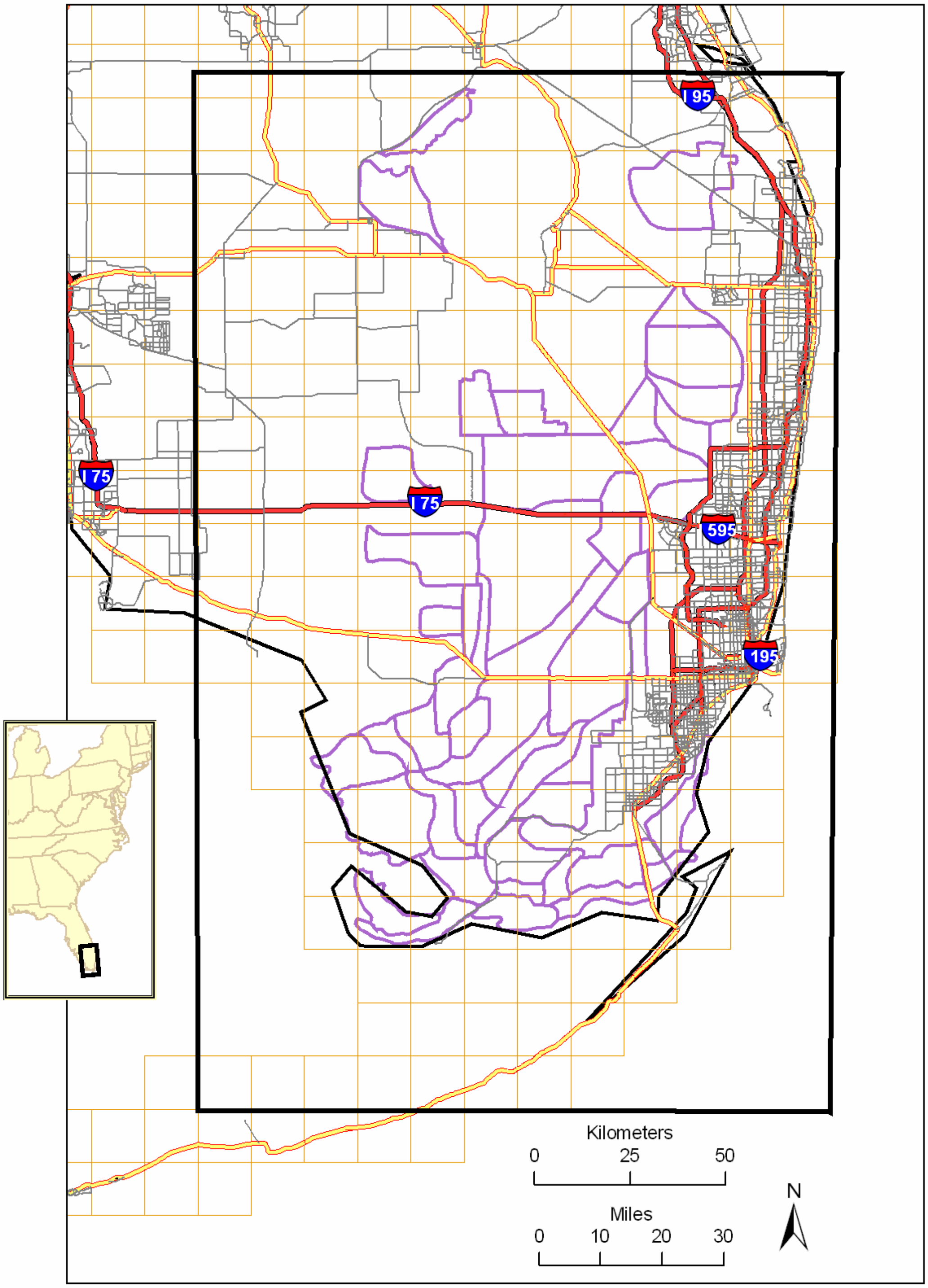

Figure 1 Overall extent of the EDEN grid is indicated by the large black-lined rectangle. Boundaries of the Everglades landscape units are shown in purple. For scale, USGS 1:24,000 quadrangle boundaries are shown in light yellow. Major highways are shown in red and yellow. Both minor roads and county boundaries are depicted using light grey lines.

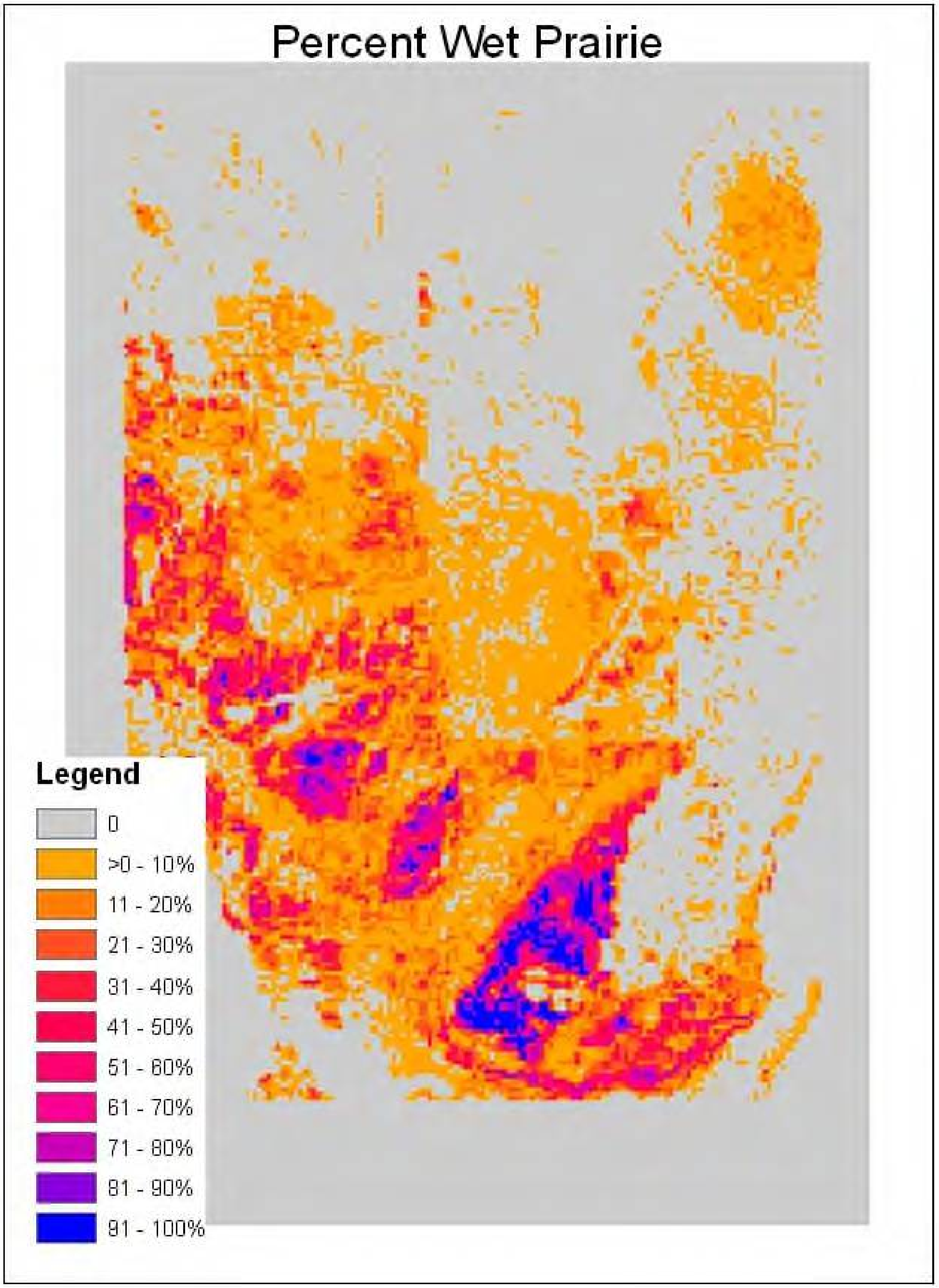

Figure 2 Sample analysis output showing the percentage of each EDEN grid cell covered by wet prairie as estimated from early 1990's Landsat satellite data processed for vegetation associations and land cover types.

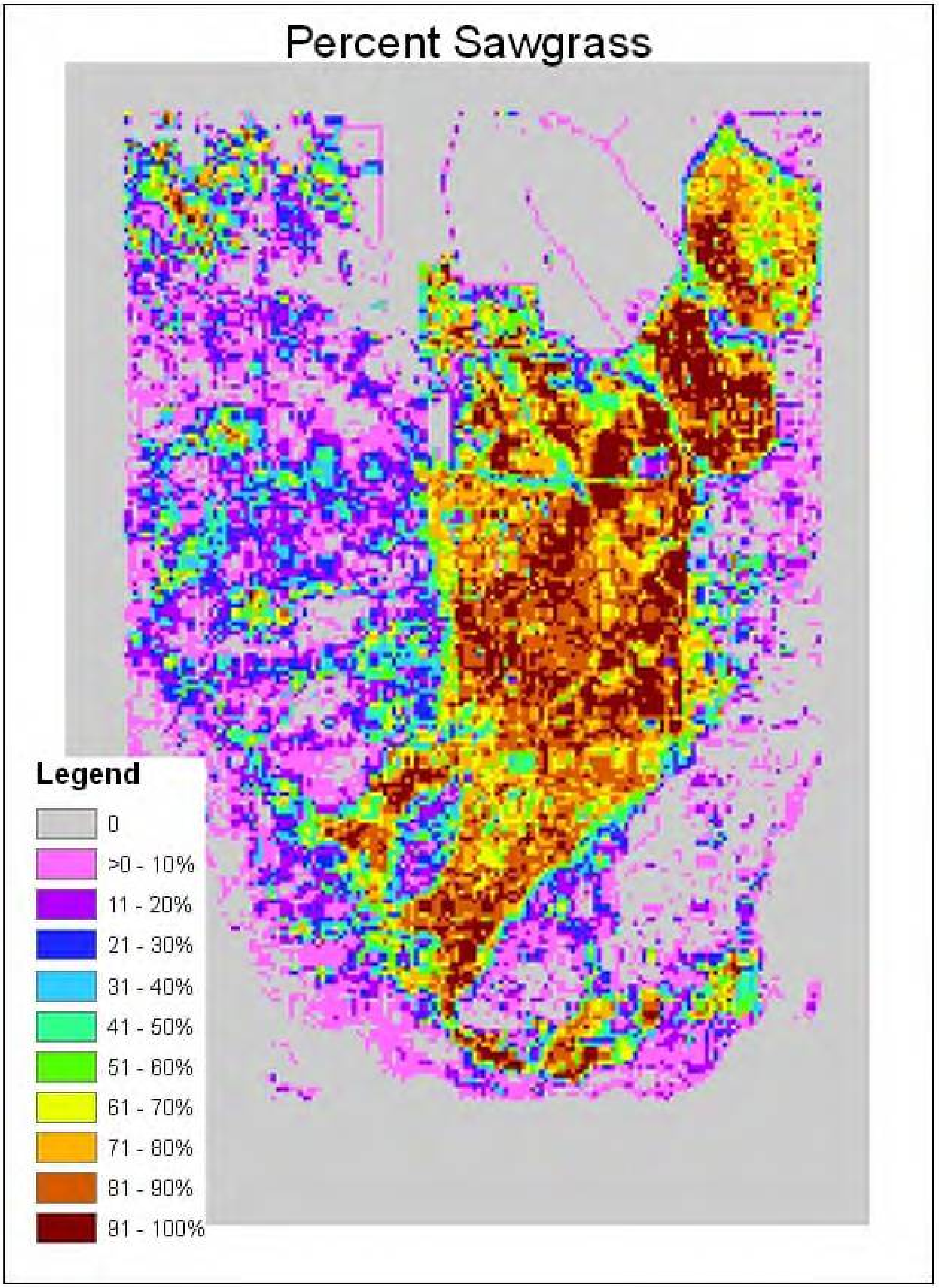

Figure 3 Sample analysis output showing percent of each EDEN grid cell covered by sawgrass as estimated from early 1990's Landsat satellite data processed to yield vegetation associations and land cover types.

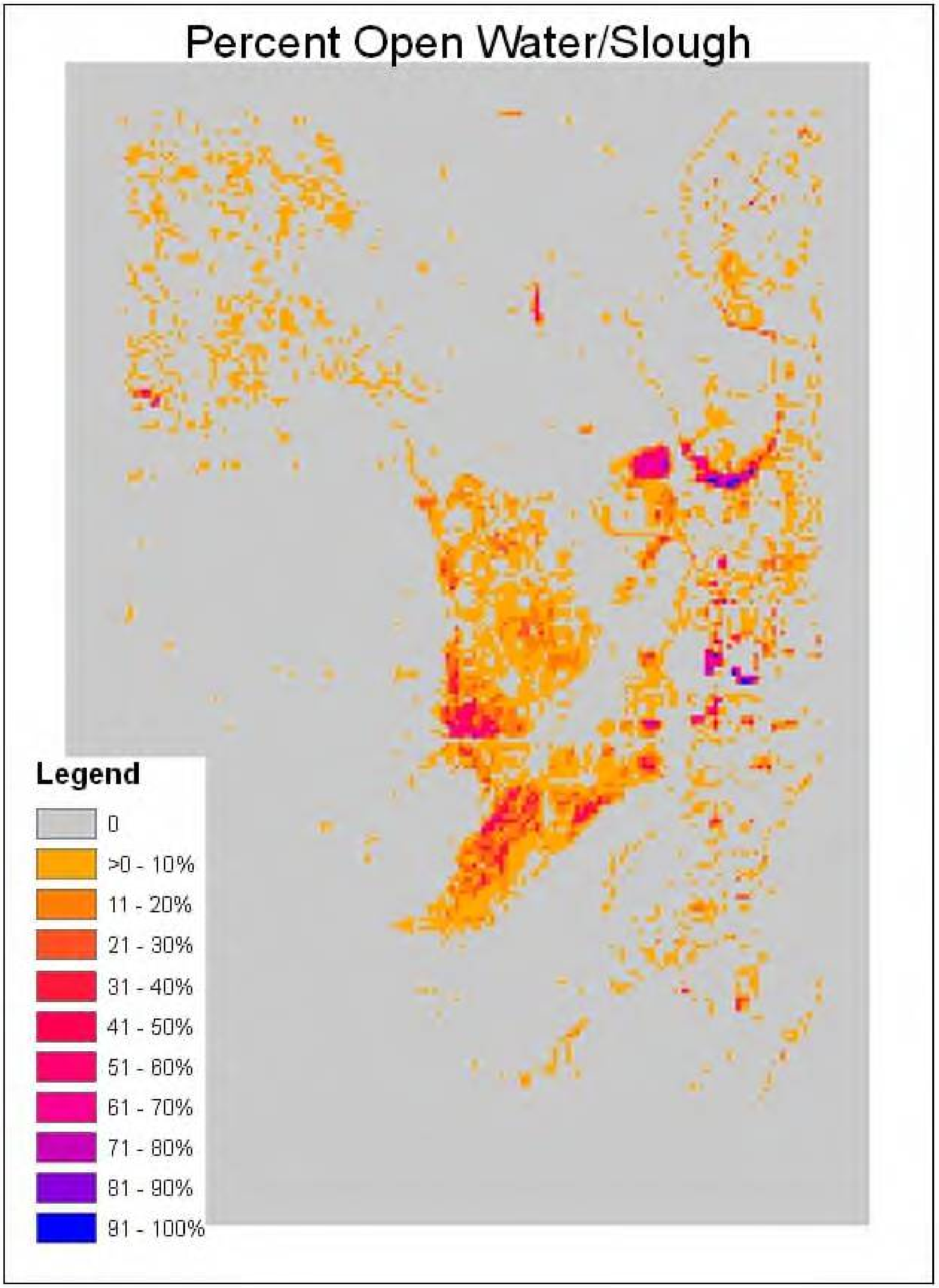

Figure 4 Sample analysis output showing percentage of each EDEN grid cell covered by open water or slough as estimated from early 1990's Landsat satellite data processed to yield vegetation associations and land cover.

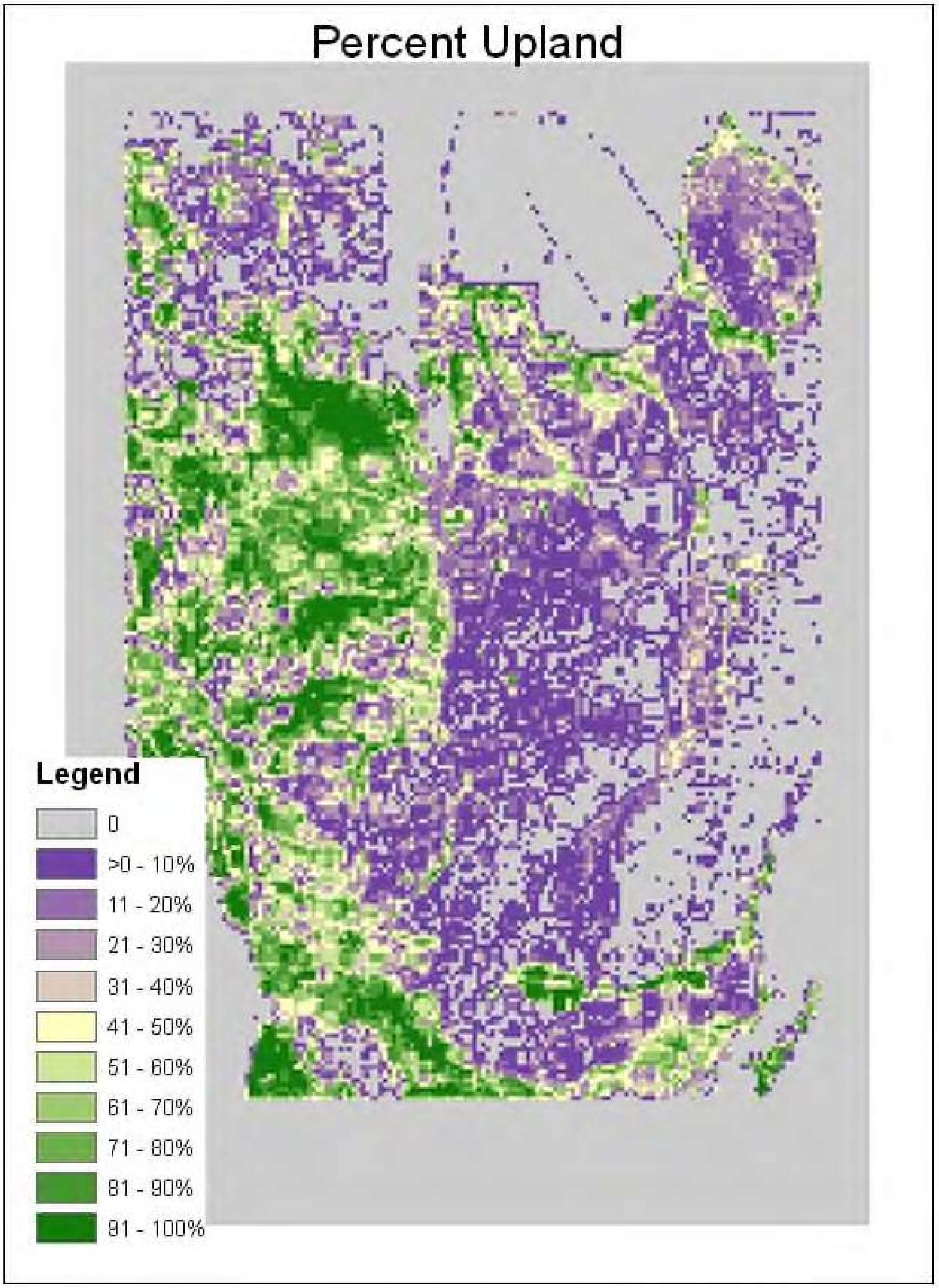

Figure 5 Sample analysis output showing percentage of each EDEN grid cell covered by upland cover types as estimated from early 1990's Landsat data processed to yield vegetation associations and land cover types.