TITLE: Pre-Settlement Land Cover Mapping from GLOS Records

AUTHORS: Alvan A. Karlin, Keith A. Albury, and Lauren B. Shapiro.

ABSTRACT: Recent environmental regulation in Florida, specifically studies relative to Minimum Flows and Levels legislation, has focused renewed interest on understanding pre-settlement land use patterns. This paper outlines the procedures used and highlights some of the difficulties we encountered in constructing a pre-settlement land cover map from Government Land Office Survey (GLOS) records and recent soil surveys. The study was performed on a 27-square-mile tract in the phosphate region of central Florida.

INTRODUCTION: Since the early 1950's, 60's, and 70's (Bourdo, 1956; Finley; 1951; Gordon, 1966; Marschner, 1957, 1974; McIntosh, 1962; and Stearns, 1974) and continuing through to the present (Delcourt & Delcourt, 1996; Schwartz & Travis, 1995) construction of Pre-settlement (1850 – 1880) vegetation maps have been developed through the interpretation of Government (General) Land Office Survey (GLOS) records. Although these efforts relied heavily on the GLOS records, ancillary materials from early botanical surveys, geomorphology and soil patterns (Delcourt & Delcourt, 1996) aided in the interpretation.

Figure 1. General Location Map showing Florida's "Bone Valley" (tan), Major Rivers, Peace River Basin (stippled line), and Hardee County Study Site (red).

The "Bone Valley" region of Florida (see Figure 1) contains one of the world's major phosphate reserves. Phosphate mining and its related service industries constitute the major economy of the region. Along with the mining proper, companion industries include, material hauling, phosphate processing, and fertilizer manufacturing.

The phosphate industry is regulated by several federal and state agencies. Since 1975, strict permitting requirements must be met prior to mining. When environmental impacts of wetlands in Florida may result from surface mining, the US Army Corps of Engineers (US-ACOE), the Florida Department of Environmental Protection (FDEP), the Southwest Florida Water Management District (SWFWMD), as well as, county and municipal agencies are responsible for the permitting and subsequent monitoring. During the permit application process, extreme care is taken to identify and delineate the on-site wetlands and to evaluate the functions of those wetlands for future mitigation and replacement.

Recent environmental regulation in Florida, specifically the studies relative to the Minimum Flows and Levels legislation, has focused renewed interest on understanding pre-settlement land use patterns with the goal of restoring mined lands to natural/pre-settlement conditions. As there is currently little information available for most of the state (Schwartz and Travis, 1995), and specifically in the important Peace River Basin (see Figure 1), this project was initiated.

METHODS AND MATERIALS:

Study Site: The study area is a 27-square mile (approximately 15,000 acre) parcel in Hardee County, Florida (see Figure 2) currently belonging to Cargill Fertilizer, Inc. At the time of the study (1998 – 2000), Farmland-Hydro, Inc. was exploring permitting the parcel for future phosphate mining. The study site contains wetland systems along Horse Creek and Oak Creek which flow southward into the Peace River, which forms the eastern boundary of the parcel. In general, the project encompassed all or part of 27 Public Land Survey System (PLSS) sections, approximately 15,000 acres in west-central Hardee County, Florida within the Peace River Basin.

Methods: We started the pre-settlement land cover mapping portion of this project by constructing a current land use/land cover map (Figure 2; uplands in browns, scrub habitats in oranges, and wetlands in greens) using the Florida Land Use Cover and Forms Classification System (FLUCFCS) following the 1999 Florida Department of Transportation guidelines for Level III mapping . The polygon boundaries were derived from a massive on-the-ground, agency (SWFWMD) approved and supervised, wetland delineation combined with ground, differential Global Position System (dGPS) and aerial interpretation of upland habitats.

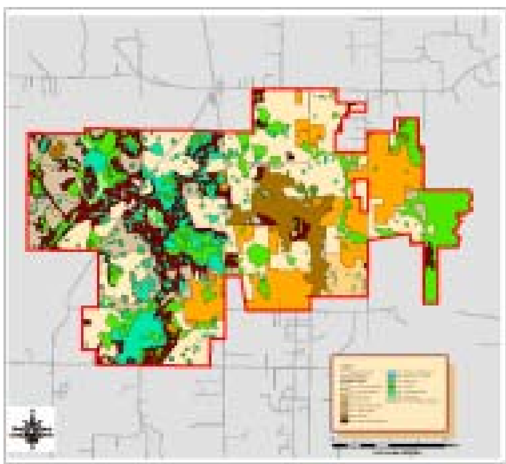


Figure 2. Hardee County Study Site showing Current Land Use (Green = Wetlands; Brown & Orange = Uplands).

The goal of the pre-development mapping effort, in this case, was to determine the degree of anthropomorphic impact. We focused on those areas currently mapped with FLUCFCS codes 1000 – 2999. We treated the current native habitats (FLUCFCS codes 3000 – 6999) as most likely representing native habitats that have been undisturbed since pre-settlement times.

The next step in our pre-settlement analysis was to identify the Soil Survey Geographic Database (SSURGO) soils in the study area, map them relative to their hydric nature, and test for soil-land cover associations. Using a combination of their hydric group class (A-D) and their description from Hydric Soils of Florida

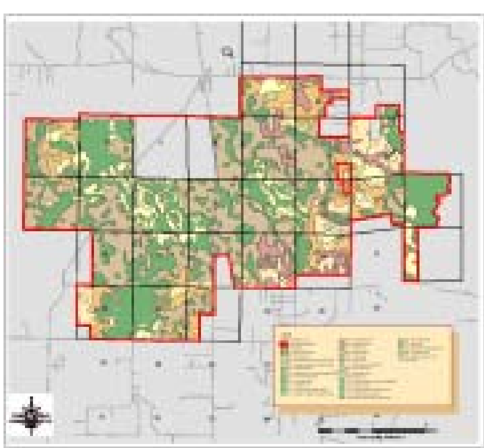
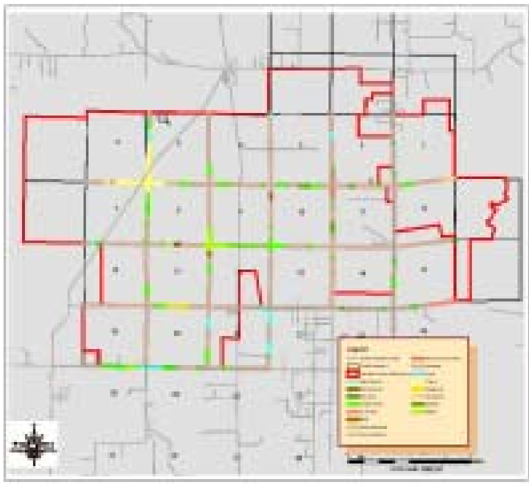


Figure 3. Hardee County Study Site showing SSURGO Hydric Soils (Green = Hydric).

Handbook, 1995, we classified each Map Unit (MU-ID) as either hydric or non-hydric (see Figure 3; hydric soils are shown in shades of green). By comparing Figures 2 and 3, there is a clearly observable association between the shades of green for the hydric soils and for wetland vegetation types.



Because our focus was on determining the pre-settlement land cover for present-day anthropomorphically disturbed areas, we needed to determine what the most likely vegetation cover was for those areas. To obtain the best relevant historical data, we obtained the GLOS records from the Hardee County Courthouse. Subsequent to our work, LABINS [Land Boundary Information System: www.Labins.org] photocopied the General Land Office Survey (GLOS) records from the 1860s and 1870s.

Figure 4. Hardee County Study Site showing Arc/INFO Attributed PLSS traverses.

When we started the assessment project, we had a surveyor perform a boundary survey and identify the PLSS section corners. As indicated previously, at the time of the survey, the project limits had not been finalized, so several of the PLSS corners that we subsequently used were either derived from the FDEP PLSS database or from Hardee County Certified Corner Records (CCRs). Using the PLSS corners, we reconstructed the section lines (see Figure 4) and inserted vertices at 66' (=1 chain) intervals.

We organized the GLOS records by PLSS section, transcribed the records for ease of database compilation, and a GIS Analyst attributed arc-segments with appropriate habitat descriptions as indicated in the records. For this project, we predetermined the available range of FLUCFCS codes and we constructed a "translation matrix" for the GLOS records to aid in rapid attribution. For example, often in the GLOS records the surveyor simply noted "pine" or "oak", whereas other surveyors may have noted Longleaf Pine or Turkey Oak, Swamp Oak, Live Oak. This process resulted in an Arc/Info database of attributed lines approximating transects of the pre-settlement land cover (see Figure 4).

We then used the disturbed FLUCFCS polygons from the current land cover database to spatially CLIP the lines from the GLOS database and INTERSECTED the lines with the SSURGO soils polygons. Then we UNIONED the SSURGO polygons with the current FLUCFCS polygons to assign them a "pre-settlement" land cover class (see Figure 5).

As part of the QA/QC process, we cross-tabulated the soil type and habitat type, and inspected the resulting table for apparent inconsistencies; ex. Current agricultural use on a hydric soil classified as a pre-settlement wetland. As there were only a small number of

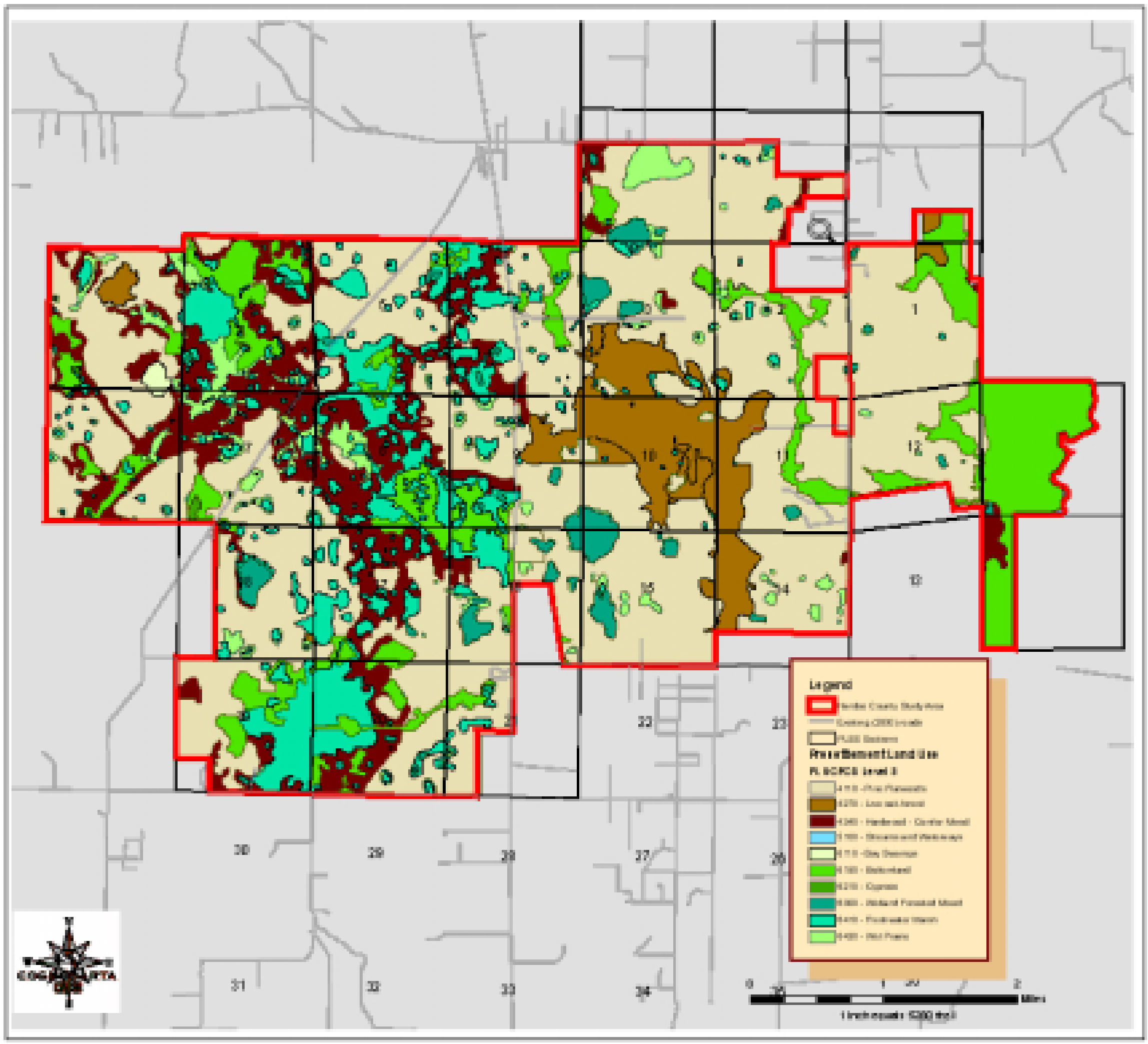


Figure 5. Hardee County Study Site showing Pre-Settlement Land Use. (Green = Wetlands; Brown = Uplands)

these, each was examined on a case-by-case basis. In some cases, historic aerial imagery was consulted to aid in interpretation.

RESULTS AND DISCUSSION: To evaluate the differences between the current land use/vegetation and the pre-settlement land use/vegetation, we constructed a table of polygons and acreages classified by predominant FLUCFCS. In general, Table 1 shows that there was an overall conversion of approximately 248 acres of wetlands and 6550 acres of native uplands into agriculture land uses. This loss of native habitat was accompanied by an overall fragmentation of the habitat from 621 polygons in pre-settlement times to 754 polygons in the current landscape.

Table 1. Comparison between Current and Pre-Settlement Land Use.
Classes as defined by the Florida Land Use, Cover and Forms Classification System, 1999.

Description (FLUCFCS)	Number of Polygons (Current)	Number of Polygons (Pre-Settlement)	Change resulting from Settlement*	Current Land Use (acres)	Pre-Settlement (acres)	Change resulting from Settlement*
2100 - Cropland and Pasturelands	74	0	74	4396.4	0.0	4396.4
2110 - Improved Pastures	1	0	1	0.0	0.0	0.0
2140 - Row Crops	1	0	1	292.8	0.0	292.8
2200 - Tree Crops	31	0	31	2017.0	0.0	2017.0
3200 - Shrub and Brushlands	13	0	13	90.7	0.0	90.7
4110 - Pine Flatwoods	47	40	7	1511.1	8062.8	**-6551.8**
4270 - Live Oak	8	8	0	938.7	1025.8	**-87.0**
4340 - Hardwood-Conifer Mixed	75	38	37	1743.4	1663.4	80.0
5100 - Streams and Waterways	16	4	12	13.2	13.2	0.0
5340 - Reservoirs	6	0	6	2.4	0.0	2.4
6110 - Bay Swamps	0	13	**-13**	0.0	27.4	**-27.4**
6150 - Bottomlands	129	31	98	2204.7	1865.7	339.0
6210 - Cypress Swamp	4	4	0	10.0	10.0	0.0
6300 - Wetland-Forested Mixed	0	72	**-72**	0.0	363.8	**-363.8**
6410 - Freshwater Marshes	279	264	15	1520.1	1543.3	**-23.3**
6430 - Wet Prairies	68	147	**-79**	352.7	525.3	**-172.6**
6440 - Emergent Aquatic Vegetation	2	0	2	0.4	0.0	0.4
Totals	754	621	133	15093.5	15100.8	

* A positive number indicated that there was a gain in this class resulting from settlement; negative numbers indicate a loss resulting from settlement

As we constructed the pre-settlement map, we assumed that current wetlands and native upland habitats have persisted from pre-settlement times. Thus, our major effort was focused on the evolution of the current agricultural land use polygons. As these agricultural uses resulted from either filling-in of wetlands or clearing of uplands, to understand their evolution, we relied heavily on the SSURGO soils mapping in Robbins, et al. (1984) and the GLOS records.

Wetland soils were mapped from non-disturbed vegetation markers by the Soils Conservation Service (now National Resource Conservation Service) for Hardee County in the mid-1930's (Cook, 1945). The soil types, as presently reported, are consistent and in good spatial agreement with both the National Wetlands Inventory (NWI) mapping from the 1960's and 70's and the current wetland mapping. Because it is costly to fill-in wetlands agricultural conversion focused on “high and dry” uplands for development and, for the most part the wetlands were preserved. Almost 95% of the pre-settlement wetland acreage (4335 acres) remains in today’s landscape (4090 acres).

Similarly, any native habitats including, long leaf pine savanna (FLUCFCS = 4110), dense hardwood hammocks imbedded into the wetlands (FLUCFCS = 4340), and scrub and brushlands (FLUCFCS = 3200) remaining intact were presumed to have been perpetuated since pre-settlement times. Because these “high and dry” lands are those which we anticipated have been diminished by settlement, these were our focus. The conversion of these habitats into pasture and grazing lands represent those anthropomorphic changes which were detected through the methodology. Table 1 indicates that agricultural conversion of almost 6800 acres (55% of the study site) resulted primarily from pine flatwoods clearing (96%; 6552 acres), and secondarily from wetland infill (3.5%; 247 acres) and live oak harvesting (1%; 87 acres).

There are several questions that arise from this mapping analysis that may affect the conclusions. First, there are the obvious sources of spatial error introduced from digitizing soils, National Wetland Inventory misalignments, and NRCS interpretation, which we leave for others to address. At this time, we will limit the discussion to the potential errors arising from the mapping methodology.

We used the NRCS soils data to define the extents and geometry of the polygons, but we relied on the GLOS records as the primary information source to identify the actual land cover. The directions to the surveyors were,” … *You are to enter into your Field Book, in a neat and distinct manner; notes or minutes of the following objects:*

1. *The description, course and length of every line which you have run,*
2. *The name, and estimated diameters of all comer and bearing trees, and the courses and distance of the bearing trees from their respective corners,*
3. *The description of all mounds which you shall erect as corners in prairies, or places where there shall be no trees convenient for bearings,*
4. *The names and estimated diameters of all those trees which fall in your lines, called station or line trees, with their exact distances on the line …*

13. *All prairies, swamps, and marshes…*” (from Delcourt and Delcourt, 1996).

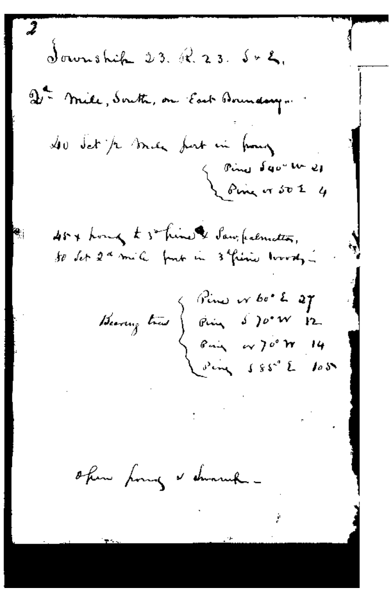


Figure 6. GLOS Field Book Page.

Although these were the directions as issued to the General Land Office Surveyors, A.D. 1833-1850, the actual Field Book pages were frequently difficult to read and often sparse in information (see Figure 6). In this case, only 6 pine trees were encountered along a 1 mile traverse, and four of those pine trees were the witness trees at a section corner. We encountered several cases where the pages were very difficult to interpret resulting from the script used at the time.

Another source of error arises from the descriptions themselves. Usually, the notes only indicate pine tree, or oak tree, or swamp, with little other information. As these notes were dependent on the knowledge of the chief surveyor and the abilities of the scribe, the level of details varied. While even this much information can be indicative of an upland habitat, it is difficult to determine the nature of transition zones that would be valuable in refining the polygon geometries. Hence, we determined that the best geometry would be obtained from the soil surveys. With this decision, though, we were limited to redefining those polygons on the best available information, thus precluding any meaningful fragmentation analysis.

Future Directions: In the above discussion, we have identified several avenues for future research. We are currently investigating the use of neural networks (see Hertz, Krogh and Palmer, 1991; Corne, et al., 2000) for the process of decision making and assigning attributes to the polygons as an alternative to other methods (Prasad and Iverson, 2000). Using the GLOS records and positions along the section lines, neural networks can be trained to distinguish the most likely vegetation classification for the intersecting polygons. Another use of neural networks may be to aid in densifying the classifications along the section lines. This may aid in refining the soil polygon geometry. Finally, additional research may be directed at better understanding the associations between soils, drainage classes and vegetation.

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AUTHOR INFORMATION: Alvan A. Karlin, Senior Spatial Analyst, Biological Research Associates/CognoCartaGIS, 3910 US Highway 301N, Tampa, FL 33619, phone: 813-664-4500, fax: 813-664-0440, akarlin@biologicalresearch.com

Keith A. Albury, Database Administrator, Biological Research Associates/CognoCartaGIS, 3910 US Highway 301N, Tampa, FL 33619, phone: 813-664-4500, fax: 813-664-0440, kalbury@biologicalresearch.com

Lauren B. Shapiro, Senior GIS Analyst, Biological Research Associates/CognoCartaGIS, 3910 US Highway 301N, Tampa, FL 33619, phone: 813-664-4500, fax: 813-664-0440, lshapiro@biologicalresearch.coms