MONITORING GEORGIA'S WETLAND TRENDS USING REMOTE SENSING

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REFERENCE: *Proceedings of the 2007 Georgia Water Resources Conference*, held March 27–29, 2007, at the University of Georgia.

Abstract. According to various sources of inventory data in 2002 there were anywhere from 4.9 to 7.7 million acres of wetlands in the state. Trend analysis from historic records dating back to 1780 and more recent records to 1980 indicate that during this time period Georgia has lost anywhere from 20-25% of its wetland acreage. We have been calculated wetland trends from 1974 to 2001 using Georgia Land Use Trend (GLUT) maps derived from Landsat imagery. Trends for these 27 years show that Georgia has converted 747,000 acres of wetland to other land uses at a rate of 26,700 acres per year. This represents an overall loss of 16.2% of the state's total wetland acreage.
The greatest loss of wetlands occurred in the Atlantic Coastal Plain. Much of the land conversion was from deciduous forested wetlands to intensively managed pine plantation. The major conversion of wetland areas to pine plantation occurred between 1985 and 1992. The greatest conversion of wetlands to agriculture occurred in the period from 1974 to 1985. There was an increase in harvesting occurring during the period of 1998 – 2001, this may be due to the record droughts which allowed access to riverine areas due to low flows.

INTRODUCTION

US Fish and Wildlife Service has been assessing wetland status and trends since the mid-1980s. The studies use a stratified random sampling design to estimate wetland change over the entire US, from aerial photo delineation. The trends program reports start with estimates from 1780 – 1980's (Dahl, 1990) and then follows with decadal reports (Frayer et al, 1983, Tiner 1984, Dahl et al. 1991,Dahl, 2000, and Dahl 2006). These data are reported by wetland type over the entire ecoregions and do not provide a true spatial data set with these reports. In contrast, the National Wetland Inventory (NWI) represents a single snapshot of the spatial extent of wetlands across the nation. For Georgia, these data were derived from 1:60,000, true-color aerial photography flown in the mid-1980s. They provide high resolution information for a single point in time. The development of a hand delineated photo-based mapping program is extremely expensive and at this time there are no planned updates for NWI maps for the nation and limited local updates may be performed.

USDA has two programs that assess the status and trends of land use and natural resources. These are the US Forest Service's Forest Inventory and Analysis program and the NRCS' Natural Resource Inventory. These programs use a national sampling scheme for data collection and report their results by state and by county. However, they too don't provide a spatial distribution map of wetlands, just tabular data. The FIA program puts out periodic reports that describe land ownership and forest harvesting of wetlands in the SE US (Brown, et al. 2001), but it is difficult to establish and compare these data with trend data provided by NWI, because they use different classification systems.

There are a number of USGS mapping programs that develop land cover data for the US. The GIRAS or LUDA maps were derived from aerial photographs taken in the mid-1970s. The USGS is coordinating the National Land Cover dataset (NLCD) which developed two land cover maps from Landsat satellite imagery for 1991 and 2001. These products come from the same data source, Landsat, however, they use different classification systems and different methodologies for classifying the raw imagery.

All of these different data products make it difficult to get a true assessment of trends over time. In response to this dilemma, the Georgia Land Use Trends (GLUT) program was established. The goal of the project is create a time series of land cover maps that are developed by the same methodologies and use the same classification system. The maps are derived from Landsat imagery from 1974, 1985, 1992, 1998, 2001 with 2005 in progress. This unique dataset provides us with the ability to analyze trends in land cover changes for the State of Georgia. This study provides an analysis of wetland change in Georgia for the period of 1974 – 2001.

METHODS

Landsat imagery from 1974, 1985, 1992, 1998, and 2001 were obtained from the USGS's archive at Eros Data Center. For each scene area a minimum of two dates were used, one from winter or leaf-off condition and one from spring, or leaf-on condition. All scenes were georeferenced, terrain corrected and co-registered to each other.

The Landsat program was established by NASA in 1972 with the launch of Landsat 1, the program has collected data continuously, currently Landsat 5 and Landsat 7 are currently collecting data. The Early satellite systems (Landsat 1, 2, and 3) had a spatial ground resolution of 80 meters; the next generation of Landsat (4,5,6 & 7)has a ground resolution of 30 meters. Because of this difference in spatial resolution and a corresponding difference in spectral resolution we were limited to mapping 13 land cover classes for trends assessment. These classes include sand/beach, open water, low intensity urban, high intensity urban, mines/quarries, deciduous forest, evergreen forest, mixed forest, clearcut/sparse vegetation, agriculture, forested wetlands, emergent freshwater wetlands, and brackish wetlands.

The satellite images for each time period merged together, to create a multi-band image (leaf-on and leaf-off). These images were then corrected for radiometric and phonological differences. In addition to the satellite data a number of ancillary data were used in the analysis, these include, Digital Elevation Models (DEM), hydrography, and NWI. Each multi-band image was then extracted by ecoregion. All land cover classification was performed on these mosaic ecoregional images.

Land cover classification included spectral supervised and unsupervised techniques, topographic modeling, and regression trees modeling. Land cover mapping was performed first on all classes and then further refinement for each class required multiple additional tools and techniques. Forested wetlands were classified using a topographic model and constrained by USGS NHD data and USFWS NWI data. This helped to separate out upland forest categories from wetland categories. Emergent freshwater and brackish wetlands were separated using a fixed zero salinity line which was constant for all dates. All ecoregion maps were then merged into a single statewide land cover map for each date. For this paper we will report only changes to forested wetlands.

RESULTS

We estimate that there were approximately 2,216,610 hectares of forested wetlands in Georgia in 1974, or approximately 14.4% of the State (Table 1). In 2001 we estimate there to be 1,779,494 hectares or approximately 11.6% of the State. This represents a loss of 435,116 hectares in the 27 year period (Table 1). The largest loss of wetlands occurred between 1991 and 2001, with a loss of 171,468 hectares of forested wetlands over that time period (Table 1). However, in looking at an estimated daily rate of change, the period of 1974 to 1985 showed a change rate of 29 hectares per day, from 1985 to 1992 the daily rate of conversion averaged 58 acres per day and from 1992 to 2001 the rate averaged 47 acres per day. Much of the change is from clearcutting activities. This can either result in a transformation to highly managed pine plantation or the area reverting back to natural forested wetland. We did not attempt to separate the tranformations.

Figure 1 shows the distribution of wetlands within each of the major ecoregions of the state of Georgia. The coastal plain region is divided east and west based upon their watershed drainage patterns. The western coastal plain drains to the Gulf and the eastern coastal plain drains to the Atlantic. The greatest loss of wetlands has occurred in the eastern coastal plain. The western coastal plain shows a steady decline and there is a slight increase in wetlands observed in the piedmont ecoregion.

Table 2 shows the top 10 watersheds that lost wetlands for each of the time periods. The change is based upon acreage lost. Most of the loss occurred in watersheds with existing high acreages of forested wetlands. The majority of the wetland changes in these areas were due to forest management practices and the conversion of wetland areas to intensively managed pine plantations or maintaining the natural vegetation for the area. For example forested riparian wetlands often were cut but not replanted with pine. Forested wetlands that were further from stream and river corridors were converted to managed pine systems. High harvesting activity was seen in 2001 a period of extreme drought.

Table 1. Area of forested wetlands in both hectares and percent of the state in forested wetlands for each map dates.

Year	Hectares	Percent of State
1974	2,214,610	14.4
1985	2,098,817	13.6
1992	1,950,962	12.7
2001	1,779,494	11.6

Figure 1. The percentage of area of wetland in each of the ecoregions in Georgia for each date mapped.

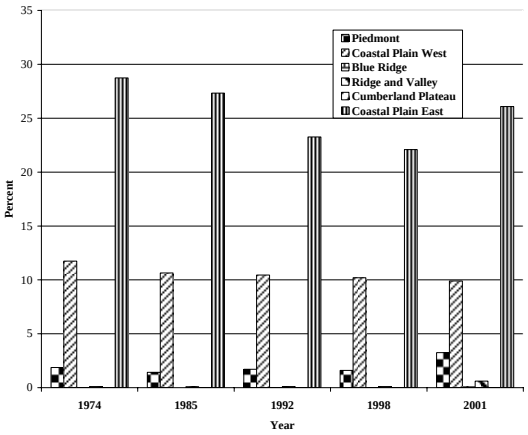

Table 2. A ranking of the Top 10 HUC8 watersheds based on wetland area lost for each time period.

1974 – 1985	1985-1992	1992-2001
Ogeechee Coastal	Upper Swannee	Satilla
Satilla	Satilla	Lower Ocmulge
Altamaha	Alapaha	Lower Oconee
Lower Ogeechee	Altamaha	Upper Ogeechee
Upper Ogeechee	Lower Ogeechee	Ogeechee Coastal
Little Satilla	Little Satilla	Lower Ogeechee
Brier	Conoochee	Altamaha
Canoochee	St. Marys	Canoochee
Uppe Suwanee	Lower Ocmulgee	Ohoopee
Ohoopee	Withlacoochee	Upper Suwanee

DISCUSSION

Satellite imagery provides a cost effective tool for tracking and measuring change in land cover over time. The Georgia Land Use Trends program had developed a series of land cover maps from the period of 1974 to 2001 and will produce land cover for 2005. These data provide information beyond many federal programs that use national scale sampling protocols to measure trends in various land cover and forest categories. These data are useful in providing overall trends but do not provide a tool to look at these trends spatially.

Over the course of the 28 years that were mapped for this project, approximately 435,116 hectares were lost or modified. These trends were similar to those found by other trend studies. The majority of wetlands were lost due to agricultural and forestry activities, and very little were lost due to urbanization.

There were a number of government policies and programs that may have influenced these conversions over time. These programs include requirement of irrigation for farm insurance in the late 1970's, provisions in the early farm bills for putting marginal lands into cropland for federal payments. In addition new technologies in the forest product industry allowed increased access to marginal lands for planting. These technologies included raised-bed planting and rubber tired equipment that could access wetter areas. Finally, the market for pulpwood over that period provided incentive to land owners to convert marginal lands into pine plantations.

As markets change and we begin to identify the value of wetlands to provide ecosystem services and function, we will begin to see a decrease in the rate of change of forested wetlands. For example, the swamp-buster provision of farm bill provides an incentive program to restore wetlands. Wetland mitigation banking can be used to provide an income to landowners to restore forest lands back to wetlands. These programs are becoming popular and as we measure land cover trends we hope to be able to quantify the results of these programs in the future.

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