IMPACT OF URBANIZATION AND ENVIRONMENTAL PROTECTION POLICIES ON TIMBER AVAILABILITY: A GIS APPLICATION*

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ABSTRACT

This study illustrates how remotely-sensed data and GIS can be utilized to allow planners to evaluate the relationship between land use, environmental protection policies, and resource availability. The case study examines St. Tammany Parish in Louisiana which has experienced tremendous population growth and land use change in the past two decades. To date, work has been completed on developing most of the coverages. The preliminary results indicate that applying remotely-sensed data on land use change and timber production potential allows planners to identify potential areas to maintain for timber production and other resource values. Future work will include evaluating the impact of population growth and environmental protection policies on timber availability.

1.0 INTRODUCTION

Projecting the future availability of timber in the United States has been problematic historically, primarily due to fluctuating markets for timber, changing landowner objectives, and a number of data and analytical problems. During the past two decades, however, social and institutional factors have emerged as important determinants of timber availability nationwide. The impact has involved not only the obvious effects of a reduced forest land base, but it also has resulted in increased public concern regarding management activities and often new regulations limiting timber harvesting. Most often, these new regulations are not federal policies. Greene and Siegel (1994) noted that of the 644 forest regulatory laws in the United States in 1992, more than 80 percent were at the local level. Moreover, they conclude that by 2040, these regulations could result in as much as a 14 percent reduction in the annual supply of softwood stumpage from the region. Balancing such resource uses and environmental protection is a major challenge for resource management, especially in areas characterized by rapid population and economic growth (Renew America 1989; Alig et al. 1988, 1986; Stoll et al. 1984).

Currently, however, policy makers, regulators, and landowners have little information on how changes in land use or regulations could affect resource availability from southern forests. A Geographical Information System (GIS) allows for a graphical depiction of the spatial and temporal dimensions of the biological, economic, legal, and social attributes related to land use change and

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resource availability. A GIS would facilitate an assessment of the relationships between land use, regulations, and the provisions of a myriad of goods and services from southern forests. Moreover, it would allow policy makers and analysts to evaluate the effects of future land use or regulatory scenarios on forest distribution.

The primary purpose of this ongoing study is to develop the GIS capability to examine the relationships between land use patterns, environmental regulations, and timber availability in St. Tammany Parish. The specific objectives addressed by the study were to:

1. Develop a GIS that incorporates spatial data on the biological, economic, legal/political, physical, and social attributes of the area for analysis.

2. Assess the temporal variation in land use patterns, forest cover distribution, and timber availability.

3. Project changes in timber availability under various scenarios regarding future land use patterns and regulatory environments.

2.0 METHODS

2.1 STUDY SITE

St. Tammany Parish is located northeast of New Orleans and adjacent to Orleans Parish. In 1974, the parish was a sparsely populated area (63,700 individuals) with an economic base evenly distributed between retail trade, service industries, manufacturing, and government. By 1992, the population had more than doubled to 156,200 individuals and its economic activity was dominated by service industries (more than 40 percent of all wages and salaries). At the same time, the importance of manufacturing industries declined sharply to account for approximately 8 percent of parish-wide wages and salaries (U.S. Department of Commerce 1994). Due primarily to migration of workers from New Orleans to outlying communities such as Slidell and Mandeville in St. Tammany, the parish's economic base was transformed and land use patterns altered dramatically. The increased urbanization has resulted in tremendous land use conflicts between residential and commercial, agricultural, and forest interests. Several ordinances have been adopted in St. Tammany Parish regarding timber harvesting and transportation as a result of the increased urbanization as well.

2.2 GIS DEVELOPMENT

The GIS development required acquiring data for the variables of interest and incorporating them into a format suitable for the GIS. The specific data layers developed included Political Boundaries and Infrastructure, Hydrography and Topography, Soils, Population, Land Use, and Forest Conditions.

2.2.1 Political Boundaries/Infrastructure

The first layer consisted of city and town boundaries, transportation networks, wildlife refuges and management areas, state parks and forests, other public lands and public use facilities, historical and

cultural resources, utility transmission lines, and restricted activity areas. Much of the data for this layer had been acquired and incorporated into a GIS for a previous study conducted by the Entergy Spatial Analysis Research Laboratory (ESARL) (Regens et al. 1996). Work for the proposed project was limited to updating the current data and adding the boundaries of public lands and restricted activity areas. In addition, utility transmission lines were buffered as appropriate to reflect rights-of-way.

2.2.2 Hydrography/Topography

This layer includes streams, rivers, lakes, and other water bodies as well as the elevation of St. Tammany Parish. DLG hypsography data were acquired for high resolution elevation surface modeling, slope determination, and slope and aspect estimation.

2.2.3 Soils

Soil series information from the 1990 soil survey for St. Tammany Parish was incorporated in the GIS. The data were utilized in determining productivity classes and management capabilities. The soils data were georeferenced to the map coordinate base and evaluated for goodness of fit against the DLG information and Digital Raster Graphics (DRG) files of the 1:24,000 scale maps for St. Tammany Parish.

2.2.4 Population

Population growth projections for St. Tammany Parish during the next ten years will be based on data from the 1980 and 1990 Censuses. The 1990 population by census blocks or block groups are available in Topographically Integrated Geographic Encoding and Referencing (TIGER) files from the U.S. Census Bureau. The 1990 maps may be associated with the 1980 census data on the block group level. The 1980 census block groups will bevalidated to ensure boundary locations are error free.

Available information includes total population and population by income, occupation, and education. This information will be used to model changes in timber availability as a function of population growth and demographic change.

2.2.5 Landcover Classification Procedures

Data on land use were obtained via multispectral satellite imagery and evaluated for three points in time -- 1974, 1981, and 1992. Land Use was classified into five categories: agricultural, pine/coniferous forest, deciduous forest, residential/commercial, and wetlands. The 1974, 1981, and 1992 satellite imagery were processed through ERDAS Imagine raster processing software to develop initial land use/landcover information using standard processing modules in ERDAS.

Multispectral satellite data has been available for landcover mapping applications for nearly 25 years. Multispectral sensors located on the earth-orbiting Landsat satellites operated by the U.S. government scan the earth in selected wavelengths of the electromagnetic spectrum to record information about the earth's surface. The Multispectral Scanner (MSS) sensor collects data in four bands or channels, 1 (green) - .50-.60 microns, 2 (red) - .60-.70 microns, 3 (infrared) - .70-.80 microns, and 4 (infrared) - .80-1.10 microns. Each individual band range records specific information for specific

applications, such as green wavelengths for vegetative applications, red wavelengths for geologic applications, and infrared for hydrologic applications. Ground resolution of unprocessed MSS data is approximately 50 X 80 meters. MSS data is normally resampled to 50 meters square after processing with computer ground coordinate referencing software.

After early years of research with data from the MSS sensor, the Thematic Mapper (TM) sensor was developed with a greater number of bands and bands more focused for greater landcover phenomena differentiation. The TM sensor has seven bands; 1 (blue) - .45-.52 microns, 2 (green) - .52-.60 microns, 3 (red) - .63-.69 microns, 4 (infrared) - .76-.90 microns, 5 (mid-infrared) - 1.55-1.74 microns, 6 (thermal infrared) - 10.40-12.50 microns, and 7 (mid-infrared) - 2.08 - 2.35 microns. Ground resolution of TM data is 30 meters square. TM data is collected by Landsat satellites 4 and 5.

MSS and TM data reveal highly accurate landcover information when processed through applicable computer programs and used in conjunction with other information for specific areas of study. Landsat MSS and TM satellite data over St. Tammany Parish, Louisiana was obtained for 8 November 1974 and 14 February 1992. The raw data were georeferenced to Universal Transverse Mercator (UTM) coordinates and all data were resampled to 80 meter resolution. Satellite data derived landcover classifications were developed using clustering classification routines in ERDAS 7.5. All bands from the MSS data were used in the 1974 and 1981 classifications and bands 2 , 3, and 4 from the TM were used for the 1992 classification. Bands 2, 3, and 4 were used from the TM to keep wavelength consistency within the classification process.

Initial classification parameters were set up to request 50 class output. Output classified files resulted in several classes of overlap and confusion. Attempts to reduce this confusion by requesting 100 output classes still resulted in confusion between some classes. A masking procedure using the digitized general soils of St. Tammany was employed to enable regional delineations for wetland, floodplain, and upland areas. These general area masks were applied to the remotely sensed data for classification again using the clustering routine. Classes developed in this manner were named to fall into the final category scheme. The final class groupings for wetland, floodplain, and upland were then combined into a full parish-wide coverage. The original 9 class landcover scheme was reduced to the five final classes of forest, wetland, pasture/agriculture, water, and urban.

2.2.6 Forest Conditions

Two additional conditions or properties of forest land will be evaluated and incorporated into the GIS. Current volumes for the pine forests will be estimated for St. Tammany Parish, based on data from the latest forest inventory for Louisiana. Specifically, plot level data will be obtained from the USDA Forest Service Forest Inventory and Analysis Unit. Although imprecise, these data will allow us to develop a methodology for assessing inventory effects of development and environmental protection policies.

In addition to the volume estimates, site productivity values will also be calculated for the parish, based on soil series information described above. The site productivity estimates will be used in identifying the critical areas for maintaining productivity in the future in the face of further urban expansion and development.

3.0 PRELIMINARY RESULTS AND NEXT STEPS

The preliminary results of our analysis demonstrate that St. Tammany Parish did experience a substantial shift in land use change between 1974 and 1992. The land use changes were as expected. Urban/inert land cover increased by more than 400 percent, from 71,475 hectares in 1974 to 360,710 hectares in 1992. The land area classified as Agricultural/Pasture decreased substantially (23 percent) during the period. Wetlands increased by 8 percent, much of which may be attributed to forested wetlands that had been cleared during the time period. As expected, forest coverage experienced a significant decline between 1974 and 1992, decreasing from 1,572,352 hectares to 1,178,234 hectares. This reduction clearly can be attributed primarily to the loss of forest cover to urban and residential uses. In addition, however, St. Tammany Parish also experienced increased timber harvesting between 1980 and 1990, due not only to residential expansion but to increased timber demand (Rosson, 1995; Rosson et al., 1988).

To better illustrate the land use changes that occurred during the time period examined, Figure 1 depicts the land classifications of 1992 that had changed from the 1974 classification. The figure illustrates the growing urbanization northward from the shore of Lake Ponchartrain along the southern border of the parish. The three largest population centers in the parish, Covington, Mandeville, and Slidell are situated on the shore of the lake. As the population of these centers has grown, development has been restricted by water to this northward pattern. Interestingly, the 1992 classification also reveals a large area of urban/inert land cover in the northwest section of St. Tammany Parish. Although several small communities are located in this area, the size of this land class shift was surprising. Two factors may account for this change. Clearly, the population has grown in this portion of the parish since 1974 and has resulted in a great deal more urbanization of the area. Moreover, much of the area that has not been converted to large housing developments has been altered significantly. Northwest St. Tammany Parish, for example, has become a center for large horse farms and other non-traditional agricultural enterprises.

Improvements to the current land use data will include fine-tuning the landcover classifications to address the issue of confusion in classes that still remains, especially within the 1992 TM classified file. Possible approaches to this refinement include creating additional areas for masking using ranges of digital elevation model data that has been created from 1:24,000 scale USGS digital line graph (DLG) elevation contours. Masking in this manner could serve to break out additional classes in the Northwest quadrant area more cleanly, since this appears to be the area most affected by class overlap. Additional options available for the TM data could be the inclusion of additional bands of information from the original data set and the application of processing steps to the unresampled 30 meter data and resampling to the 80 meter resolution in the final procedure.

Future work will also include a more recent computer generated landcover of St. Tammany currently under development by the National Wetlands Research Institute/USGS located in Lafayette, Louisiana. Since wetland mitigation issues in areas of rapid development have become such important areas of public policy consideration, this classification will include a more geomorphically aligned set of wetland classes based on the National Wetland Inventory (NWI) developed by USGS. Upland areas of the region were classified using 1993 Thematic Mapper satellite imagery and the ERDAS Imagine classification routines that were used in the earlier satellite data sets from 1974, 1981, and 1992. The current classification scheme includes 23 landcover types which will be ultimately reduced to a lower

number of more general landcover types, probably 10 to 12. These 10 to 12 landcover types will be collapsed into a scheme more in line with the five types selected for this study.

The GIS also will be utilized in evaluating the relationships between land use, regulatory variables, and timber availability and in assessing the potential impacts of changes in land use and regulations on future availability. In addition to graphically displaying the temporal variation in land use patterns, the GIS will allow us to calculate the area and volume of timber affected by the land use patterns. This will be accomplished by identifying previous forest areas and their volumes that were assigned to a non-forest land use in subsequent periods. The relative importance of the non-forest land uses will be estimated as forested acres lost to these non-forest classes.

Regulatory impacts will be assessed in a similar fashion. The analysis will be conducted for the most recent satellite image only, to ensure that the results reflect the current regulatory environment. Two regulatory issues will be examined: water quality protection and local harvesting ordinances. Water quality policy will be limited to the potential effects of a mandatory streamside management zone for logging operations. Buffers of various widths will be established along all identified streams in forest cover in the parish. The area included in these buffers will be estimated, as well as the volume associated with these buffers. In addition to the macro-scale analysis, aerial photographs and on-site inventories could be used in a selected case to verify the FIA data. Local harvesting ordinances will be examined in a similar fashion, with the affected areas and volumes being identified and tallied. By utilizing the site productivity data, we also will be able to determine the relative importance of the areas affected by water quality protection and local ordinances to future timber production.

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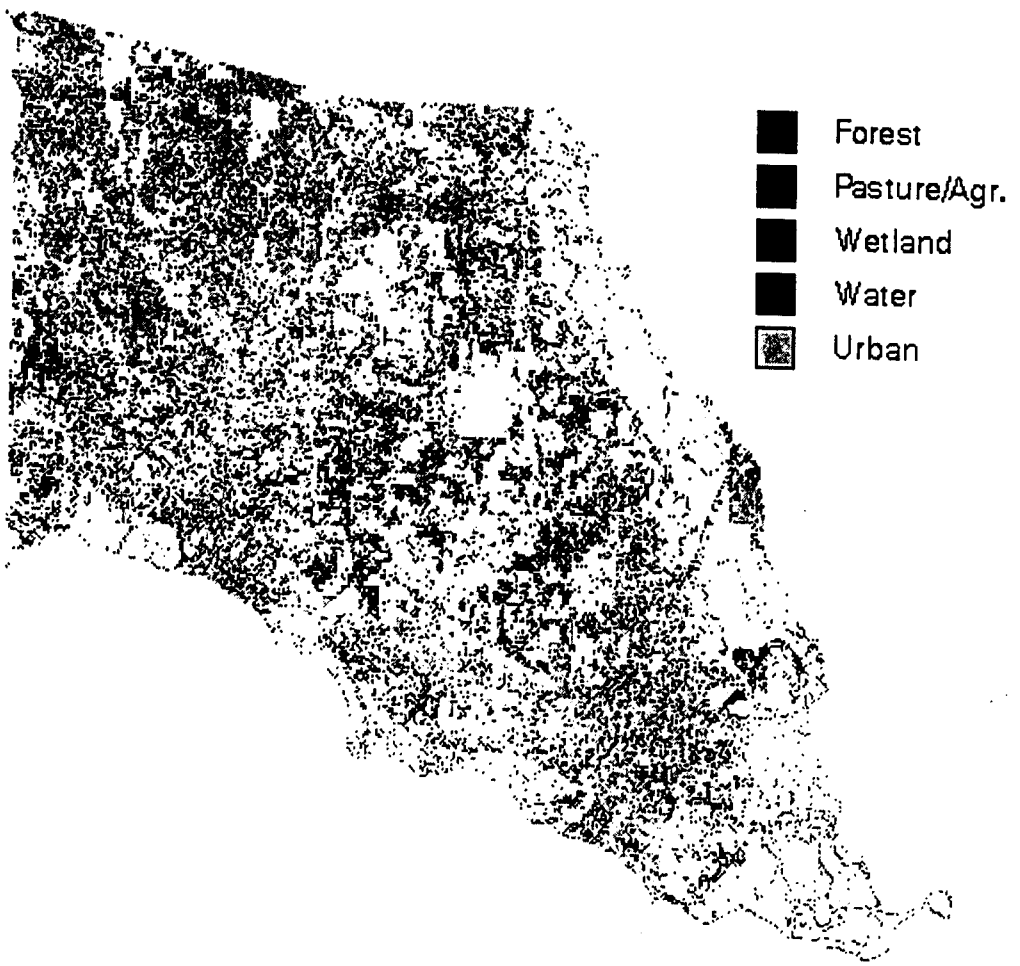

Figure 1. 1992 Landcover Classes in Areas Identified as Changed from 1974 Classification.