Implementation and Evolution of a Multipurpose GIS in a Rural County: The Case of Beaufort County, North Carolina

Gil Robbins
Beaufort County Land Records Supervisor

The North Carolina present use value system, the 1994 property revaluation, and value defense/contest all created a need for a modern land records management system in Beaufort County, North Carolina. The existing manual system was inadequate to answer an increasing number of questions, and so the county began to explore the possible implementation of a geographic information system (GIS). Though its development was often arduous, the resulting GIS system found many uses as a decision support tool outside the confines of taxation, fueling additional system growth. Growth and technological evolution present a challenge not to be taken lightly. However, through vigilance, opportunism, and a keen sense of industry direction the future continues to look bright for the Beaufort County GIS.

Introduction

Geographic Information Systems (GIS) have become a valuable tool utilized by local governments, particularly in the area of property tax assessment and the maintenance of the modern cadastre. However, the variety of these governments, their resources, and their abilities to attract qualified system operators have given rise to wide disparities in system capabilities across the state and country. In my professional career, which has spanned 10 years (four with Westinghouse Landmark GIS and six with Beaufort County Land Records) I have gained a first-hand look at the development, planning, and deployment of one such system. The case study that follows details the development and evolution of a GIS in a rural county, from its inception as a land records management system to its current status as a multipurpose decision support tool. Special emphasis will be given to the stages of development, and problems encountered at those stages.

Study Area

Beaufort County is located in the lower coastal plain of North Carolina (Figure 1). It covers approximately 827 square miles of land and another 132 square miles of water. The county is bisected east to west by the Pamlico River and borders the Pungo River along its northeastern border. The population in 1990 was approximately 42,283. The only major city in the county is Washington, with a population of 9,160. Other smaller towns include Chocowinity (population 624), Bath (population 154), Belhaven (population 2,269), Aurora (population 654), Washington Park (population 486), and Pantego (population 171) (Beaufort County Government, 1997).[1]

The economy of Beaufort County is based primarily on agriculture and industry but also relies on a significant retail trade segment. Lesser economic activities include commercial fishing and recreation. County records indicate that in June of 1998 there were approximately 38,000 individual real property holdings within its tax jurisdiction. The total county budget for 1998 was approximately 32 million dollars on a tax base of approximately 2.00048 billion dollars.

Recognition of Need and Initial Planning

Demonstrated Need for a GIS

In the early 1970s the State of North Carolina created the present use value system through legislation (See North Carolina General Statutes 105-277.1A through 105-277.7). This system allows private land owners to defer a tax that is based on the difference in value between the "market value" (that which would be transferred in

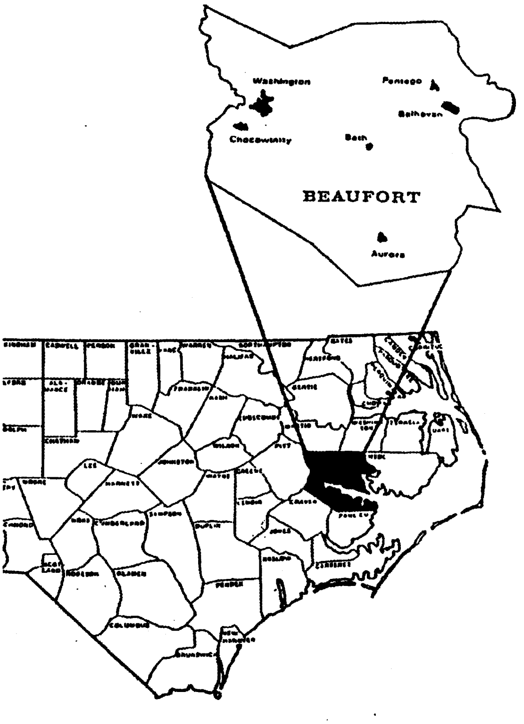

Figure 1. Beaufort County

an arms length transaction between a willing buyer and a willing seller) and its value under its present use (based on its ability toproduce agricultural, horticultural or silviculture commodities). Should an individual sell all or a portion of this property while included in this program, the taxes on the deferred amount would become due on the current year and the prior three years on that portion that was conveyed out of the program. The available manual methods of mapping and tax record management made it very difficult to calculate these taxes. This is because each land class (cultivated and forested) and each soil type (46 types reduced to six classes) has a different productivity rating resulting in a different value. Therefore the program required the identification of each class segment from the split tract be calculated for value and the result subtracted from the associated parent segment. The difference between this value and the market value would then be subject to the roll back. With the advent of soil mapping, and their link to the productivity brackets, there could be many segments. Each would then be calculated individually on a calculator for tax and interest and summed. The capability of GIS to automate all or parts of this process was a driving factor supporting its development.

In 1994 the upward revaluation of real property within Beaufort County aggravated the condition described above. Until the 1994 cycle, assessed values based on present use were often at or above those of the assessed fair market values. For most owners the present use deferral system offered little or no benefit. For this reason most owners that were eligible did not participate. In the most recent cycle however, present use values were significantly lower than the fair market values, sending Beaufort County taxpayers flocking to the Assessor's office to enroll in the system. Furthermore, many did not understand the 'roll back' characteristics of the program. The additional workloads associated with both the present-use program itself and the associated rolled back taxes inundated the tax office.

Rising land values themselves created a need for the planned GIS. When taxpayers saw the increases in their property values, many scheduled meetings with the tax office (and still do) to discuss the increases. GIS has become a valuable tool by which property value assessments can be defended. Just as important, as taxpayers became more savvy and inquisitive, the system would become a tool by which they could gather information to contest their assessments.

The State of North Carolina has recognized the need for improved land records management procedures. In 1977 the North Carolina Legislature established the North Carolina Land Records Management Program (LRMP) to provide technical and financial

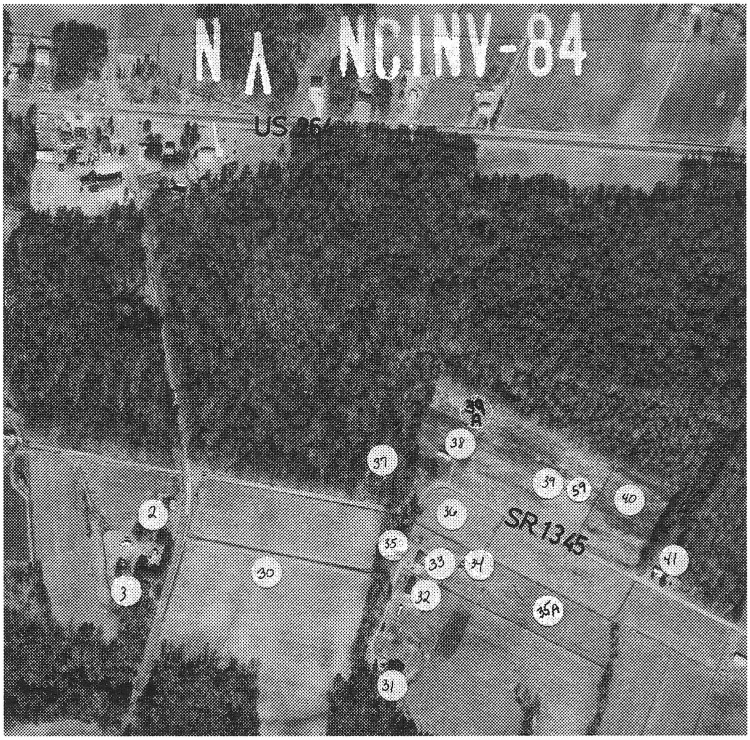

Figure 2. Note the paper dots affixed to the photo. These depicted the general location of listed properties within the county, but offered little additional information.

assistance to local governments to modernize their land records systems. In 1987 LRMP released its Technical Specifications For Base, Cadastral And Digital Mapping (Land Records Management Program, 1987) to aid in the maintenance of cadastral data (now moving to a digital format) for tax assessment purposes. This text still stands as the guide for the development of the cadastral database in North Carolina. Most, if not all, local governments that contract for the creation of digital graphic representations of their real property cadastre use this document as the base specification on which the data set will be created. According to a survey by the North Carolina GICC (Geographic Information Coordinating Council) over 60% of North Carolina counties have completed cadastral mapping. Forty-three of those were mapped to the specifications described above.

Pre-GIS Land Records Management System in Beaufort County

Some of the techniques used in past years to assess real property have themselves contributed to problems within the cadastre that could be addressed using GIS. Until recently, Beaufort County required taxpayers to list their properties yearly. Only 50 to 60% of the county's real property had an associated document (a deed, will or other instrument) reference by which the property came into the hands of the person doing the listing. This left many of the listings subject to the understanding or descriptions of the owner, including essential property valuation information such as the size and location of the property. In turn, this led to many low acreage listings, high acreage listings, unlisted property, and duplicate listed property. Furthermore, the existing mapping system consisted to a large extent of 'dot maps'. These were 1" to 660' scale glossy aerial photos, generally purchased from timber companies, with white paper stick-on dots affixed at the approximate location of the property (Figure 2). In most cases, no property lines were delimited on the photos. These maps offered little additional information, such as size or configuration, (information critical to a proper assessment) but were the standard (and only) spatial tool of the old system. Keep in mind that in these pre-GIS days the present use value was not a pressing issue because the market values remained lower, thereby minimizing the effect of less than adequate mapping.

During this period, ownership tracking was done by way of index cards that were associated with numbers applied to the paper dots on the maps described above. When a deed or other transfer instrument was recorded, a copy was made and sent to the Tax Assessor who instructed his/her staff to update both the digital tabular record (in the assessment database) and the index card. These cards were also available to the public for researching property characteristics.

It became evident that the existing system was inadequate to address daily issues faced within the assessment process. The labor-intensive nature of its maintenance had become prohibitive. Furthermore, the revaluation set to go into effect in 1994 was looming in the not too distant future. Until this time, the Tax Assessor, perhaps out of concerns centered on the upcoming revaluation, or fear of the massive change in the way of doing business, had refused to consider modernizing assessment methodologies.

As discussions began concerning the contracting of the aforementioned revaluation, the topic of the poor state of the existing record continually came up. The cost of revaluation would be significantly higher without good mapping. Under the provision that the County undertake up-to-date mapping, one contractor produced an attractive bid. This would prove to be a long-term benefit at short-term costs. The County, by request of the Tax Administrator, would use the lower revaluation cost to defray some of the costs associated with mapping the County using modern techniques. The Board of County Commissioners agreed to the project. Bids were let and a vendor chosen. As it happens, I was an assistant department supervisor for this vendor. The plan was simple: have the mapping done by 1992, and allow the revaluation contractor access to it thereafter. Any additional planning was limited to specifications proposed by the vendor and agreed to by the County's designated representative. The only exception was the laying off of the County into the scale grid, which will be discussed later in this text.

Initial Implementation

Platform Selection

Probably the most critical decision that had to be made by the County in 1990/91 was which platform (hardware and software) they were going to build their system around. There were a number of software choices available including ESRI's Arc-Info, Genesis, Intergraph, Map-Info, Strings, and even Auto-Cad. The mapping contractor could deliver its output as the County wished. But, the system had to cross a few hurdles. Most systems of that period were DOS-based PC platforms or launched from heavier mid-range computers and run on workstations. Those options that resided on the midrange systems were cost prohibitive to the County and were excluded. The company that supplied the tax assessment software was pushing their package 'Strings' (INFOCEL, Raleigh, NC, originally Geobased and later to become EDS). This package was cost effective and performed admirably in demonstrations. Furthermore, the level of expertise required by operators to become productive was far less than that of other systems reviewed.

The system would be required to generate the most accurate depiction of the real property cadastre as the documentation, and human hands, would allow (in other words, system precision had to be greater than personal accuracy). The system would also require a routine that would allow for a topologic soils/land-use overlay analysis that would facilitate present use valuations as described above.

Strings was the system that Beaufort County chose. Though I was not a part of this decision, I have not regretted it. Our primary concern was centered on the ease of editing. In the DOS era its menu and mouse driven editor proved to be quick, reliable, and easy to train. Though some of the other features (including plotting, system integration, and global editing) were more complex, I could manage them, allowing the technicians to focus on map maintenance.

Creating a Database

Beaufort County had no digital graphic data on hand at the time of project inception. The entire graphic cadastral data set therefore had to be created. Digital tabular data (textual descriptive data such as ownership, references, values, and type codes) had been maintained for a number of years, first on a Prime midrange computer system using a PASCO tax package and later on a Hewlett Packard 9000 using INFOCEL. These data would be the base on which all else was built.

Though I was privy to the planning elements described above, my personal involvement in system development began as an employee of Westinghouse Landmark (the database development contractor). The contract for the database development of the

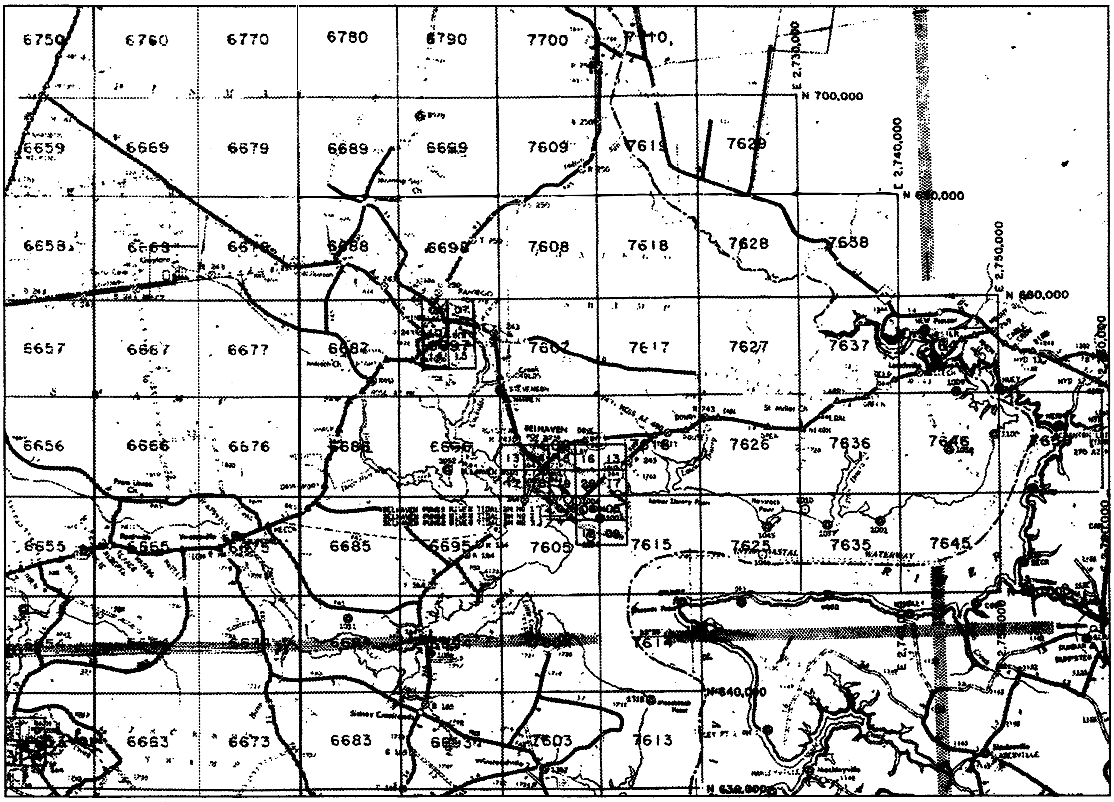

Figure 3. This is a portion of the grid depicting northeastern Beaufort County. Note the larger scale sections in the denser populated areas of the Town of Belhaven and the Town of Pantego.

graphic cadastral set consisted of five separate phases. The first phase centered on necessary map scales. A rough description of the process is as follows. Because aerial photography must be flown at different altitudes, it was incumbent upon County officials to establish the desired scales for different portions of the county depending on parcel densities. Though larger scales could have been chosen, they decided on 1:1200, 1:2400, and 1:4800 (in the industry, more commonly called 1" to 100', 1" to 200', and 1" to 400' respectively, for simplicity in application). Naturally, the larger scales were applied to the local municipalities and the smaller scales for rural areas. A grid showing the primary (small scale) panels was provided and larger scales drawn in where necessary. The resulting grid (Figure 3) was provided to the photographic unit where flight lines were drawn. Note that these flight lines included an 80% overlap to allow for stereo rectification processes. The pilots would then fly the lines in February or March (after leaf fall but before leaf out) and the resulting photography would be processed. This left a very small window during which photo capture could be attempted. Beaufort County was flown over a two-year period with the southern half flown in March of 1990 and the northern half in March of 1991. Following capture, the Photogrammetry department would process the film into bonded positives that were provided to the Stereo department for digital rectification. In this phase a DEM (digital elevation model) would typically be produced for counties with varied topography. In Beaufort County's case however, low elevation ranges would allow for simpler techniques. The elevation model would be based on USGS quads. Using the OR-1 machine (a German machine designed to manipulate photography) this model would be used to program the focus of a series of lenses to re-expose another run of film and rectify it. Photogrammetry would take the resulting negative and create the final othopositive and send it to CAD (computer aided drafting) to receive it's final markings such as easting, northing, scale, date of capture etc. The resulting orthophotography is critical in the accurate capture of cadastral data.

The second phase involved the gathering of initial data. A team was organized that orchestrated the gathering and binding of data that would be used in the compilation phase. This information included all existing property record cards (PRCs), any deeds called for in these records attached by staple thereto, any existing property maps (photocopied) held by the County, and the most current few years of maps or plats (photocopied). If a deed had an adequate metes and bounds description, a plot was produced using an automated drafting package. This plot would also be attached to the work packet for that particular property. Microfilm from the North Carolina State Archives of the entire Beaufort County deed record was purchased for the purpose of research during the compilation stage. PRCs were marked with identifying numbers on the tax maps. These existing tax maps were gridded to correspond to the orthophoto grid and PRCs placed in files for each photo, based on these grid lines and the property location markings on the maps (generally white paper dots with a number affixed) (Figure 2). This information was then boxed and shipped to the Compilation department (the office to which I was attached, located in Greenville, North Carolina).

The third phase was compilation. This is the phase where the gathered documentation is applied to a working copy of the orthophotography. A draftsman is given the file of information described in phase 2 and has the responsibility of interpreting those data and drafting them onto the worksheet. This is generally done by initially reviewing the file and separating the "good" information from the "bad" information. That information that is well supported or concise is the first that is applied. Through a building-block type process the entire worksheet is "mapped" using the orthophotgraphy to "ground truth" the mapper's findings. When deed descriptions were poor, other techniques were applied.

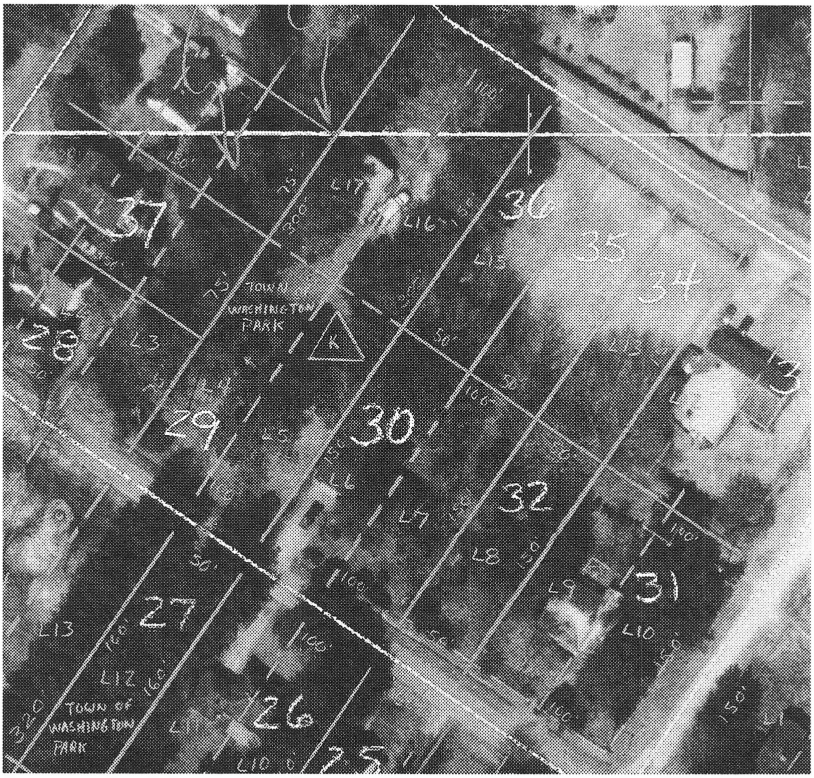

Figure 4. This figure depicts the manual drafting of linework from deeds, maps and other source information. It was later captured digitally.

Often a line of shrubs, distances to an intersection, or method of ground maintenance are elements that support or contradict placement of the property. Sometimes extensive research would be required to track down precedential information to assist in mapping. Descriptions from ancestral properties could yield insight critical to proper placement. When no deed was present (Beaufort County's records were about 50% to 60% referenced at project inception, now about 95%+) extensive research was applied as well as field trips and owner contacts to locate a deed or clear up a placement issue. When a scaled plot was attached to the work packet it could be slid under the ortho (orthophoto) and adjusted for goodness of fit and drafted where best suited based on acquired information. Eventually the puzzle would be filled in. At the time of compilation Beaufort County had about 33,000 individual properties, which were hand drafted in this fashion. After mapping a mapping code was attached to the PRC. Each code represented a mapping method: (1) was by deed or plat; (2) was by surrounding property information; (3) was field review and personal contact; and (4) was other information such as photo interpretation. Approximately 98% of the parcels were locatable and subsequently mapped. This is not to say that all of these properties were perfectly placed or accurately drafted. A lot of effort would be spent "cleaning up". As additional information (deeds, plats, or personal contacts) was provided, many properties would be "adjusted" to be more precise. If a change from the existing tax record was required to adhere to State specifications, a change order was created and sent to the County for approval. This documented the change and the associated reasoning for the change. If the County did not respond, the change was considered accepted as is.

Upon completion of this phase, the resulting worksheets (Figure 4) would go to the Digitizing department for data capture. Because "Strings" (our chosen GIS platform) had a particularly (for the time) robust editing element, the contractor used the same package for its data capture. This was convenient because it precluded the necessity of converting the data to another format after capture. The digitizing team took each of the worksheets provided by Compilation and captured it digitally. Also, for each sheet a "grid" (legend) was created to facilitate independent reproduction of the digital product at a later date. Using standards set forth in the 1987 Specifications for Base, Cadastral, and Digital Mapping provided through the State of North Carolina's Land Records Management Program, capture was completed. The product was returned to Compilation for quality control.

After the maps were checked by the compilation team and approved, a blueprint was made of the product and sent to the County for quality control and subsequent approval. Upon acceptance, the final phase of database creation was complete.

Initial Problems Encountered

After the County's acceptance of the mapping product, and about the time I became the land records supervisor for Beaufort County, we found that the County had failed to apply the "change orders" previously described. Therefore the tabular database of the Tax Assessor's office did not correctly correspond to that which was delivered by the mapping contractor. When a mapping project is completed an electronic file is created. In it such things as the document by which the property was mapped, any associated documents (plats, special proceedings, etc.), calculated acreage, and the associated PIN (parcel identification number) are provided. A piece of code is written that merges this information into the database. If the database is correctly updated the merge is essentially seamless and the resulting information appends to the correct parcels. However, with several thousand parcel splits and merges having taken place, and the merge of the two sets allowed to go through, a large number of inconsistencies became apparent. In the case of splits only one of the resulting parcels would 'hit', leaving one or more in the contractors data set without an associated parcel, and leaving a reduced acreage for the one that did. In the case of a merge, the resultant parcel in the contractors data set would hit with a high acreage and leave an associated 'no hit' in the Assessor's data set.

To further aggravate that condition, the insistence by the revaluation contractor that the new mapping be used in their contract prior to reconciliation of inconsistencies would result in values that were erroneously applied. Indeed, despite repeated complaints through my office, the maps were taken immediately upon delivery from the contractor, bluelined, and sent to the field for use. Often the appraisers were adjusting properties based upon the mapping that had not been reconciled between the data sets, in effect creating double listings of many properties. Often "no hits" (those properties on the maps that had no record in the tabular record) would be brought to Land Records and we would immediately be required to reconcile them. Though this corrected that problem (often requiring the rework of two or more parcels and reappraising them) it would impede efforts to electronically reconcile the two sets.

If the change orders had been correctly applied, reconciliation would have been (to

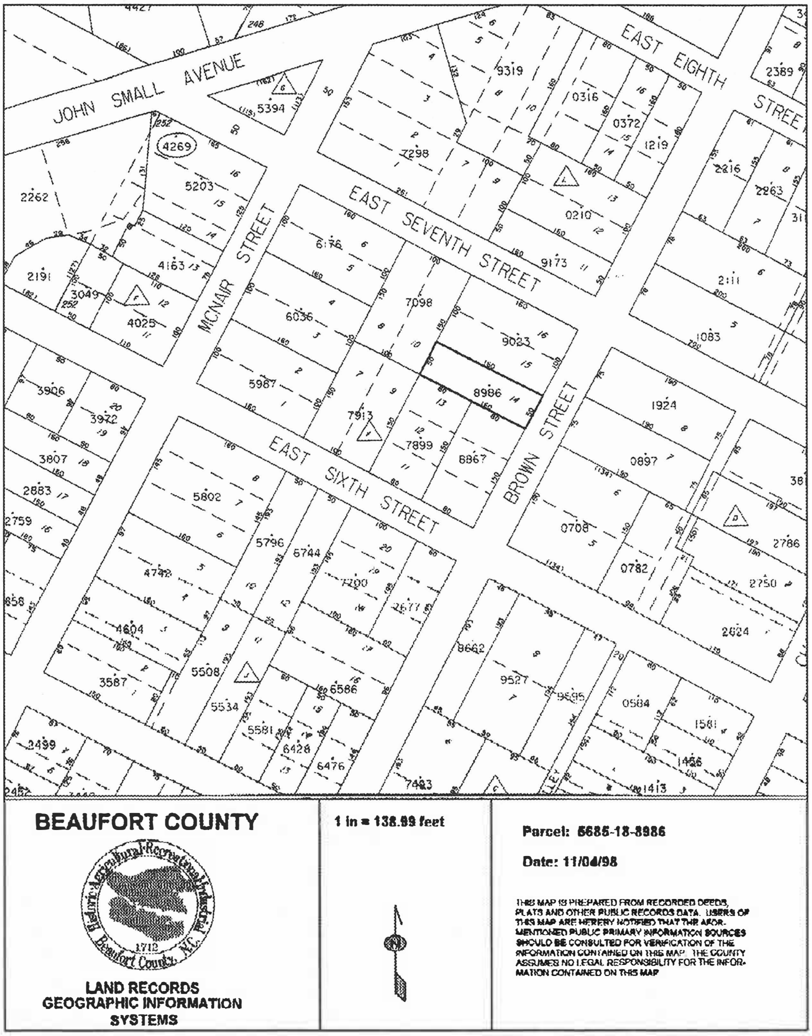

Figure 5. This is a "page plot" of a parcel of land from the Beaufort County Public Access System.

a large extent) limited to acreage, name, and PIN inconsistencies. Now however, we had to develop techniques to locate "no hit" PINs and subsequently work them backwards to a database match and apply the adjustments manually. Because this process could not be completed by the time that initial values were mailed to the citizens of our county, a large number of confused and concerned citizens turned to our office for answers. We conducted approximately 4,000 personal contacts during which we both corrected mapping errors and facilitated reconciliation, in an effort to alleviate taxpayer complaints where warranted. While this was not the preferred method for reconciliation, the process was effective, and the project was completed in this manner.

At this point the GIS was fully functional, but operating at a one to two year lag to the recordation of transfer documents, because the Assessor's transfer operations were this far behind. The Land Records Department assumed these responsibilities and began a concerted effort to bring the tabular record up to date. From the perspective of our systems, this would also had both positive and negative aspects. Nonetheless, a seamless county-wide graphic cadastre and associated land-use and soils coverages was now in place.

Evolution From a Land Records Management System to a Multipurpose GIS

Because other departments, for decision support purposes, required reports and other information, and because our systems were heavily automated, other department heads began to come to us to create their reports. We understood the operating systems (DOS, UNIX, and Windows) as well as the primary tax software and our own GIS. This rendered us as the '*de facto* data processing department' for several County departments. At first this was primarily associated with the Tax Administration (Collections, Assessing, and Land Records) but it would eventually include a number of other departments. Land Records' growing internal need for connectivity, and the County's lack of resources, would put Land Records in the unusual position of building our own network through a series of smaller contracts.

Network Development

In 1996 the State of North Carolina's need for more space in our County Courthouse would drive us into new facilities. This move would have both up and down sides. On the down side, it would move us away from the Office of the Register of Deeds. This department houses all of the vital information for research on property transactions. On the upside, however, it gave us the opportunity to upgrade our local area networking (LAN) capabilities and expand our operational base. That is to say, increase the hardware to which we could supply connectivity to the system and better distribute the work as well as the results.

We were allowed to work with the architect and the wiring contractors to specify 10/100 MBPS certified category 5 wiring pulled through the walls to a patch panel in the computer room. This would allow us to provide voice and data access to any point in the building by 'patching them in'. Also, and more importantly, it would facilitate a change in our networking protocol to TCP/IP and allow installation of an NT server on which to house our graphics. The old configuration was a pier to pier network that was inefficient. I can remember having to call across the room to tell someone that I was sending something, or going to get something, from their desktop, in order to preclude a data collision that would 'lock up' the system. Our increasing network traffic was making that an ever more frequent occurrence. It would also provide (through the new protocol) enhanced access to the midrange computer on which the Tax Assessor's database was housed and allow our desktops to exchange information with it more freely. In the past the connectivity to that system was restricted to a serial interface on the desktop (PC), or the operation of a CRT (cathode ray tube) simultaneously with our desktops. We still find that there is benefit in both cost and flexibility in the use of serial interfaces. This is mostly where technicians require visual access to both systems simultaneously (they operate a CRT and a PC side by side). In most applications though, the single click switching between applications on a single desktop PC is more desirable.

One of the greatest benefits of this configuration was our ability to 'pipe' information to remote parts of the building. This allowed us to utilize older machines as public access terminals elsewhere and use the system as a traffic control tool. On the other hand, it also allowed us to give other departments access to visual tools, and opened the door to additional system growth.

New Applications

As stated above, the ability to 'pipe' data throughout the building was a great plus. It allowed us to consider public access from a different perspective. When the system was in its infancy, public access required the full attention of one of the technicians who understood both the mid-range system and the GIS. Assisting a taxpayer in getting information on their property would take as much as thirty minutes of valuable time. Abilities to reproduce graphic depictions were limited as well. The end result was much time spent to produce a gaudy raster image of their property. Nonetheless, citizens found these capabilities and related services important. In short order we were being inundated with requests for information. With the change in infrastructure we could now view public access as a means of traffic control.

Our GIS vendor had been working on some new viewing tools. The original DOS tool, PMS (parcel management system) was outdated, and, name not withstanding, a new system was required. The result was a software product called 'Breeze'. With a few modifications to its reproduction capabilities, we built a public access system which allowed the viewing of all layers, maps, and individual properties (Figure 5). The personal interface was easily mastered and the system was quickly accepted by the primary users (attorneys, realtors, loggers, appraisers, etc.). We continue to support onetime users over the counter because the time to train the user would match the time to simply produce the property plot.

After implementing the system we began to send the same outputs (in conjunction with other supporting documentation) to the Tax Assessor to depict any changes that Land Records might have made to a particular property. Soon the appraisers decided that the benefit of an accurate map in the field was immeasurable. They sent lists down to us for reproduction. In short order we were overwhelmed again by these additional requests. Once again our attention to infrastructure in the Seaboard Building paid off. We simply placed an additional PC in the Assessor's office, loaded it with the necessary software, and trained the appraisers on its use. For most properties visited in the field, the appraiser will have a plot of the property in hand for notes and reference.

The utility of these outputs created additional demand from the Environmental Health Department, who wanted to use them to map the location of proposed septic fields, and Building Inspections, who required them to accurately locate proposed structures or improvements for permitting purposes. A machine was networked into these offices to facilitate their requests.

The primary mandate of the Land Records Office remains the support of the Tax Assessor and maintenance of the split and transfer processes associated therewith. However, the wealth of information that is generated through that process is in great demand. Our ability to fashion means by which this information could be delivered in various useful formats placed us in the position of acting as the County's information exchange.

Beaufort County had undertaken a project to convert its addressing to the E-911 format. A contractor was hired to create the system based on the centerline file that we had saved from the database generation processes for the cadastre. The idea was to base the address assignments on a 5.28 foot increment (allowing for 1000 possible addresses per mile), which would allow for quick field conversion of address to distance over ground. This information would be integrated with our centerline file and used to create an incident mapper that would be placed in the dispatch center at the Sheriff's Department. It became apparent that different segments of the industry viewed graphics from very different perspectives. When we began testing the incident mapper, we found that many addresses were coming out on the wrong end of a street segment and on the opposite side of the road. We quickly determined that the digitized direction of the roads was not in sync with the direction of addressing. The contractor did not appear to be aware of the requirement for this. In the end we had a piece of code written that would allow us to flip individual line segments to make them correctly correlate to the appropriate address directions. It is imperative when undertaking development of applications while dealing with more than one contractor that you apply a holistic approach and are aware of the technical requirements of the entire application, as well as attend to the inevitable evolution of those requirements as they relate to multiple tasks. As you become aware of new requirements you must pass them on to all contractors involved in various activities so that they may respond. Furthermore, you must periodically check the contractor deliverables to make sure that those technical requirements are being met.

Likewise, the address maintenance systems provided by the contractor were inadequate to do the job. In conjunction with the Planning Department we determined that "SAM" (Street Address Manager), a system developed by Digital Mapping Technology, Inc. (DMT, Raleigh, NC), was going to be our best choice as a replacement. It used the same data format as our GIS and would allow the use of our other map layers to assist address placement. This program, used by our County Planner, is utilized in conjunction with other data sets to enhance his address assignment accuracy and capability.

The same contractor that developed the centerline file for E-911 also was contracted by the Beaufort County Board of Elections to produce a series of digital map files. These maps included congressional districts, senatorial districts, precincts, and school districts, which would be used with the fire and rescue districts maps for E-911. Aware of the previous problems associated with prior deliverables, we engaged in extensive quality oversight on behalf of both Planning and the Board of Elections. We found that adjacent polygons (closed areas representing a feature, in this case districts) were actually mapped with a 50-foot gap between them. If an address may be assigned every 5.28 feet and the gap between districts is 50 feet there is a potential loss of 9 addresses at every point where a road crosses a district line. If an address falls in this 'no mans land' who do we dispatch? These problems were caught and we required that the contractor address them. These maps, even after capture, had to be brought into our office for remastering and conversion for use in our GIS.

The damage caused by hurricanes Bertha and Fran in 1995 created a new set of demands on our office. An excessively wet period created a boom in mosquito reproduction that had health officials very concerned. A plan was developed to spray certain populated areas to control the explosion in population growth of the pesky bugs and provide some relief for the local population. The problem was that they knew the general targets but did not know the size and therefore did not know the area to which the insecticide would be applied. This information was critical to quantity determinations. They came to us with their problem. We inquired of the areas to be sprayed, the anticipated flight lines (the insecticide was to be applied by helicopter), and the width of spray dispersion at a standard spraying speeds. With this information we calculated the area to be covered without threatening waterways and mapped them for use by the Health Department. Luckily, the rains went away and by the time the spray teams could be organized and approval secured (some local residents were naturally concerned over developments, and the thought of spraying poisons so broadly across the landscape), the spraying never happened.

Another effect of the hurricanes was the destruction or damage to real property along county waterways. The Federal Emergency Management Administration (FEMA) offered grants to local jurisdictions for hazard mitigation purposes. This money was to be used to raise houses to the 100-year flood level. A number of residents applied for grant assistance. Among the criteria for raising the homes was location and elevation. FEMA and the planners contracted to administer the grants asked us to create a map that would show the dispersion of the properties as well as accurately depict their locations. One base map showing county-wide dispersion was created as well as a series of inserts to depict the actual location of the properties in relation to roads and waterways.

Each structure was then surveyed to the nearest benchmark to determine its elevation. This process is ongoing.

A change in building codes to create a '110 mile-per-hour wind-zone' was another result of government hazard-mitigation steps. New structures built within one mile of the river at any point that was more than one mile wide at a forty-five degree angle must be built with materials and components to withstand wind forces sustained in excess of 110 miles per hour. In this case, we utilized a corridor tool to create a buffer around the rivers at points that met the base criteria. This layer was placed in the GIS viewing catalog and shaded to allow the inspectors to call up a parcel based on its Tax ID or NCPIN (based on NC State Plane Coordinate System). They could then apply the windzone layer and know immediately whether the parcel fell in or out of the zone.

The City of Washington came to us for the creation of their official city zoning map. We instructed them on preparation of source information and created a map, which included an index map and sixteen individual panels showing parcels, hydrology, zoning, historic district, city limit and extra-territorial jurisdiction.

They also needed assistance with determinations as to property owners within areas of the county that were to be annexed. In these cases we used Point-In-Polygon (PIP) analyses to acquire PINs (parcel identification numbers) and then shipped them up to the midrange system where we created a standard query engine that downloads specified data fields back to the PC in an ASCII (American Standard Code for Information Interchange) format. These data were then imported into a DBMS (database management system) for manipulation and output. The city was provided with electronic listings of property owners, values, deed references, addresses, and other information specified by them.

Local fire departments came to us wanting to know their constituencies for fund-raisers etc. We PIP'd the fire districts over the parcel layers and used the same strategy as above to create an electronic reference of names and addresses within their respective jurisdictions. Even the public got on the bandwagon with requests like "I need to know all of the land owners that front on Gum Swamp so we can have the beaver dams blown and the creek snagged".

It appeared that all roads lead to Land Records. Our unique perspective and broad reach have made us a valuable resource to attorneys, Realtors, surveyors, loggers, farmers, and the list goes on. At the same time other government agencies view us as a starting point. Now they can efficiently associate a point on the ground with an increasing variety of information and begin their problem solving responsibilities with a tremendous head start over only a few years ago.

Though the system has been generally successful, there have been problems associated with hardware and software evolution, year 2000 issues (mostly on the database side), and system robustness. All systems do not evolve at the same pace, forcing us to slow our approach to technology advancements including networking and primary system upgrading (Beaufort County Government, 1997).

Rapid system and budgetary growth, as well as increased capability, also proved to be formidable problems. Educational requirements grew with the technology, and manpower needs increased with demands. Our capabilities exposed us to issues that were often unexpected as we sought to fulfill requests from various users.[2]

Future Trends and Developments

In an environment in which technology evolves so swiftly, it is important to recognize developments as they occur. Systems can be rendered nearly useless in short periods of time. An example could be seen in our original network configuration. Increased flows of graphic information bogged down the peer-to peer system to the extent that we would have to call across the room to announce traffic on the system. Now a new technology would add a tremendous amount of traffic to that system essentially incapacitating it. I speak of digital ortho-imagery. These files can consume 25 to 30 megabytes of data each, and must be rapidly accessed and displayed by the seeking desktop unit. The only alternative would be to hold a large number of copies and load each desktop with hard disk space, or CDROM (compact disc read only memory) and RAM (random access memory) capabilities to handle the increased volume. Nonetheless, the utility of this graphic layer makes it highly desirable. It facilitates 'heads up' digitizing (allows the technician to draft on the desktop alone without the aid of digitizing tables and orthophoto mylars). They provide a tremendous visual aid to users of cadastral and other data. They also provide for easy output in numerous sizes and formats. More and more local governments in North Carolina are moving toward this type of photography in lieu of the hardcopy orthophoto on mylar. Planning is now underway for digital capture of Beaufort County in its entirety.

In conjunction with the above image capabilities, there is a move toward reproduction over highspeed networks on top-end plotters. Some of these configurations can produce raster images at speeds of 1" to 2" per second. Now complex (multiple layers) images can be produced quickly and at high resolutions from a desktop, increasing the value of the cadastre as it relates to decision support.

High-speed networks as described above (10/100 megabit certified) will also enhance system integration. The improved traffic handling capabilities of network protocols (TCPIP and others) is allowing us to consider new and exciting ways to deliver geographic information for decision support. We are presently working to bring the appraisal offices 'online' with a desktop tool that will allow them access to both tabular and graphic data (rasterized structural photos, ortho-imagery, maps, and tax data) simultaneously. This should reduce out of office work times, as well as produce more accurate valuation decisions as they pertain to real estate.

The World Wide Web is introducing public access options into the GIS field. Already, there are companies that will (for a fee) house your graphic and tabular tax data and the appropriate engines for query purposes. Though locally there is some discord between those that see this as exporting local business and those who see is as expanding a market, this alternative is seeing some interest in government circles, particularly as a marketing tool for industrial development. In a matter of time it will probably cover most areas of public information.

WAN (wide area network) connectivity is another area where high-speed networks have benefited local governments. The ability to link Local Area Networks (LAN) into a broader network structure has enabled information to be passed among local agencies, not only for administrative purposes (finance, payroll, etc.), but also to deliver decision support information to other parts of the government in a closed environment. We are now planning (and will soon be implementing) just such a network which will allow several additional agencies access to the web, administration, and our graphic data.

Conclusion

I have watched the Beaufort County Land Records GIS evolve from a single 386 DX2 PC to a vital integrated network of over 25 PC's and 26 CRTs that provide information to the Tax Assessor, the public, and a spectrum of other agencies. Still others are attaching to our network to reach the Internet or to develop other connectivity needs for such things as finance or payroll. The evolution of the technology, while exhilarating, has sometimes been so fast paced as to threaten the system itself. Learning and relearning operating systems, network operations, GIS operations, etc. has been a challenge in itself. The goal of providing a geographic perspective to often mundane objects and seeing the results is quite exciting. Watching the world's desire to use these outputs grow at such an extraordinary pace is imposing. The challenge of managing a modern GIS in the government environment requires vigilance, opportunism, and a keen sense of industry direction. With these qualities we hope to propel the Beaufort County GIS into the 21st century.

References

Beaufort County Government (1997) *Beaufort County, NC 1997 Land Use Plan,* Washington, North Carolina, table 3 County Population, page I-19.

Land Records Management Program (1987) *Technical Specifications for Base, Cadastral, and Digital Mapping,* Division of Land Resources, North Carolina Department of Environment, Health, and Natural Resources, Raleigh, North Carolina.

Endnotes

1. Our departmental long-range plan included a sustained effort to enhance integration to the tax package, in an effort to consolidate information on the desktop for use by the appraisers. The tax package is a voluminous program that creates and maintains county assessment and collections information. It is used to create abstracts, bills, and receipts, as well as act as a pool for critical assessment information such as land types, structural types, etc. We felt it important to maximize the amount of information available to appraisers at minimal effort. This decision support, we felt, would pay dividends in the long run in quality of output and value defense capabilities. Unfortunately, this effort had to be set aside as it became evident that the vendor that supported the tax package would be preparing to discontinue that support. The package (an old pick/basic system) had not been maintained nor evolved with technology for too long. Now it was unclear as to whether any effort would be made prior to the year 2000 to enhance it. It was even questionable whether the package would be made 2000 compliant at all. In an era of fiscal restraint, it was not feasible to spend that amount of money on the short-term gain of integration versus pursuing the long-term gain of conversion to a new and more robust package written in modern code. The offer of 'hooks' (points of interface written into the code to allow other packages, such as GIS, or raster imaging to operate hand in hand with the application) laid in specifically for that purpose made the move even more practical. We took the latter option despite disappointment at the pace of integration advancement. We also had some problems with PC operating system evolution. 'Pedit' (the 'Strings' editor) was a DOS-based application. The rapid evolution of viewers and other peripheral programming toward the Microsoft NT operating system has prompted many vendors to suggest these as the 'preferred' platform on which to run their systems. This included our GIS vendor. The only problem was that a 32-bit version of the editor was not yet available. We purchased two units with NT-Workstation on them and immediately found that we could not run our 'legacy' (old applications that still do what we need, but use old technology to accomplish it) applications on them. We had to reformat the hard drives and load DOS then upgrade the OS (operating system) to Windows 95 to allow enough DOS capability and still allow us to run the new applications. The new 32-bit editor is in beta testing and should be released in the near future. As more and more desktop units were deployed (and requests still come in for others) training operators, even for simple and repetitive tasks became an issue. Our staff levels could not sustain much more. Likewise, as the network grew, it became apparent that the old peer-to-peer network model on which the original network was designed could not sustain the traffic. As stated above, we used the move to our present location to switch to a client/server model and Ethernet connectivity.

2. The rapid growth of our system, from a one PC office to a vital network of information, has brought with it its own set of problems. Increased traffic flows associated with information-seekers is very distracting to employees who are torn between serving the public by whom we are employed and maintaining already excessive work loads. Likewise, the proliferation of project

requests from other agencies, departments, as well as the public with limited manpower with which to perform the associated tasks, leads to resource allocation issues. Greater capability exposes your office to a broader user base and thereby to a broader political spectrum, which will sometimes approach you for answers for which you have no authority to address. While delivering information for decision support, we operate independently of the decision making process. For example, we were once working with Craven County GIS to correlate the location of our mutual county line and correct the associated tax records. At the same time, there was a dispute over the potential location of an intensive livestock operation near the county line in Craven County. We were accused of moving the county line to facilitate its acceptance. I had to respond to this complaint with a detailed synopsis of the reconciliation project and its basis in fact. In this case our line had not been moved at all. Craven County was adjusting theirs to match. Neither office had any contact with higher authorities concerning the placement of the operation. In another example, the Tax Assessor had inadvertently billed a significant number of incomplete valuations. A new subdivision had been divided and lot values had not been placed on the individual lots. Rather, the original value (according to procedure) still remained. Once again we were called on to explain the failure of the system (though value is the exclusive domain of the Assessor). Now all values are rolled back to zero until new values are assigned. We wrote a piece of code to identify these parcels prior to billing to assist the Assessor in tracking them. As the systems budget grows, that budget naturally becomes a greater target for cuts in times of fiscal constraint. Under these conditions it is important to position yourself technologically for future advancements everywhere that it is practical, with an eye on market (in terms of technology) and evolution (it is easier to sustain what is in place than it is to add additional services). It is equally important I think, to design your systems and deploy them using modular concepts to facilitate severability in times of fiscal constraint and minimize performance impediments should you loose some assets or resources. And, make sure that there is uniform support for specific applications design prior to accepting the challenge. This leads to a measure of security and assures sustained support for the cost of code maintenance and evolution.