APPENDIX L

GEOGRAPHICAL INFORMATION SYSTEM (GIS) METHODOLOGY

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GEOGRAPHICAL INFORMATION SYSTEM

BACKGROUND

The Geographical Information System (GIS) component of the Cypress Bayou Study consists of a digital geospatial database detailing the physical, natural, and economic characteristics of the watershed. The GIS was designed to serve a variety of objectives including support for many of the environmental and economic studies outlined throughout volume as well as serving as a digital appendix of baseline data and results to facilitate resource management, education, and future GIS-based analysis in the watershed.

For the present study, the GIS provided a means for basic mapping, spatial analysis, and environmental/economic modeling. The GIS supported study efforts in wetland restoration, vegetation mapping, assessment of aquatic diversity, non-point source pollution/water quality, urbanization trends, deforestation trends, endangered species distribution, and cultural resource locations. To support the longterm goals of the study, the final Cypress Bayou Watershed GIS database has been copied to cd-rom and made available to the supporters and participants of the study to support future in-house GIS-based analysis and to distribute to interested parties. Detailed information on the content and format of the GIS database is included at the end of this section.

The database consists of 25 separate maplayers or themes including basic physical geographical data such as topography (elevation, aspect, slope), satellite imagery (landsat Thematic Mapper), hydrology (streams, lakes, & watershed delineation), soils (digital Soil Conservation Service maps), geology, and economic features (roads, utilities, wells airports, railroads, state and county boundaries from TIGER Census database). These data have been compiled from public sources, in cooperation/cost sharing with other state and federal agencies including United States Geological Survey (1:24,000 scale digital elevation), United States Department of Agriculture - Natural Resource Conservation Service (digital County soils maps), Texas Parks and Wildlife Dept. (vegetation landcover/wildlife habitat mapping). Geology was digitzed in-house from the hardcopy version of the Geologic Atlas of Texas by the US Army Corps of Engineers.

Other maplayers have been generated in the course of the Cypress Valley Watershed study including vegetation/landcover distribution, water quality assessment, tourism/recreational resources, endangered and threatened species, lake & bayou aquatic data, and documented cultural resource locations (archeological and historic sites). A description of the data sources and analysis methods involved in the production of each datalayer are outlined in this section.

SOFTWARE:

A number of different GIS, remote sensing, and database management software were used in the creation and management of the Cypress Bayou GIS. ARC/INFO Version 7.1 and GRASS Version 4.1 were the two GIS software products employed in this study. They are both "C" language based GIS's that work within the Unix operating system. GRASS (Geographic Resources Analysis Support System) is a raster based public domain GIS with vector overlay capabilities developed by researchers at the U.S. Army Construction Engineering Research Laboratory (USACERL) Champaign, Illinois to support environmental planning and land management on military installations.

The final GIS database has been delivered in electronic media in Arc 7.1 format. ARC/INFO is a vector based GIS produced by Environmental Systems Research Institute (ESRI) in Redlands, California. ARC/INFO uses a relational and topological model to store and manage georeferenced database tables of statistical and thematic information linked to the graphical spatial features in the digital map. Final production of the color hardcopy maps was also performed using the ARC/INFO software on an Encad Novajet III color plotter. Image processing in this study was performed using the proprietary ERDAS image processing package, Version 7.5, also running in the UNIX environment. Erdas (Version 7.5) was the remote sensing software used to process and classify raw Landsat Thematic Mapper satellite imagery. Informix-Sql (Version 4.00) was the relational database management system used to store data for some of the maplayers.

HARDWARE:

Four SUN Sparc 2 workstations with a combined 128 Megabytes of ram, 27.8 Gigabytes of disk capacity, three 150 Megabytes 1/4" tape drives, three 8mm tape drives, a Cdrom drive, M-4 Data Systems 6250 BPI, 9-track tape drive, and an Artecon erasable optical 10 disk jukebox with 650 Megabytes storage capacity per disk.

SUN Sparc Card 2 for Pentium - PC

Kurta IS/3 digitizing tablet

Versatec 8900 color electrostatic plotter

Encad Novajet III color plotter

GEOGRAPHIC INFORMATION SYSTEMS:

A GIS is a computerized system that allows the user to collect, manage, display, overlay, integrate, and analyze large volumes of digital spatially referenced data. Spatial data consist of the various features that are defined by their geographic location and descriptive attributes such as elevation, slope, vegetation, soils, and hydrology. These features can have physical point, line, or areal characteristics that are visually discernible, such as streams, roads, lakes, or they may have invisible boundaries, such as county lines or zoning districts. Many of these map data are available from government agencies and commercial vendors in digital form on tape or cartridge. Data may also be digitized from existing hardcopy maps or generated from outside databases. Information in a digital format is also compatible with the digital satellite imagery useful for landcover classification and can be used in a cell-by-cell/pixel-by-pixel digital analysis.

There are at least two ways of representing topological data in a GIS: raster and vector representations. A raster structure (ex. GRASS, ERDAS, etc.) divides an area into a regular grid of cells or pixels each representing a square area commonly 10 to 100 meters on a side referenced by coordinates and containing a value of an attribute. In contrast, a vector structure (ex. Arc/Info) contains points, lines, and areas made of closed lines. Points are similar to cells in that they are referenced to coordinates, but points have no area. Lines consist of sets of connected points forming a feature of some measurable length.

Attributes associated with sites, lines, and areas vary depending on the information content of the maplayer. In some GIS's, there may be multiple attributes stored for each point, line, or area. Common attributes for lines are elevation, street names, types of road or road material, power lines, rail use, stream order, etc. Attributes such as soils, geology, and land-cover are commonly represented as areas. Raster structures are perhaps the simplest way of modeling areas because entities are represented explicitly in the structure of the map whereas vector entities are implicitly stored in a linked database. As a result, in pure vector systems, much effort is expended in defining polygons for overlaid data layers. Many low cost GIS's (such as GRASS) and large-scale environmental applications that frequently use satellite data are based on a raster system. One strength of the GRASS software lies in its ability to store both raster and vector data, however analysis of the data is only performed in the raster environment.

A GIS provides analytic and manipulative tools for operating on geographic data that are difficult and time consuming, if not impossible, to perform with a traditional (non-GIS) database. An additional advantage of using the GIS for modeling and analysis is the reproducability of the results. For instance, in the present study, the GIS provided a platform for assessing complex environmental processes by supplying a physical digital model of the watershed comprised of topography, soil, vegetation, roads, and urban develoment to model water quality and the pace of deforestation and urbanization.

LANDCOVER/VEGETATION DETERMINATION

Remote Sensing as a Tool for Landcover Analysis

Remote sensing provides a effective means of performing a quantitative digital analysis for resource planning over a large region of interest such as the Cypress Bayou Watershed. There are many advantages to using digital imagery for landcover mapping. Satellite imagery is collected from a stable satellite platform orbiting the earth and can provide reliable imagery over an area on a bimonthly or weekly basis. Satellites orbit the earth in a sun-synchronous north-south/south-north orbit meaning that they orbit at the same rate as earth axis rotation so that data are always collected at the same local time over the same region. Satellite imagery is collected at the same altitude, sun angle, and azimuth year-round making it easier to compare imagery collected from different days or times of year. Thus, the data compiled for the Cypress Bayou Watershed Study can be integrated easily with other multi-spectral data in any future followup studies. In addition, the digital nature of the satellite data also allows for the ready integration into the GIS for overlay and analysis with other map layers such as elevation, soils, hydrology, and global positioning system (GPS) derived field ground truthing points.

Remote sensing is the science of acquiring information about the composition or qualities of objects without coming into direct contact with them. Aircraft and satellites are the most common platforms from which regional remote sensing observations are made. A regional application generally employs methods that utilize reflected or radiated electromagnetic energy as the means of measuring and detecting the characteristics of the targeted objects. By this definition, remote sensing collecting techniques would include photography, radar, sonar, and multi-spectral sensors. The principle benefits of using digital image processing methods are their economy, accuracy, versatility, repeatability, and preservation of original data precision.

Multi-spectral sensors operate on the principle that all matter reflects and radiates a range of electromagnetic energy (EMR) that can be measured in wavelength ranges called channels or bands. The spectral resolution of a multi-spectral sensor is a measure of the number of bands a device is capable of sensing and recording. The Landsat Thematic Mapper (TM) data used in this study consists of 7 spectral bands of reflected and emitted energy in the visible, reflective-infrared, middle-infrared, and thermal infrared regions of the electromagnetic spectrum. A sensor contains detectors that gather electromagetic energy and convert it to signals for processing on the ground. Each band of information is stored on computer compatible tapes as digital data. The digital nature of the multi-spectral data makes it possible to restore, enhance, and extract information from any one or a combination of bands based on the digital values of individual pixels.

An image is made up of many thousands of pixels each corresponding to specific areas on the ground recorded by the multi-spectral sensor. The position of any pixel is determined by an "X" and "Y" coordinate; while size, usually recorded in meters, is determined by the sensor's spatial resolution or ability to discriminate between closely spaced objects.

Objects may be recognized as a group of many pixels displaying a distinct pattern of reflected or emitted energy known as a spectral "signature". Spectral pattern recognition using these distinct signatures is the basis for classifying any type of multi-spectral imagery. During the classification process, pixels identified by their signature are statistically analyzed and sorted into classes by a predetermined set of criteria that recognize similar patterns of signatures. Classes may be associated with recognizable features on the ground or may look different to the computer due to some more subtle spectral distinction not visible to the human eye. In order to assign meaning to the classification, it is common practice to sample field inspect the locations of classes to gather ground truth data for assigning final definitions to the entities the classes represent (e.g. bare ground, asphalt, agricultural field, paved road, lake, hardwood forest, etc.).

GAP Analysis and The Landcover Classification System

The objective of the image classification was to derive a landcover map encompassing major landuse and vegetation classes distributed within the Cypress Bayou Watershed for use in a number of natural resource assessments. First, the information for vegetation would provide an approximation of the status, type, and extent of broad plant communities in the study area and guide the design of plans for long range wildlife and timber management. Second, landcover would contribute to the generation of a preliminary GAP based classification for east Texas. Third, landcover would serve as a basemap in combination with other environmental data for assessment of natural resources in the Cypress Bayou Watershed such as threatened and endangered species, wetlands, aquatic data, and water quality. Finally, the landcover map would also be a vital component in further GIS-based environmental study on future urbanization, deforestation trends, and non-point source pollution modeling.

The classification model to be employed in the Cypress Bayou Watershed satellite imagery analysis was the GAP Analysis Vegetation Classification System for Texas (McKinney 1994). GAP is a nationwide effort sponsored by the U.S. Fish and Wildlife Service to identify and delineate natural communities important to maintaining biological diversity at regional, state, and local levels (Winckler 1992:74). The intent of GAP is to identify areas where gaps in federal and state protection exist so that proactive cooperative efforts can be taken to establish adequate natural preserve areas and partnerships with private landowners (Winckler 1992:74-81). As noted in the Conservation Strategies Appropriations Documentation for GAP: "Management for biodiversity is intended to maintain representative populations of naturally occurring species and vegetation cover types in sufficient abundance to insure their longterm viability" (Defenders of Wildlife 1992:2). In conserving biological diversity, GAP seeks to address the shortcomings of the Endangered Species Act with its reactive crisis focus on endangered individual species with a comprehensive ecosystem approach to biological conservation and habitat protection (Winckler 1992:80).

GAP analysis involves overlaying, modeling, and analyzing mapped information on land ownership/landuse, animal and plant community distributions, and natural resource preserves in order to answer questions on the status of biological diversity. GIS is a critical tool for the accomplishment of these tasks which include compilation, integration, and analysis of data from diverse sources such as multi-spectral satellite imagery, videography, vegetation, soil types, geology, topography, and landownership/landuse. To meet the demanding data and research requirements of GAP implementation, GAP programs nationwide build cooperative agreements with government agencies, universities, and private interests to collaborate on and share costs for the generation of statewide GIS databases and baseline natural resource mapping.

GAP efforts in Texas have been organized around a network of state and federal agencies and universities who have an interest or jurisdiction in natural resource management and vital geospatial data necessary for construction of the basic GAP maplayers. These have included The Nature Conservancy, US Fish and Wildlife Service, US Army Corps of Engineers, National Park Service, USDA-Natural Resource Conservation Service, Texas Parks and Wildlife Department, University of North Texas, Rice University, Texas A&M University, University of Houston, and Texas Tech University (Defenders of Wildlife 1992:18). The US Army Corps of Engineers Fort Worth District works closely with GAP officials in Texas and has pledged assistance in sharing data pertinent to GAP study goals whenever possible and adopting the Texas GAP Classification scheme in Corps GIS vegetation mapping.

Vegetation mapping in Texas has been initiated for some parts of the state with completion of the mapping for the entire state planned by June 1998. The Mapping Sciences Lab at Texas A&M has been selected to compile boundary maps of public conservation areas, obtain Landsat TM Satellite imagery, process the airborne videography, and construct the vegetation map for East Texas. A minimum mapping unit of 40 ha was chosen for the maps which will be produced at a scale of 1:100,000 (National Biological Survey 1995:1-2). As planned, the Texas GAP Project will rely on airborne videography for ground truth data and validation and will not entail actual fieldwork.

The Texas vegetation classification scheme has gone through several drafts and reviews. An initial scheme was developed by the Mapping Sciences Lab at Texas A&M University utilizing the UNESCO-format (UNESCO 1973) and also incorporating vegetation series recognized by the Texas Natural Heritage Program (TNHP 1993). The UNESCO system is an integrated ecological land classification scheme uniting several fundamental elements of the landscape including vegetation, soil, landforms, climate, and water in a hierarchical framework that defines general and various sublevels of plant community associations. The TNHP list includes 89 plant community series defined for the Nature Conservancy's Biological Conservation Database (BCD).

At the time of implementation of the Cypress Bayou Watershed landcover mapping in June 1994, Draft 7 of the Texas GAP Classification was undergoing additional revisions planned for 1995 implementation designed to streamline the classification and bring the scheme closer in line with the methodologies of videography and satellite imagery. The revisions sought to collapse the current 120 classes down to a workable 60 classes by eliminating some smaller plant communities and also collapsing similar plant community classes that could not be distinguished from each other without intensive field checking (David Diamond and Tony McKinney, personal communication 1994). In meetings between Ft. Worth District Corps and GAP officials from Texas A&M and Texas Natural Heritage Program, a decision was made to conduct Cypress Bayou Watershed landcover classification within the Draft 7 scheme with the intention of adjusting the classification later to reflect new GAP landcover classes.

The responsibility for field ground truthing and adapting the GAP Draft 7 scheme to the Cypress Bayou Watershed area fell to the Texas Parks and Wildlife Department. They subcontracted to Dr. Bill Sheffield, a biologist with considerable field experience in east Texas. Dr. Sheffield found it necessary to make additions to the GAP scheme to include transitional plant community types for successional types and Pine Plantation (see Sheffield's section - this report). Dr. Sheffield worked closely with US Army Corps of Engineers Biologist Ishmael Williams who processed the Landsat satellite imagery and classified the imagery into a landcover map using Dr. Sheffield's field observations.

Landcover Classification of Landsat TM Satellite Imagery

To accomplish the classification, Landsat Thematic Mapper satellite imagery was obtained along Path 25 Row 37 which encompasses most of the Cypress Bayou Watershed. Full Scenes were obtained for April 7 and July 28 1994 to provide a multi-seasonal classification. To fill in a small area at the west tip of the Cypress Bayou Watershed, a Movable Miniscene was also obtained for Summer 1994 (September 5) along Path 26 Row 37. The Full Scenes cover an area approximately 185 km by 170 km while the Moveable Mini-Scene is about 100 km by 50 km. The data were obtained from Earth Observation Satellite Company (EOSAT) through the Defense Mapping Agency in Universal Transverse Mercator projection (Zone 15) using the Clark 1866 Earth Ellipsoid.

There are two approaches that can be taken in the classification of satellite imagery: Supervised Training and Unsupervised Training. In Supervised Traning, classification in controlled by the analyst who chooses an area of pixels that represent known homogenous vegetation patterns on the ground. From this information, the computer then identifies all pixels with similar multi-spectral characteristics. In contrast, Unsupervised Training clusters the data statistically to create classes of pixels based on the total multi-spectral variation in the data. It is then up to the analyst to attach meaning to the classes that have been defined in the data (Erdas 1992:105-106).

There are advantages and drawbacks to both methods. The advantages of Supervised Training is that, if enough information is available, class definition can be directed to an outcome by the analyst. Disadvantages are that a high degree of knowledge about the study area is required, the clustering works best when classes are distinct and homogenous, and unanticipated patterns and variation within clusters in the data are not revealed to the analyst. The advantages of Unsupervised Training are that many classes including irregular heterogenous distributions and classes due to unexpected multi-spectral variation in landcover may be defined. The redundancy in these classes may be eliminated by lumping similar categories together later.

For several reasons, the Unsupervised Training Method was chosen for the Cypress Bayou Watershed Study. The Cypress Bayou Watershed is an expansive area encompassing parts of 10 counties in two states extending from Western Louisiana west more than 100 miles into East Texas. The study area takes in a wide variety of natural plant communities and artificial landcover types, the multi-spectral variation of which were not completely understood beforehand. Vegetation in the area is characterized by considerable mixed plant elements and transitional communities that are not homogenous nor distinct in distribution. Finally, Unsupervised Classification allows the most flexibility in classification permitting the generation of a large number of classes that can be defined and recombined and adjusted later when the final GAP Scheme is completed.

The determination of landcover classes from the multi-spectral satellite data was accomplished through a process of initial multi-variate clustering of the band data, followed by field ground truthing and reclassification into meaningful landcover types, and then assessment, review, and further adjustment of classes. The first step involved statistical manipulation of the raw band data.

The seven spectral bands were loaded into the ERDAS v.7.5 software where an unsupervised classification was conducted of Bands 1, 2, 3, 4, 5, and 7. The classification algorithm employed was the ISODATA (Iterative Self-Organizing Data Analysis Technique) clustering method. ISODATA is an iterative method (repeatedly performs an entire classification and outputs statistics) that assigns each pixel to one of a specified number of clusters based on a comparision of spectral signatures of pixels and cluster means. A minimum spectral distance is specified for assigning pixels to clusters and clusters are initiated with arbitrary starting means that then shift to the values of the pixels assigned to them as pixels are iteratively shuffled to clusters (Erdas 1992:120-121). The ISODATA cluster classification produced a new GIS map that separated the data for the images into 100 spectrally distinct but unknown landcover categories. The classified GIS file was converted to GRASS v.4.1 format and projected into Albers Equal Area Conic coordinates from the original UTM coordinate system. The procedures described above were carried out for each of the two Full Scenes and one Moveable Mini-Scene.

Inspection in the GIS of the classified images derived for the Cypress Bayou Watershed area suggested several discernable landcover patterns, particularly easily recognizable categories such as bodies of water, wetlands/cypress swamp, forested areas, and urban areas. Generating a meaningful landcover map from the classification required the detailed ground truth data to define how the multi-spectral based classes articulated with the classification scheme. The process would be one of lumping the multi-spectral classes into related groups identified from the ground truthing, assessing overlap between and across groups, and resolving the membership of mixed classes falling close to two groups. Most of the clustering of classes at this stage is done by hand using GIS tools to recluster and test the classification against the ground truth data and aerial photos.

The field ground truthing was conducted by vehicle and foot by biologists with Texas Parks and Wildlife Department using a Rockwell model GPS receiver to collect point coordinates at imagery ground truthing locations. Since data were collected at large contiguous spectral signatures, extreme locational precision was not required and so waypoint averaging and differential correction were not employed. Sufficient precision was maintained at each point by closely monitoring error due to differential satellite availability (accuracy as a function of the numbers of satellites being received).

Ground truth locations were chosen during field survey to cover a representative range of landcover types and transition zones accross the study area. To gauge the range of spectral signatures within each landcover type and insure that data sufficient for collapsing redundant classes was obtained, multiple observations were made for each landcover type at widely scattered locations across the study area. At each location, GPS readings were taken and observations were made concerning the type and extent of vegetation characteristics. A form was developed by Dr. Sheffield to guide the collection of field observations which included site number, date, investigator names, GAP Classification Code, coordinates, USGS Quad name, site characteristics, canopy/midstory/surface cover, dominant species, tree height, and a sketch map. Photographs were made at sites to help guide the classification.

A total of 116 ground truth points were collected from a wide area encompassing the entire Cypress Bayou Watershed for landcover classification. For further GIS analysis, these points were entered into the computer as a maplayer of coordinates for overlay and comparison with the classified imagery. The points were subset by landcover type and overlayed as groups on top of the classified imagery. The Landcover maplayer was generated by assigning landcover types to the 100 categories where they coincided with ground truthed field descriptions, collapsing similar spectral signatures (reclassing) into single classes when appropriate, and reconciling the transitional landcover classes in cases of signature overlap. The ground truth data were supplemented with Black and White aerial photographs of some areas and two field visits to the Watershed by the biologist doing the Imagery GIS manipulation. Derivation of the final landcover classes was accomplished using input mainly from the two Full Scenes starting with the April 7 Scene and then proceeding to the July 28 Summer Scene. The Moveable Mini-Scene was classified through a combination of ground truth points and an assessment of the area of overlap with the two Full Scenes.

The initial landcover classification using just the April 7 imagery and the first 89 ground truth points encountered problems separating hardwood and pine for two of the spectral classes. The difficulty was confined mainly to classes 41 and 46 of the classified image raster map where, based on the ground truth data, locations could be assigned to either pine dominated or hardwood dominated vegetation types. To be certain of the mixed signature, the class groupings were rechecked against the ground truth data, and Texas Parks and Wildlife Department biologists rechecked ground truth locations dominated by classes 41 & 46. These two classes tend to fall out in large contiguous blocks encompassing much of what is identified as either bottomland hardwood or upland pine, but also some possible mixed hardwood and pine. The problem with mixed signatures may stem from the April 7 date of the image which may be too early in the growing season to provide complete discrimination of the early hardwood leaf growth and pine evergreen cover.

The mixed pine/oak signature was resolved with the introduction of the July 28 imagery suggesting that the problem with the April data was in large part seasonal. A reanlysis of the ground truth data with this new imagery produced more congruent classes of hardwood, pine, and mixed pine/oak. The July imagery also provided a clearer distinction between water, cypress, and aquatic plants which was missing on the Spring (April 7) imagery. However, the spectral variation that existed between these classes was difficult to sort out over so vast an area as the Cypress Bayou Watershed. While some success was had in separating aquatics in the Caddo Lake area, the signatures were also distributed in pixels in other areas in the watershed where the existence of aquatic vegetation had not been documented. Some of these signatures appeared to be mixed showing both aquatic vegetation and other terrestrial grassy growth. It was concluded that insuffficent ground truth data were available to permit clear separation of aquatic plants from open water and cypress across the entire watershed. The final classification in our landcover map contains an open water class and a cypress class but these two categories probably overlap to an extent and also contain amounts of aquatic landcover. A study focused on delineation of submerged aquatic plant communities in East Texas employing imagery and videography is in progress at the US Army Corps Lab at Waterways Experiment Station and should be consulted by the reader for detailed information on aquatic distributions in East Texas.

The final landcover map consists of 11 classes (Table 1, Figure 1) constituting a total of 19,304,324 acres. A tabular map category report of the acreage and percent coverage for the landcover categories show that dominant landcover types are Hardwood at 19.96% (3,852,998 acres) and Hardwood/Woody Second Growth at 23.55% (4,545,708 acres) followed by Improved Pasture with 18.98% (3,663,266 acres), Pine at 15.51% (2,993,375 acres) and Urban/Exposed Ground with 10.59% (2,044,171 acres). Water at 3.41 % or 658,347 acres, Mixed Loblolly Pine/Oak at 2.88% or 555,519 acres, Coarse Pasture/Grassland with 2.43% or 468,507 acres, Cypress Swamp at 1.22% or 236,327 acres, Cultivated land/Managed Grassland at 1.17% or 225,715 acres, and Agricultural Land/Clearcut at 0.27% or 51,258 acres constitute the minority classes (Table 1).

The Hardwood class encompasses most of the mesic bottomland hardwood as well as some upland hardwood along stream margins while the Hardwood/Woody Second Growth constitutes a minor bottomland hardwood, most of the upland hardwood in the study area and what appears to be young hardwood woody second growth in recently logged stands in the eastern portion of the study area. The Hardwood/Woody Second Growth class is also evident throughout the eastern Piney portion of the area as ribbons of hardwood growth along roads and utility line rights-of-way. The Mixed Loblolly Pine/Hardwood cover type includes a pine dominated mixed forest of mature pine and hardwood common in the Caddo Lake area and Caddo Lake State Park.

Table 1. Summary of Landcover/Vegetation from Landsat Satellite Imagery Classification for Cypress Bayou Watershed

Category Description #	Acres	Cell Count	Percent Cover (%)
1. Hardwood	3,852,998	2319084	19.96
2. Hardwood/woody second growth	4,545,708	2736020	23.55
3. Pine	2,993,375	1801685	15.51
4. Water	658,347	396253	3.41
5. Urban/exposed ground	2,044,171	1230368	10.59
6. Improved pasture	3,663,266	2204886	18.98
7. Mixed loblolly pine	555,519	334362	2.88
8. Cypress Swamp	236,327	142243	1.22
9. Coarse pasture/grassland	468,507	281990	2.43
10. Cultivated/managed grass	225,715	135856	1.17
11. Agri/clearcut/urban devel.	51,258	30852	0.27
Total	19,304,324	11619095	100.00

The grassland/agricultural categories: Improved Pasture, Coarse Pasture/Grassland, Cultivated Fields/Managed Grass, and Agricultural/Clearcut constitute 4,408,746 acres or 22.85% of the total area of the Cypress Bayou Watershed (Table 1). These landcover types are in most abundance in the agricultural areas of the Red River Floodplain of the eastern portion of the study area and as grassland in the western half of the study area. In the western portions, this most typically is managed pasture (Improved Pasture) with some coarser grassland (Coarse Pasture/Grassland) appearing mixed within improved pasture. Other areas of coarse grassland include range-like areas dominated by wild plants, field/pasture margins, and old field succession. Cultivated/Managed Grassland is the major category for agricultural fields with some improved pasture falling in as a minority element as well. The Agricultural/Clearcut Category is a minority high reflectant catchall category that appears to encompass mainly areas with low plant energy absorbtion such as plowed fields, cropland, clearcut areas, and urban areas. The predominant category for highly reflectant exposed ground is the Urban/Exposed Ground class which includes plowed fields, nearly bare croplands and pasture, and a major urban/transportation component consisting of reflective developed areas marked by buildings, asphalt, and concrete. The Urban/Exposed Ground class includes nearly all of the signature for roads, highways, railroads, towns, and industrial areas (buildings and mines).

<u>Conclusions</u> - The final landcover maplayer categories are more general than the ground truthing observations and are less detailed than is desirable in a GAP analysis. There are several reasons why a greater level of detail was not achieved in the GIS analysis. The primary challenge confronting the field biologists and GIS staff was the broad geographic extent of the project area which encompassed 19 million acres of very diverse biogeography extending from the Red River bottoms and piney woods of East Texas west to the xeric sandy hardwood covered hills of east-central Texas. The ground truth data requirements for adequate sampling of the vegetational variability within such an area are immense.

Multi-spectral variability over such an extensive area can often exhibit spectral signature drift within classes from one end of study area to the other and mixed signatures in which multiple classes scattered across the area are defined by overlapping spectral signatures. To remedy this, landcover classes need to be extensively sampled with ground truth observations across the full extent of the study area in order to provide a good picture of the range of spectral signatures within each class. For GAP analysis in Texas, detailed high resolution color images compiled from videography are employed to obtain sufficient detail of the kind and extent of vegetation. The present study did not have access to videography, but rather depended on the field ground truthing supplemented with existing aerial photography for some portions of the project area. One additional limitation on the ground truthing coverage was the restriction of access to state, federal, and public lands (roadsides). No field investigations of private lands were conducted. This severely effected the degree to which vegetation types could be adequately sampled across the full extent of the watershed.

Imagery analysis was further constrained by the fact that many of the vegetative classes and subclasses defined by the ground truthing effort were based on sub-canopy characteristics, covariation of plant species within the same genus, graded and transitional types, and other vegetative distinctions. Such classificatory criteria were not discernible using the multi-spectral satellite imagery which provides canopy dominated indications.

The 116 ground truth observations collected by the field biologists represent an accurate sample and description of major vegetational patterns in the study area. However, they provide insufficient coverage of the full range of spectral diversity existing both between and within classes of vegetation to allow corresponding classes to be defined in the satellite imagery. In the end, the two data on Cypress Bayou landcover: the vegetation ground truth observations and the landcover GIS maplayer should be regarded as two different but converging views of the same biogeographic phenomena. They both represent valuable information on the distribution of vegetation across the Cypress Bayou Watershed that with further study can be refined to address future economic and natural resource management needs across the region.

<u>Universal Soil Loss Equation (USLE) and Non-Point Source Pollution Modeling</u>

The objectives of the Universal Soil Loss Equation (USLE) and non-point source pollution modeling were to obtain a general view of existing conditions across the study area with respect to high potential erosion areas, soil loss, and the problem of nutrient runoff as a non-point source of water pollution. Soil loss estimates and nutrient loadings were obtained through application of the USLE model while assessment of nonpoint source pollution was obtained by applying a sediment delivery ratio to estimate sediment/nutrient yield due to surface erosion (Mills et al. 1985).

Non-point sources are pollution processes that originate from water runoff as opposed to point sources of pollution such as sewage outlets and industrial effluent. The USLE is a model that provides insight into the processes of soil loss and identifies those locations that <u>may be</u> at risk for erosion under certain conditions. This model does not identify specific areas that are presently undergoing soil erosion, quantify the exact amount of nutrient and sediment loss, or delineate the sources of non-point water pollution. Such a determination would require much more detailed field data collection and input into the model. The present effort can serve as a baseline model for addressing such concerns in more detail later.

The USLE is a model for quantitative prediction of annual soil loss (W. Wischmeier and D. Smith). The USLE operates on the principal that field soil loss is the product of six factors:

R = rainfall and runoff erosivity index
K = soil-erodibility factor
L = length of slope factor
S = degree of slope factor
C = cropping-management factor
P = conservation practice factor

The rainfall intensity factor (R), also known as the erosivity index, is the dominant causitive factor in soil loss. It is calculated from the annual summation of rainfall energy times its maximum 30 minute intensity. It varies geographically and seasonally. In the study area the R-values range between 330 and 350 (Greiner 1979) with the lowest R-value occuring in Hopkins County in the western part of the study area and the highest R-value attained in Harrison County in the eastern portion of the study area. The other seven intervening counties in the project area (Cass, Gregg, Marion, Morris, Titus, Upshur, and Wood) have R-values of 340 (Greiner 1979).

The soil erodibility factor (K) is a measure of the cohesive character of a soil type and its resistance to displacement due to raindrop impact and overland flow shear forces. It is dependent on particle size and density of the soil matrix. These values were obtained from the USDA Natural Resource Conservation Service SSURGO (Soil Survey Geographic Database) GIS coverage (USDA 1994. The values for the K-factor for each soil type were queried from the Akfact@ field and used to reselect or reclassify the SSURGO soils coverage in Arc/Info into a distribution of K values. For the Cypress Bayou Watershed project area, these values range from X to Y.

The topographic factors: length of slope and degree of slope relate to the physics of overland rainfall runoff. Steeper slopes produce higher flow velocities while longer slopes accumulate runoff from more extensive areas and also result in higher flow velocities. Length of slope in the original USLE model was used for the length of the slope of typical fields being measured for erosion. In applications such as this watershed study which encompasses a much larger area than the USLE was originally designed to assess, this factor is impossible to code reliably. Discussions with other researchers revealed that slope length has been determined to average about 100 feet in northeast Texas region (Bruce Hunter, personal communication). Since that is about the dimensions of a cell in the Cypress Bayou Watershed GIS, the decision was made to assign the value A1" for slope length meaning that values will be determined on a cell-by-cell basis and that slope length will not weigh in to the equation very high. There is a slope length tool in GRASS (the r.watershed utility) designed for the Revised USLE (RUSLE), which is less tied to an agricultural orientation. However, for purposes of this study, a decision was made to adhere to the original USLE factors as closely as possible so that a baseline soil loss erosion estimate could be generated. Future study of the region employing USLE might consider using one of the revised methods.

For the USLE model, slope percent values were generated as GIS coverages from the detailed 1:24,000 scale USGS contour coverage. Using GRASS GIS tools, the vector contours were rasterized using the command v.to.rast and then an elevation surface was generated using command r.surf.idw, a surface interpolation utility which uses inverse distance squared wieghting. A maplayer for degree of slope was generated using the r.slope.aspect GRASS command. The maplayers were then imported to Arc GIS as grid coverages.

The cropping-management factor is a coefficient that expresses the erosion potential of landcover types as a ratio of soil loss for a given type compared to soil loss under tilled, fallow conditions. The factor ranges from 0 to 1 with values approaching 1 having the greatest potential for erosion and a value of 0 applied to standing water. In modeling alternative field management practices, the computation of this factor incorporates the effects of seasonal erosivity, tillage management, and cover/crop type. For purposes of the Cypress Bayou Watershed project, a more generalized approach to the assignment of C-factors (Table 2) was dictated by the limitations

Table 2. C factors assigned to Landcover Types for USLE Model

Landcover Type	C Value
Hardwood	0.1
Hardwood/woody second growth	0.1
Pine	0.1
Water	0.0
Urban/exposed ground	0.9
Improved pasture	0.3
Mixed loblolly pine/oak	0.1
Cypress Swamp	0.0
Coarse pasture/grassland	0.3
Cultivated/managed grass	0.5
Agri/clearcut/urban dev	0.5

of the satellite imagery derived landcover data, the large size of the study area, and the more broad-based objectives of the study. Assignment of C-factors for the study area were scaled out between 0 and 1 consistent with assignments made for similar landcover types in a previous USLE modeling effort (Walker 1990:54-55). In that study, Walker (1990) assigned the highest C value of .9 to barren and disturbed areas such as construction site and agricultural land that was exposed through cultivation was assigned a middle range value of .5. Pastures and grassland were assigned a moderately low value of .3 to reflect the height and density of ground cover available to intercept raindrops and retard soil movement while forest land was assigned the lowest C value of .1 to reflect the understory and overstory buffer on rainfall intensity.

Urban centers, suburban areas, and improved roads are characterized by little exposed soil and should be given low C values of .1. However, in the Cypress Bayou Watershed satellite imagery, the Landcover categories for Urban Development and Exposed Ground overlap. To avoid underestimation of soil loss in the critical exposed ground/agricultural areas which make up a significant part of this class, the entire class has been designated a C value of .9. This means that the urban development landcover category, a minor element in this mixed class, will have overestimated soil erosion levels.

The conservation practice factor or P-factor represents erosion management practices that would tend to mitigate the effects of water runoff such as contouring, strip cropping, and terracing. However, information about conservation practices at this detail are not available for the watershed and are not recognizable from the satellite imagery used to generate landcover. For those reasons, the P-factor was not employed in this USLE model.

Each of the five factors used in the USLE were stored as separate GIS data layers. To build the final USLE erosion potential datalayer, the five factors were combined in stepwise sequence with each other. First, the erosivity factor (R) was multiplied with the soil erodibility factor (K) to produce a rainfall/soil GIS layer. Next, the erosivity/soil erodability map was multiplied with the slope length layer (L) to produce a erosivity/soil erodability/slope length layer. In order to maintain maplayer category values under 256 classes (8 bit data file), these intermediate files were multipled by a scaling factor of 0.1 which served to redistribute the range of values without changing the relationship within the data. This multiplication process was repeated for every USLE factor to produce a final prediction of annual soil loss.

BASELINE GIS ENVIRONMENTAL DATALAYERS

The following will summarize the digital environmental datalayers compiled, acquired, and built in the course of the Cypress Bayou Watershed Study. Although, a number of different GIS and imagery processing software were used throughout the project, the final electronic media version of the database has been delivered in Arc 7.1 in the Albers Equal Area Conic Projection. Albers was employed because it produces accurate area and distance measures in the middle latitudes where the Cypress Bayou Study area is situated and there is no angular distortion and conformality exists along standard parallels.

To provide further information about each of the GIS datalayers, a report format has been employed below that summarizes basic maplayer information in outline form (source, date, scale/resolution, data type, etc.). This is intended to loosely follow the GIS data documentation requirements (metadata) established for the US Army Corps of Engineers by Executive Order 12906 and Engineer Circular 1110-1-83 to improve acquisition, access, and management of geospatial data. Metadata is an extensive listing of information about data designed to serve as a technical guide for the GIS community for sharing geospatial data. Since the present report is directed to a wide audience most of whom are not GIS users, an abbreviated, less technical version of the metadata documentation is provided.

The complete technical documentation for the Cypress Bayou GIS may be accessed by the reader from two sources: (1) metadata files accompany each maplayer in the GIS database and may be accessed in ascii format by the various governmental and academic GIS users who have recieved cdrom copies of the Cypress Bayou Watershed GIS database, and (2) the same metadata documentation for all of the datalayers, may be accessed through the US Army Corps of Engineers geospatial metadata server node named corps_geo1 maintained by USACE Headquarters in Washington D.C. Agencies recieving the cdrom version of the database include Texas Parks and Wildlife Department, National Biological Service, US Fish and Wildlife Service, and Bureau of Reclamation.

The US Army Corps of Engineers metadata node is part of the National Geospatial Data Clearinghouse (NSDI) established by the Federal Geographic Data Committee (FGDC) as a Internet linked network of computers at federal and state agencies, universities, foreign agencies, and commercial buisnesses all over the world that use and maintain geospatial data in compliance with NSDI standards. This server may be accessed through the Internet via the World Wide Web at the URL: http://corps_geo1.usace.army.mil which contains instructions on how to query the server and general information about NSDI metadata standards.

The following are the summaries of the geospatial data compiled for the Cypress Bayou Watershed GIS database:

<u>STATSGO 1:250,000 Soils</u>

<u>Title</u>: State Soil Conservation Database (STATSGO)
<u>Scale/Resolution</u>: 1:250,000
<u>Data Type</u>: Polygon coverage linked to a Soil Interpretations Record attribute relational database consisting of 16 INFO tables including mapunit, taxclass, yldunits, plantnm, comp, interp, compyld, woodland, woodmgt, forest, windbrk, wlhabit, rsprod, plantcom, layer. The tables contain over 25 soil, physical and chemical properties for each of the soil series. Information can be queried on available water capacity, soil reaction, salinity, flooding, water table, bedrock, engineering factors, cropland yield, woodland capability, and recreation development (USDA 1994:28-29; FGDC 1992: 1-30). The Soil Interpretations Record interface originally built in GRASS has not been recreated in Arc/INFO, and the user is cautioned to consult USDA-NRCS manuals on the use of the tables.
Source: United States Department of Agriculture - Natural Resource Conservation Service (NRCS) formerly SCS
<u>Date</u>: 1993
<u>Coverage</u>: Entire Cypress Bayou study area

Description: The STATSGO layer is a delineation of general soil associations at the state level for regional, multistate, river basin, State, and multicounty planning and management. NRCS cautions that they are not detailed enough for accurate interpretations at the county level and below. The data are compiled by generalizing from the detailed county soil delineations (SSURGO) or, if SSURGO is not available, by extrapolating from geology, topography, vegetation, climate, and Landsat satellite imagery. The minimum size of soil association area mapped is 625 hectares (1544 acres). Map units are defined as line segments or vectors using USGS 1:250,000 scale quadrangle sheets as base maps (USDA 1994:1-2, 14).

SSURGO 1:24,000 Soils

Title: Soil Survey Geographic Database (SSURGO)
Scale/Resolution: 1:24,000
Data Type: Polygon coverage linked to a Soil Interpretations Record attribute relational database consisting of 16 INFO tables including mapunit, taxclass, yldunits, plantnm, comp, interp, compyld, woodland, woodmgt, forest, windbrk, wlhabit, rsprod, plantcom, layer (USDA 1993: 22). The tables contain over 25 soil, physical and chemical properties for each of the soil series. Information can be queried on available water capacity, soil reaction, salinity, flooding, water table, bedrock, and sources of gravel (USDA 1994:28-29; FGDC 1992: 1-33). The Soil Interpretations Record interface originally built in GRASS has not been recreated in Arc/INFO, and the user is cautioned to consult USDA-NRCS manuals on the use of the tables.
Source: United States Department of Agriculture - Natural Resource Conservation Service (NRCS) formerly SCS
Date: 1994-1995
Coverage: Entire Cypress Bayou study area except for Marion and Harrison counties which are currently being surveyed by NRCS and will not be available for 1995.
Description: The SSURGO layer is a delineation of detailed soil associations designed primarily for farm and ranch, landowner/user, township, county, or parish natural resource planning and management. The data are compiled consistent with national standards from subsurface field observations along soil delineation boundaries and are mapped using field traverses and transects. Field observations are made on aerial photographic base maps of scales ranging from 1:12,000 to 1:62,500 with scales of 1:15,840, 1:20,000, and 1:24,000 most commonly used. Data are collected and archived in 7.5 minute topographic quadrangle units (USDA 1993:3).

7.5 Minute USGS Quadsheet Outlines

Title: 7.5 Minute Quad Sheet Outlines
Scale/Resolution: 1:24000
Data Type: vector polygon coverage
Source: USACE-PL-RE
Date: 1995
Coverage: Entire study area
Description: The USGS quads file is a vector representation of the outline of USGS 7.5 minute quadrangle maps. The file was created in Arc Info v.7.0.2 with the generate fishnet command. This is a polygon file and includes the USGS quad sheet titles.

15 Minute USGS 1:250,000 Digital Elevation Model (DEM)

Title: 15 Minute Digital Elevation Model
Scale/Resolution: 1:250,000
Data Type: vector point coverage spaced 3-arc seconds
Source: United States Geological Survey
Date: Converted to Arc/Info 1995
Coverage: complete Cypress Bayou Study Area
Description: Digital Elevation Models are records of terrain elevations compiled by the USGS at regularly spaced intervals. Slope and aspect are derived in GIS from the raw DEM data. The raw DEM data was brought into Arc and converted to a raster grid using DEMLATTICE.

15 Minute USGS 1:250,000 Contours

Title: 15 Minute USGS Map Contours
Scale/Resolution: 1:250,000
Data Type: vector polygon coverage
Source: United States Geological Survey
Date: August 1995
Coverage: complete Cypress Bayou Study Area
Description: Contours are a vector representation of elevation for the study area. Contour lines are located at 5 meter intervals and were derived from the 1:250,000 Arc/Info DEM grid using the Arc tool LATTICECONTOUR. Contours were not processed further except to remove dangling arcs lying outside the study area boundary. The arcs were not splined or generalized which may explain their Ablocky@ look.

15 Minute USGS 1:250,000 Aspect

Title: 15 Minute USGS Aspect
Scale/Resolution: 1:250,000
Data Type: Arc/Info grid (raster)
Source: United States Geological Survey
Date: Derived from DEM in August, 1995
Coverage: complete Cypress Bayou Study Area
Description: Aspect is the compass direction of the maximum rate of change in elevation of a surface. The value, a number between 0 and 360, is representative of a compass direction measured clockwise from the north. Aspect data was derived from the DEM grid in Arc/Info using the Grid function ASPECT().

15 Minute USGS 1:250,000 Slope

Title: 15 Minute USGS Slope
Scale/Resolution: 1:250,000
Data Type: Arc/Info grid
Source: United States Geological Survey
Date: 1995
Coverage: complete Cypress Bayou Study Area
Description: Slope is defined as the maximum rate of change in elevation of a surface. Slope data for the Cypress Bayou study area was derived from the DEM grid in Arc/Info using the grid function SLOPE().

7.5 Minute USGS 1:24,000 Contours

Title: 7.5 Minute USGS Map Contours

Scale/Resolution: 1:24,000
Data Type: vector polygon coverage
Source: United States Geological Survey
Date: compiled from original seperates in 1995
Coverage: complete Cypress Bayou Study Area
Description: Digital vector delineation of topography as presented on USGS 7.5 minute quad sheets for all 7.5 minute quads falling in the Cypress Bayou Watershed.

The composite Arc coverage was edited using Arcedit to remove interior errors, and edgematched for continuity of contours. No quality checks were made of the attribute values of the arcs.

7.5 Minute USGS 1:24,000 Digital Elevation

Title: 7.5 Minute USGS Map Digital Elevation Model
Scale/Resolution: 1:24,000
Data Type: Grid (raster)
Source: United States Geological Survey
Date: compiled from original seperates in 1995
Coverage: complete Cypress Bayou Study Area
Description: Digital grid model of topography for USGS 7.5 minute quad sheets for all 7.5 minute quads falling in the Cypress Bayou Watershed. The coverage was generated from USGS 1:24,000 scale contours using Arc functions TIN and GRID.

7.5 Minute USGS 1:24,000 Aspect

Title: 7.5 Minute USGS Aspect
Scale/Resolution: 1:24,000
Data Type: vector polygon coverage
Source: United States Geological Survey
Date: derived from 7.5 minute contour data using the Arc grid function ASPECT() tool
Coverage: complete Cypress Bayou Study Area (see quadmap list above)
Description: Aspect dara was derived from the contour data using Arc/Info Grid tools. The vector contour data was rasterized using LINEGRID, and the Grid tool ASPECT() was used to derive aspect data from the resultant rasterized contours.

7.5 Minute USGS 1:24,000 Slope Degree

Title: 7.5 Minute USGS Slope Degree
Scale/Resolution: 1:24,000
Data Type: vector polygon coverage
Source: United States Geological Survey
Date: derived from 7.5 minute contour data using the Arc grid function SLOPE() tool
Coverage: complete Cypress Bayou Study Area (see quadmap list above)
Description: Slope data was derived from the contour data using Arc/Info Grid tools. The vector contour lines were rasterized using LINEGRID, and the Grid tool SLOPE() was used to derive slope data from the resultant rasterized contours.

7.5 Minute USGS 1:24,000 Slope Length

Title: 7.5 Minute USGS Slope
Scale/Resolution: 1:24,000
Data Type: vector polygon coverage
Source: United States Geological Survey
Date: derived from 7.5 minute contour data using the Arc grid function SLOPE() tool

Coverage: complete Cypress Bayou Study Area (see quadmap list above)
Description: Slope data was derived from the contour data using Arc/Info Grid tools. The vector contour lines were rasterized using LINEGRID, and the Grid tool SLOPE() was used to derive slope data from the resultant rasterized contours.

Geologic Atlas of Texas

Title: Geology from the Geologic Atlas of Texas
Scale/Resolution: 1:250,000
Data Type: vector polygon coverage
Source: The Bureau of Economic Geology, The University of Texas at Austin
Date: 1979
Coverage: Entire Cypress Bayou study area except for those areas within Louisiana.
Description: The geology data was created by digitizing 1:250,000 scale hard copy maps from the Geologic Atlas of Texas (produced by the Bureau of Economic Geology, The University of Texas at Austin). This file has been clipped to the Cypress Bayou Watershed Study study area. The area includes part of the Texarkana and Tyler sheets.

The original vector files were digitized in GRASS 4.1 software using v.digit from paper maps. They were imported into Arc Info v.7.0.2 software, where they were projected from UTM to Albers, and appended to create a single file.

Accuracy of these data is based upon the source hard copy map. At least 8 ground control points were used in registering the map to the UTM grid. Root mean square (RMS) errors were kept under 30 meters (for an explination of RMS error see John R. Jensen's Introduction to Digitial Image Processing, Prentice Hall 1986). Please note that the hard copy maps from which these files were taken were printed 20 years before they were digitized. Environmental stress on the paper will cause some data to be less accurate than the original 1:250,000 scale and 30 meter RMS error indicates.

Landsat Thematic Mapper (TM) Satellite Imagery

Title: Classified Landsat Full Scene, path 25 row 37
Scale/Resolution: 30 meters
Data Type: grid
Source: Earth Observation Satellite Company (EOSAT)
Date: April 7, 1994
Coverage: Original Full Scene Satellite Image covers approximately 185 km by 170 km - Classified Image has been subset to include Eastern three/quarters of Cypress Bayou Study area
Description: Original data was delivered from Defense Mapping Agency (DMA) Hydrographic/Topographic Center in Band Sequential (BSQ) format in Universal Transverse Mercator projection (Zone 15) using the Clark 1866 Earth Ellipsoid. Data were loaded into Erdas v.7.5 where an unsupervised classification was conducted of bands 1, 2, 3, 4, 5, and 7. The resultant classified file was converted to GRASS v.4.1 format and projected into Albers Equal Area Conic coordinates from the original UTM using i.rectify. The transformation coefficient matrix input into i.rectify was generated outside of GRASS. First, a shell script was executed that retrieved 676 coordinates spaced evenly at about 5 mile intervals from the original UTM projected maplayer. This file was then reprojected to create a new set of Albers coordinates using the "project file" tools in Arc/Info and the two sets of coordinate pairs (UTM and Albers) were pasted together in a format that i.rectify expects from i.points (the manual means of creating transformation matrix). The file was then imported into Arc/Info and clipped to the study area boundary of the Cypress Bayou Watershed Study.

Title: Classified Landsat Full Scene, path 25 row 37
Scale/Resolution: 30 meters
Data Type: raster file

Source: Earth Observation Satellite Company (EOSAT)
Date: July 28, 1994
Coverage: Original Full Scene Satellite Image covers approximately 185 km by 170 km - Classified Image has been subset to include Eastern three/quarters of Cypress Bayou Study area
Description: Original data was delivered from Defense Mapping Agency (DMA) Hydrographic/Topographic Center in Band Sequential (BSQ) format in Universal Transverse Mercator projection (Zone 15) using the Clark 1866 Earth Ellipsoid. Data were loaded into Erdas v.7.5 where an unsupervised classification was conducted of bands 1, 2, 3, 4, 5, and 7. The resultant classified file was converted to GRASS v.4.1 format and projected into Albers Equal Area Conic coordinates from the original UTM using i.rectify. The transformation coefficient matrix input into i.rectify was generated outside of GRASS. First, a shell script was executed that retrieved 676 coordinates spaced evenly at about 5 mile intervals from the original UTM projected maplayer. This file was then reprojected to create a new set of Albers coordinates using the "project file" tools in Arc/Info and the two sets of coordinate pairs (UTM and Albers) were pasted together in a format that i.rectify expects from i.points (the manual means of creating transformation matrix). The file was then imported into Arc Info and clipped to the study area boundary of the Cypress Bayou Watershed Study.

Title: Classified Landsat Movable Miniscene path 26 row 37
Scale/Resolution: 30 meters
Data Type: raster file
Source: Earth Observation Satellite Company (EOSAT)
Date: September 5, 1994
Coverage: Original Miniscene covers 100 by 50 km area - Classified Image has been subset to include Western one quarter of Cypress Bayou Study area
Description: Original data was delivered from Defense Mapping Agency (DMA) Hydrographic/Topographic Center in Band Sequential (BSQ) format in Universal Transverse Mercator projection (Zone 15) using the Clark 1866 Earth Ellipsoid. Data were loaded into Erdas v.7.5 where an unsupervised classification was conducted of bands 1, 2, 3, 4, 5, and 7. The resultant classified file was converted to GRASS v.4.1 format and projected into Albers Equal Area Conic coordinates from the original UTM using i.rectify. The transformation coefficient matrix input into i.rectify was generated outside of GRASS. First, a shell script was executed that retrieved 676 coordinates spaced evenly at about 2 mile intervals from the original UTM projected maplayer. This file was then reprojected to create a new set of Albers coordinates using the "project file" tools in Arc/Info and the two sets of coordinate pairs (UTM and Albers) were pasted together in a format that i.rectify expects from i.points (the manual means of creating transformation matrix). The file was then imported into Arc Info and clipped to the study area boundary of the Cypress Bayou Watershed Study.

Landcover

Title: Landcover
Scale/Resolution: 30 meters
Data Type: raster file
Source: USACE-PL-RE
Date: 1995
Coverage: Entire Cypress Bayou Study area
Description: Landcover types were derived from classification of multi-spectral data in the three Landsat Thematic Mapper (TM) Satellite images (2537-April, 2537-August, and 2637-September). Ground truth field data on vegetation and landcover were obtained by Texas Parks and Wildlife Department contractor Dr. Bill Sheffield using Global Positioning System (GPS) to record coordinates. These data were supplemented by limited field reconnassiance by USACE personnel through the project area as well as consultation with old aerial photographs where available.

Topologically Integrated Geographic Encoding and Referencing System (TIGER) Line Files

Title: TIGER/Line Files
Scale/Resolution: 1:100,000
Data Type: vector polygon, line, and point coverage
Source: US Department of Commerce, Economics and Statistics Administration, Bureau of the Census
Date: 1992 (May 1994 reissue)
Coverage: Entire Cypress Bayou Study area
Description: The TIGER/Line files are data that describe points, lines, and areas on maps processed in 1992 for the decennial census and sample survey programs by the US Census Bureau. The files contain information on streets, rivers, railroads, utility lines, as well as political/governmental boundaries and other features. The files are organized on a county basis. They have been subset for the counties encompassing the Cypress Bayou Watershed and processed for this project. TIGER/Line also contains reference information about geospatial data including address-range, housing, economics, demography, etc. which may be linked to the TIGER linefiles. These data have not been imported into Cypress Bayou GIS dataset but are available from the USGS.

USLE Annual Soil Loss Potential

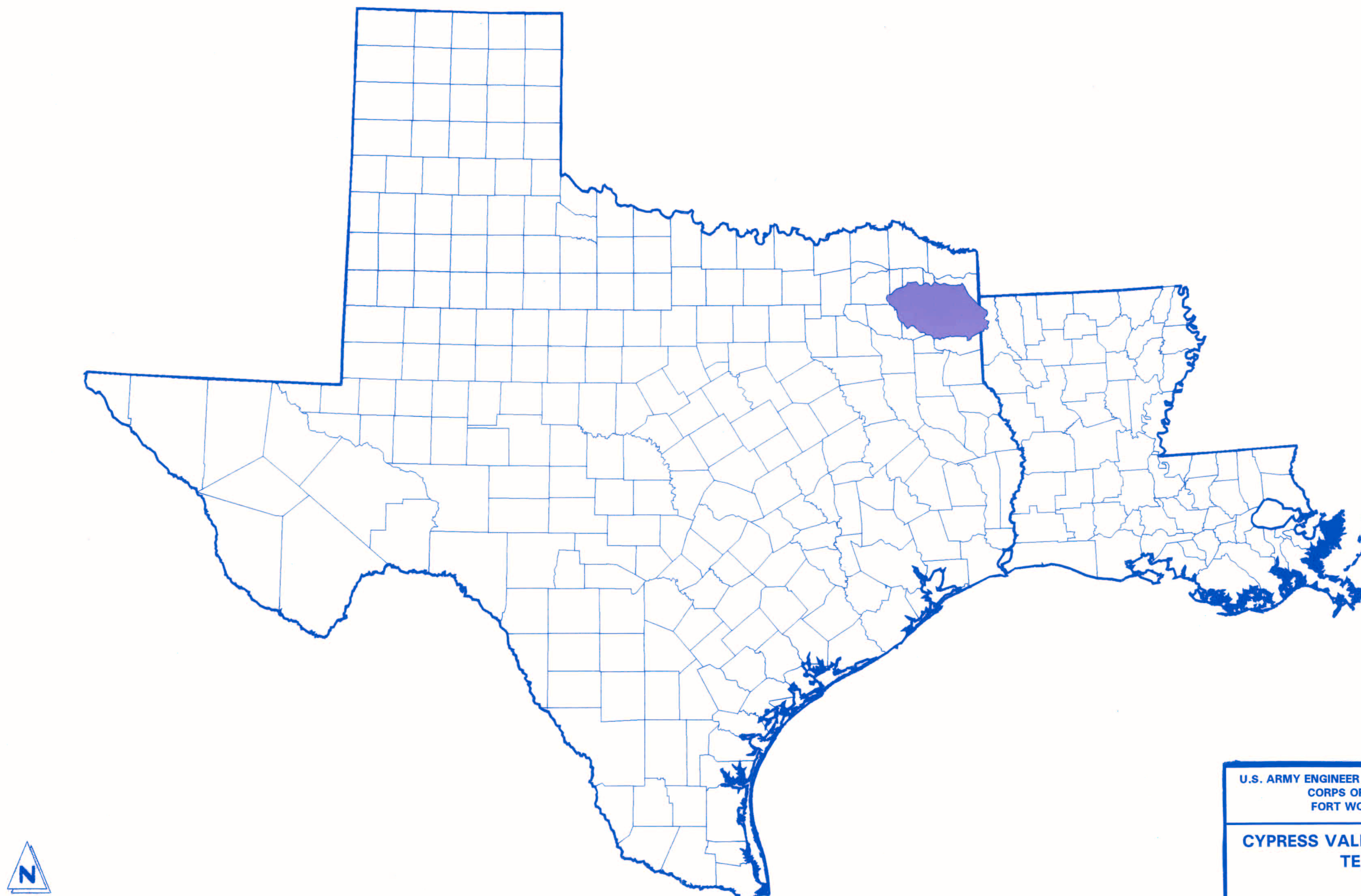
Title: Annual Soil Loss Potential
Scale/Resolution: 30 meters
Data Type: grid
Source: USACE-PL-RE
Date: 1995
Coverage: Entire Cypress Bayou Study area
Description: Annual soil loss potential through erosion was generated through the Universal Soil Loss Equation (USLE). Annual soil loss erosion using the USLE model is derived as the product of six factors: rainfall and runoff index (R), soil erodibility (K), length of slope (L), degree of slope (S), cropping management (C), and conservation practice (P). For the Cypress Bayou Watershed study, conservation practice (P), which pertains to agricultural land conservation management such as contouring, strip cropping, terracing, etc., was not used because no data were available for that detail of landuse. The other five factors were derived from three existing GIS layers: USGS 1:24,000 scale detailed contours, SSURGO detailed soils, and the Landsat TM satellite imagery based Landcover. The five factors were generated as separate GIS coverages and then combined in a stepwise sequence to produce the GIS coverage for annual soil loss potential.
Additional References:

Walker, Scott W.
1990 Modeling Land Use Change and Nonpoint Source Pollution Potential Using Remote Sensing and Geographic

Information System Technology. University of North Texas Masters Thesis. Denton.

Wischmeier, Walter H. and Dwight D. Smith
1978 Predicting Rainfall Erosion Losses - A Guide to Conservation Planning. Agriculture Handbook Number 537 United States Department of Agriculture.

Cypress Bayou Watershed Study - Location of Study Area



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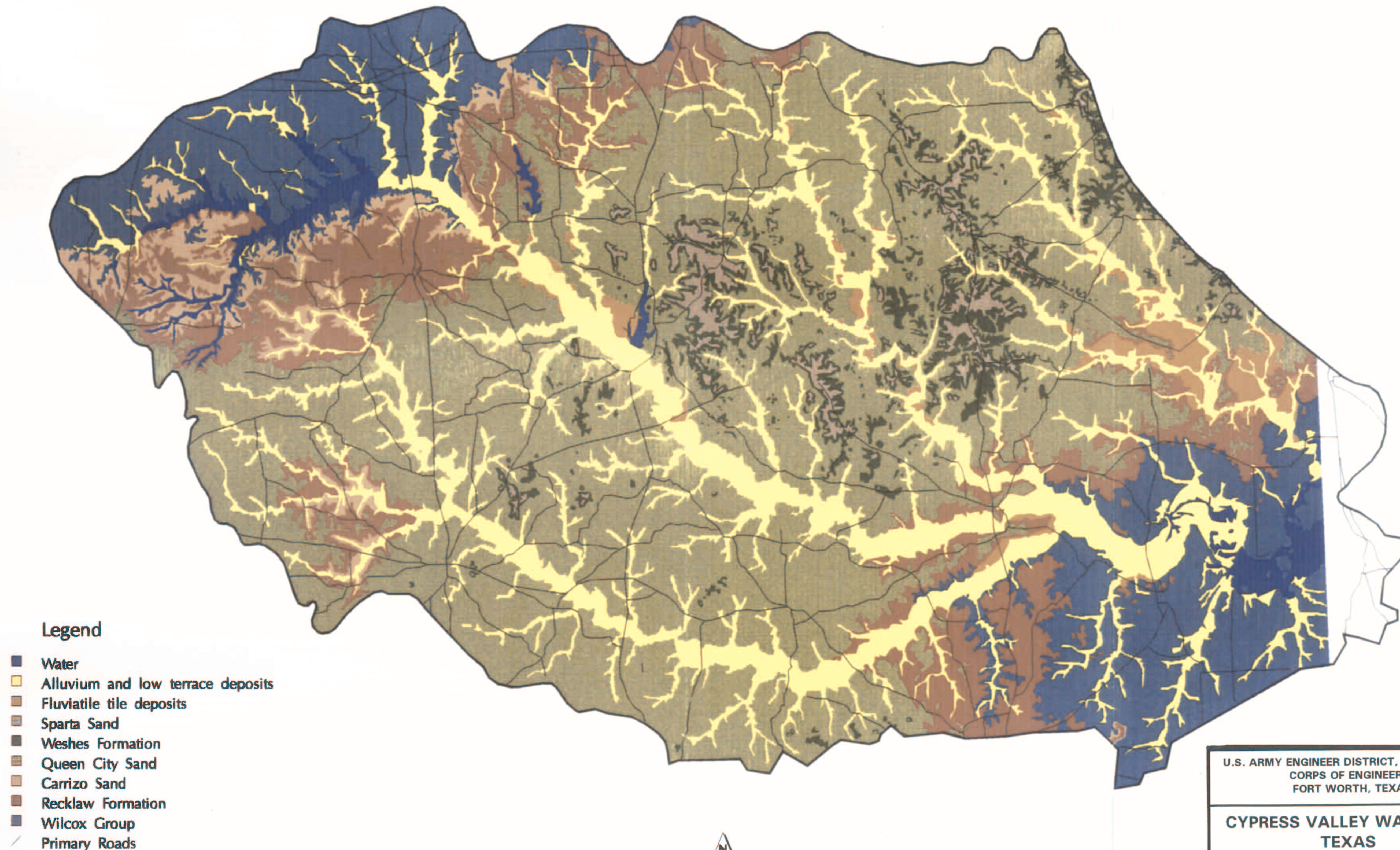
FORT WORTH, TEXAS

CYPRESS VALLEY WATERSHED
TEXAS

FIGURE 1

Cypress Bayou Watershed Study - Geology



Source: The Geologic Atlas of Texas - The University of Texas, Bureau of Economic Geology 1966

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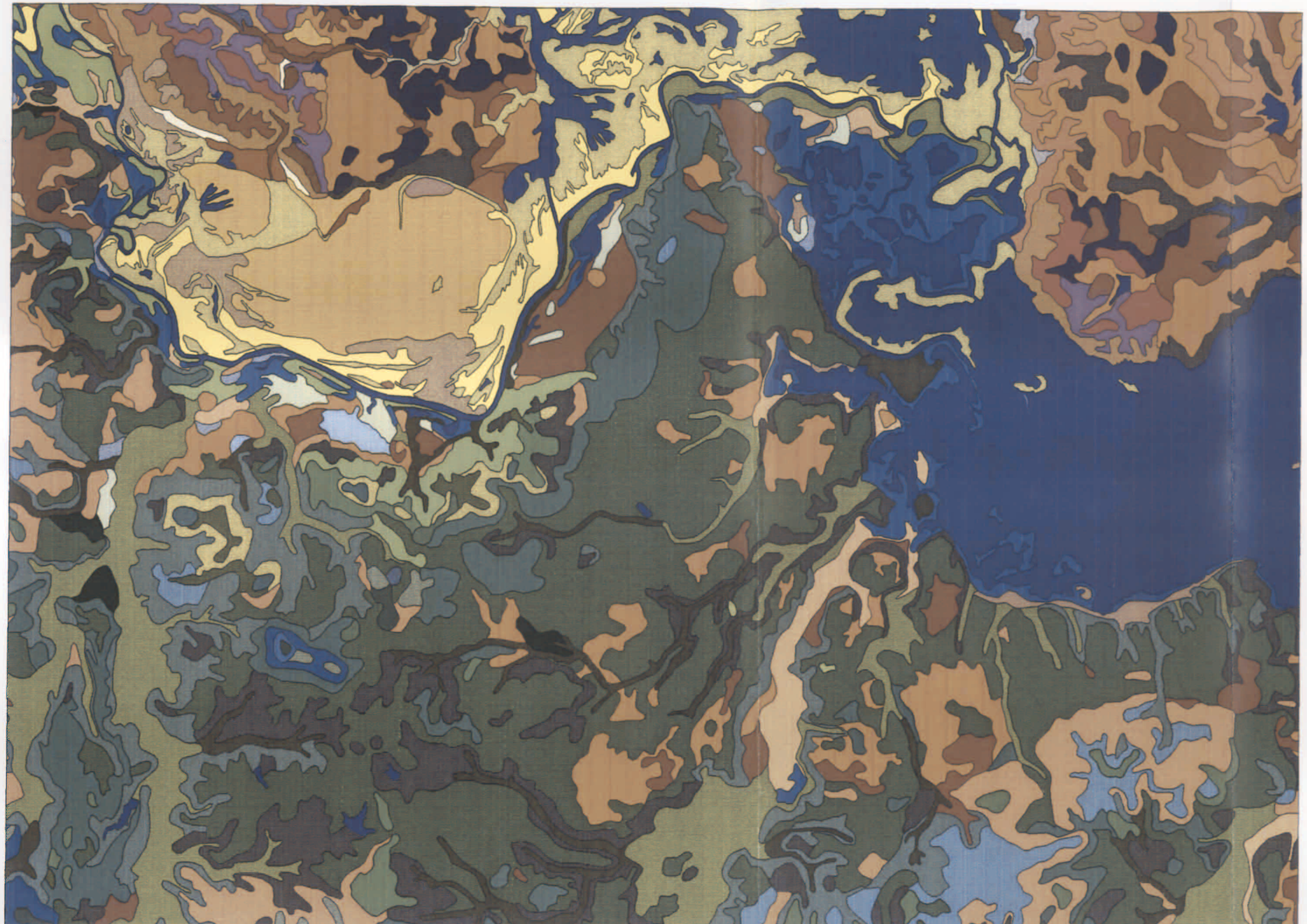
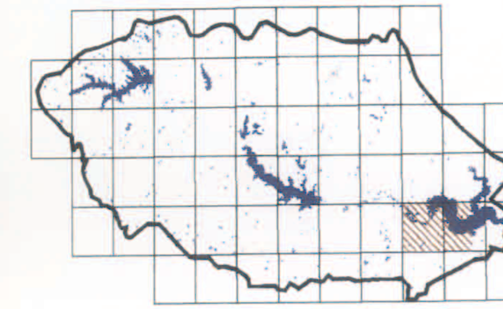
FIGURE 2

Cypress Bayou Watershed Study

Detailed soils in the southwest Caddo Lake area





Location of USGS 7.5 minute quads within the study area

Source of data:
United States Geological Survey

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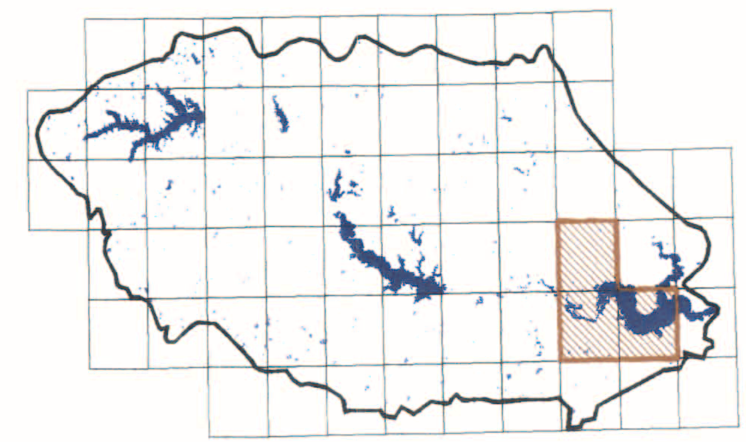
FIGURE 3

Cypress Bayou Watershed Study

Detailed topography in the Caddo Lake State Park area



Location of USGS 7.5 minute quadrangles within study area

Source of data: United States Geological Survey

contour interval = 10 feet

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FIGURE 4