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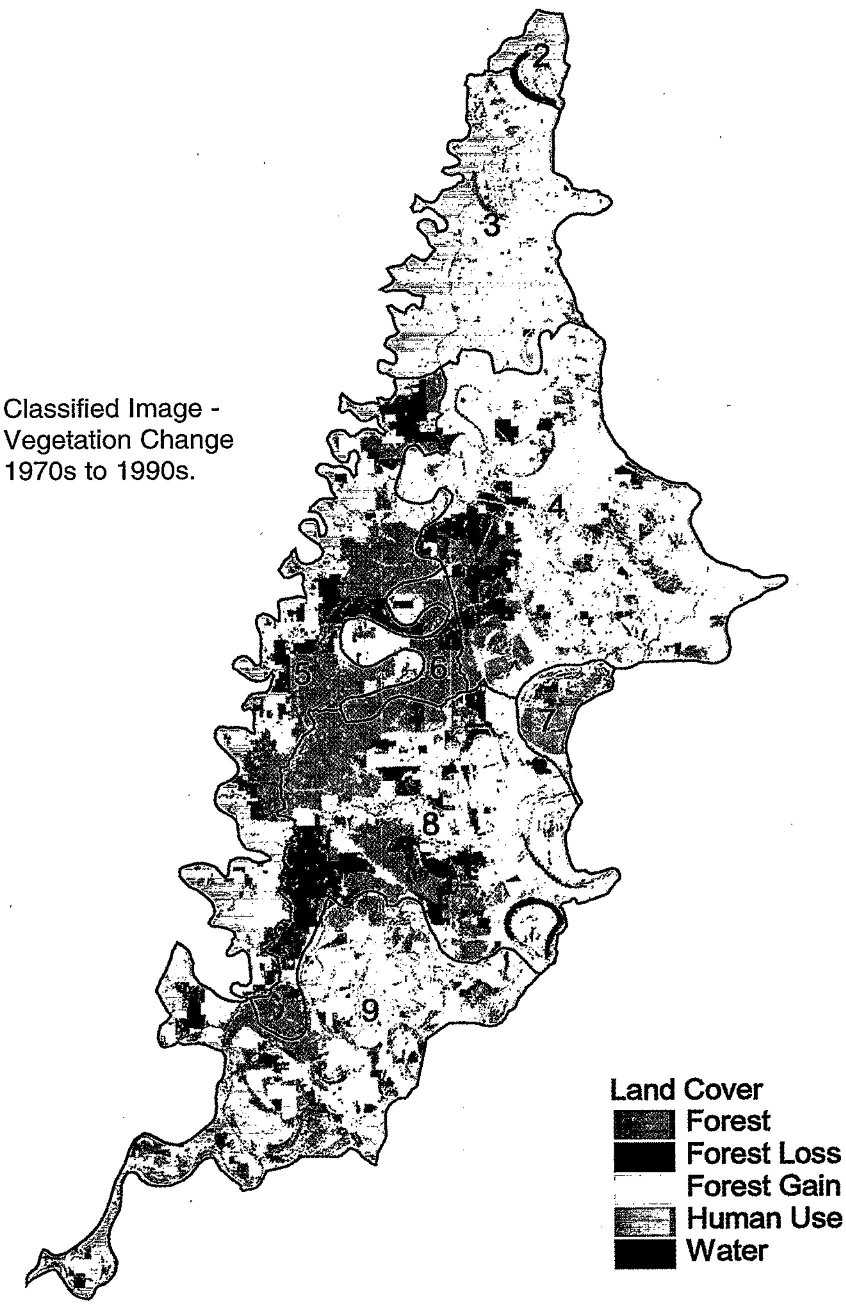
An Ecological Assessment of the Louisiana Tensas River Basin

Classified Image - Vegetation Change 1970s to 1990s.



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An Ecological Assessment of the Louisiana Tensas River Basin

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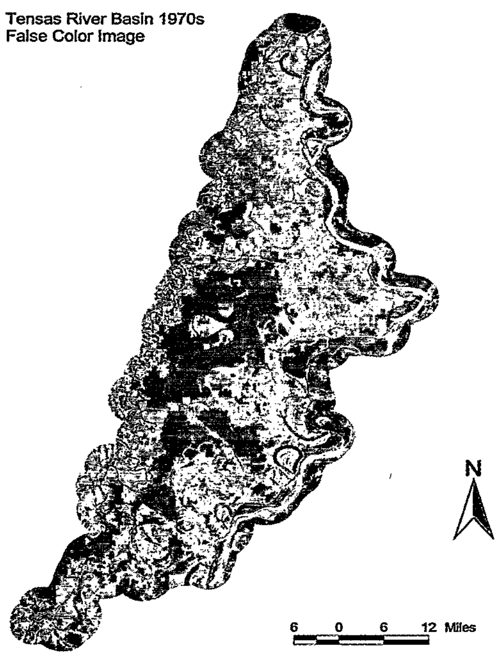
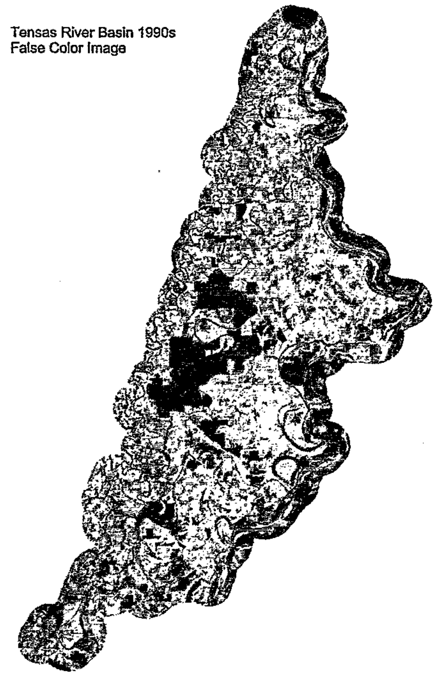




These images illustrate the 12% decrease in total forested landcover between the early 1970s and the early 1990s.

Tensas River Basin

The purpose of this document is to give the results of an ecological assessment using landscape ecology and water quality methods in the Tensas River Basin, Louisiana. This assessment can be used as a tool to estimate the impact of human land use practices that are being currently implemented to improve environmental quality. It can be also used for ecosystem targeting and help people make good decisions on the best location for restoration sites. The U.S. EPA's Office of Research and Development, Landscape Ecology Branch did this work under the guidance of U.S. EPA Region 6, the Louisiana Department of Environmental Quality and the U.S. EPA Gulf of Mexico Program by way of the Regional Applied Research Program (RARE).

The Tensas River Basin encompasses approximately 930,000 acres of Mississippi River alluvial flood plain in Northeast Louisiana. Historically, most of the Basin was covered with bottomland hardwood forested wetlands. The bottomland hardwood wetlands of the Tensas River Basin have been described as some of the richest ecosystems in the country in terms of diversity and productivity of plant and animal species. At the same time, these cleared lands are recognized as some of the Nation's most productive farmland for grain and fiber. The result is a conflict of land use between traditional row crop agricultural interests and a concern for a healthy, diverse, and stable ecosystem.

The Tensas River Basin is a target watershed of several U.S. Environmental Protection Agency environmental studies including the Nonpoint Source Management Program, U.S. EPA Region 6, and the Gulf of Mexico Program. The Nonpoint Source Management Program has identified watersheds in Louisiana which have been impaired by nonpoint pollution and where land use practices contribute to these pollutant problems. This program identified specifically what types of best management practices need to be implemented to improve environmental conditions. Using the existing data and with the cooperation of landowners, the Tensas River Basin offered a unique opportunity to implement best management practices that could help reduce the concentration of sediment, excess nutrients, or pesticides leaving the Basin. The nutrients leaving the Tensas River Basin, combined with other Mississippi Valley watersheds, are of concern to the Gulf of Mexico Program because research has shown that excess nutrients cause hypoxia (<2 mg/l oxygen) in the bottom waters of the Gulf of Mexico. This condition represents a threat to the coastal marine ecosystem and fisheries in this region of the Gulf. Landscape Ecology methods provide a tool to assess the impact of human landuse practices that are being implemented to improve environmental quality.

In years past, the freshwater marshes, stream bank areas, and bottomland swamps of the Tensas River Basin were under strong development pressures. Large portions of forest near streams and in backwater swamp areas were converted to agriculture. This loss of forested areas decreased filtering capacity that normally removes pollution and nutrients before they enter streams, lakes, and estuaries. Wetland forests also dissipate energy and nutrients associated with extreme precipitation events and therefore reduce damage to down-stream farms and cities resulting from floods. The Tensas River Basin is unique in that natural levees along the riparian vegetation lie on the highest ground in the Basin. This causes drainage water to run parallel to streams for many miles before actually entering the stream and river water channels. Wetlands and backswamps then become the vegetation filtering areas for pollutants and nutrients. Preserving or restoring wetland forests have other economic benefits including wetland-based recreation, including hunting and harvesting wetland plants. The people who live within the Tensas River Basin realize that the vegetation along a stream and in backswamp areas can influence the condition of both the stream bank and the water in the stream. Restoration efforts began in the early 1990s.

The strip of vegetation along streams is known as the riparian vegetation zone. It is commonly described by the types of vegetation it contains and by the presence of water. In an ideal situation, many pollutants and fertilizers will be intercepted or absorbed by the riparian vegetation and it's root system. This helps to keep the streams clean. Bank erosion is also mitigated by intact riparian vegetation. The conditions of the riparian ecosystem over a whole watershed can be studied in order to learn where, for example, a restoration project would most improve water quality. Similarly, a characterization of riparian conditions over the entire Tensas River Basin can help to identify which areas of the Basin are most likely to see improved water quality as a result of riparian vegetation improvements.

Land cover is the product of past land uses on the backdrop of the biophysical setting. A map of landcover is essentially a picture of the dominant vegetative, water, or urban cover in an area. The images of land cover in the Tensas River Basin for 1972 and 1991 (see above) are based primarily on images taken by the Landsat Multispectral Scanner satellite since the early 1970s. The land cover map was based on the North American Landscape Characterization (NALC) data, a Federal effort to create similar data for the entire country. The resolution of the land cover data is 60 meters, so each pixel (picture element) represents an area about the size of a football field. Although individual pixels are far too small to be rendered accurately here, the visual impression of broadscale regional patterns is readily apparent. Forest vegetation shows up on the image as red in color, agriculture shows up as light red, grey, light blue and white and almost always shows a pattern with rows or right angles typical of farm fields.

These images were then classified for landuse. The classifications were forest, human use (urban and agriculture) and water. Through the use of computerized Landscape analyses, the 1972 image was compared to the 1991 image and changes in forest areas and human use areas were calculated. As the images show, there was a tremendous forest loss over that time period. In 1972 the land cover types forest and agriculture covered an area of about 34% and 65% of the area, respectively. In 1991 the land cover types forest and agriculture covered an area of about 22% and 77% of the area, respectively. Where forests have been removed, agriculture and urban land covers become more dominant, this can be seen by comparing the images to observe the forest loss over 20 years.

The images also show how the forest, agriculture and urban landcover vary across the landscape of the Tensas River Basin. Understanding the variation of landcover with respect to landscape features, such as cities, roads, lakes and streams, is the foundation of the landscape ecological assessment. Other landscape indicators include: population density and change, human use index, roads, roads along streams, percentage of forest cover, forest fragmentation, percent of the watershed in the largest forest patch, forest analysis of the Tensas River Basin, vegetation change, vegetation change by subwatershed, forest and crop land along streams, watershed indicators, riparian analysis, vegetation change along the Tensas River Reach, backswamp area analysis, soil erodibility analysis, and wetland restoration analysis.

The Tensas River Basin is one of 2,099 individual watersheds located across the United States. Many people throughout the United States are restoring riparian vegetation areas and are in need of GIS and landscape methods to help them make good decisions on the best locations for restoration sites.

Chapter 1: Taking a Broader View

The Gulf of Mexico Program is working with its partners including U.S. EPA Regions 4,5,6, and 7 to identify approaches to reduce nutrients in the surface waters of the Mississippi River System. The problem is being addressed at the scale of the larger watershed (Mississippi River System). This report reflects the Landscape Ecology research done to characterize changing landscape patterns as they relate to potential changes in nutrient loading for one river basin. This approach can be refined and applied to other watersheds within the Mississippi River System.

Environmental quality is important to everyone. It affects our health, our quality of life, the sustainability of our economies, and the futures of our children. Yet pressures from an increasing population coupled with the need for economic development and an improved standard of living often result in multiple impacts on our natural resources. And, just as a person with a less-than-healthy life style is more prone to infection, a weakened ecosystem is less able to withstand additional stress. Unfortunately, it is often difficult to see these changes in environmental quality because they occur slowly or at scales we do not normally consider.

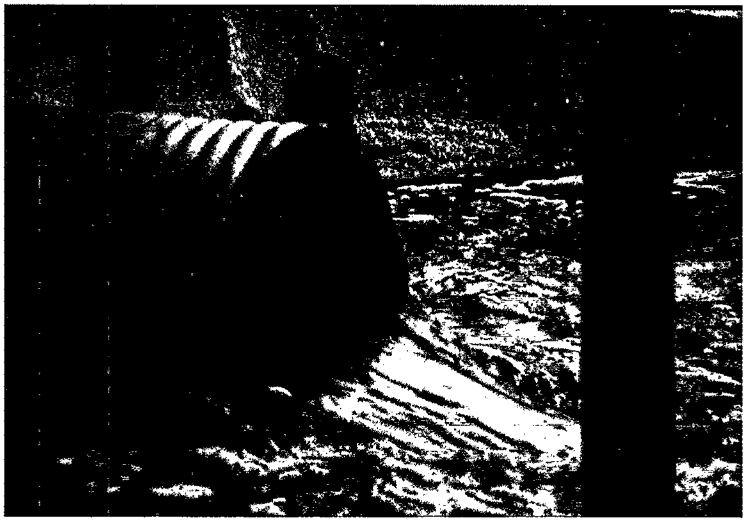
There is growing public, legal, and scientific awareness that broader-scale views are important when assessing regional environmental quality. In the past, media attention has focused on dramatic events, focusing our environmental awareness on local or isolated phenomena such as cleaning up Superfund sites, stopping pollution from a drainage pipe, saving individual endangered species, or choosing a site for a parish landfill. In an era of environmental legislation, monitors of environmental quality responded to legal standards, like those for drinking water or air quality, and as a result they reported very narrow views of the environment. Given this view of the world, scientists studied fine-scale model systems and considered humans to be external factors. Today, our perceptions are changing. We realize that humans and our actions are an integral part of the global ecosystem, and that the environment is complicated and interconnected with human activities across local and regional scales. We have begun to take a broader view of the world and of our place in natural systems.

Technology has advanced in ways that make it easier to obtain new views of overall environmental quality. Larger patterns and processes can be studied by using computers and satellites. These technologies, combined with a better understanding of how the pieces fit together, help to understand where we are now with regard to environmental quality, where we hope to be in the future, and what steps need to be taken to get there.

This atlas takes advantage of some of these technologies in assessing environmental conditions over the Tensas River Basin of Louisiana.

Just as we now watch broad-scale weather patterns to get an idea of whether it will rain in the next few days, we can develop a better assessment of current environmental conditions by combining regional and local-scale information. Broad-scale weather patterns are important because they affect and constrain what happens locally on any given day. By taking a broader view of the environment, or widening our perspective about how the environment is put together, it becomes easier to see where changes occur and to anticipate future problems before they materialize.

Bottom-land Hardwood forest of the Tensas River Basin.



Environmental issues, such as nutrient runoff are identified by the Tensas Technical Steering Committee.

Purpose and Organization of this Atlas

This atlas presents an environmental assessment of the Tensas River Basin of Louisiana (Figure 1.1). The assessment was conducted by using measurements derived from satellite imagery and spatial data bases and summarized by subwatersheds. The information presented in this atlas is intended to help visualize and understand the changing conditions across the watershed and how this pattern of conditions can be used as a context for understanding community-level situations within the region.

The atlas is divided into five chapters with one appendix. This chapter introduces the reasons for doing a broad-scale regional analysis of environmental condition. Chapter 2 places the Tensas River Basin into the context of the lower 48 states. Chapter 3 presents an analysis of landscape conditions in the Tensas River Basin and briefly explains the landscape analysis methodology. Chapter 4 discusses water quality issues in the Tensas River Basin. Chapter 5 presents some recommendations for future efforts. The Appendix provides additional data that could not be included in Chapters 3 and 4.

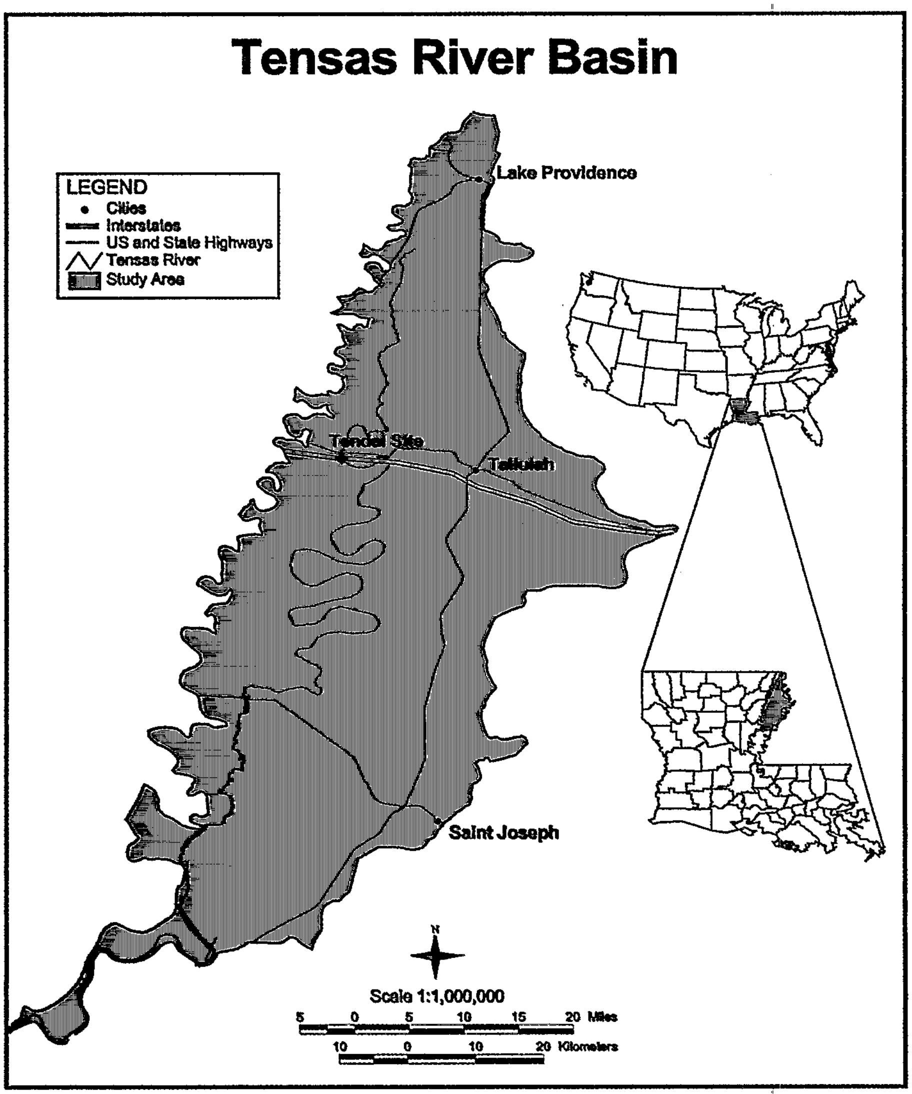


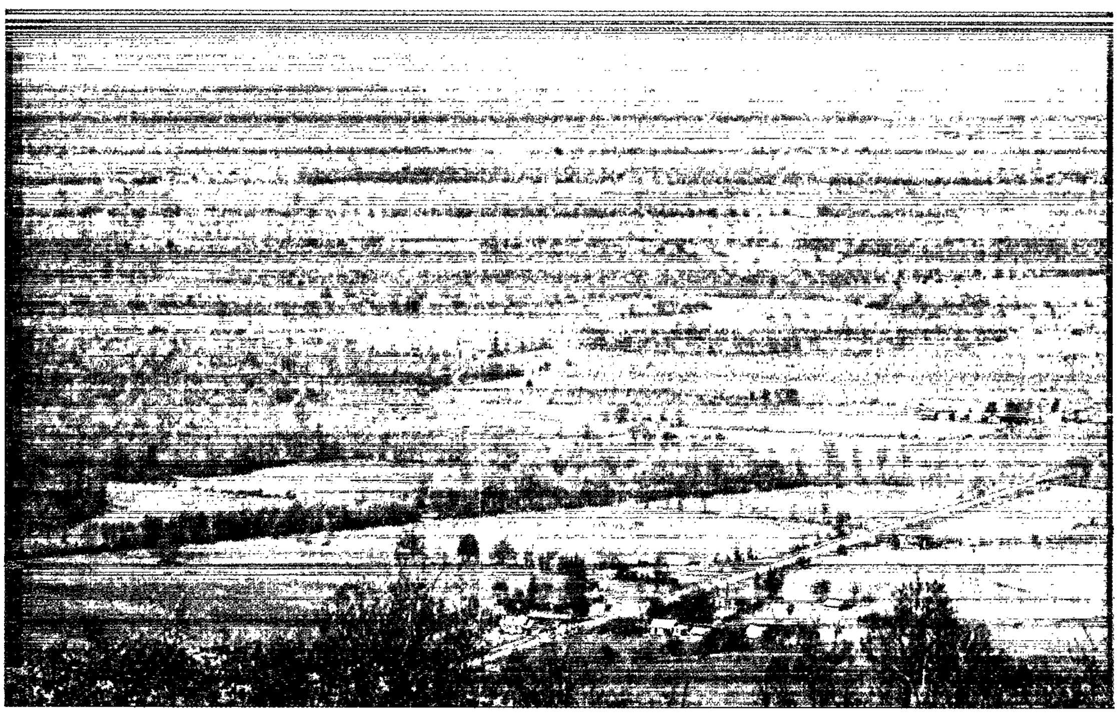
Figure 1.1

Landscape Ecology and the Analysis of Broad–Scale Environmental Condition

To most people, the term "landscape" suggests either a scenic vista or a backyard improvement project. To ecologists and other environmental scientists, a landscape is a conceptual unit for the study of spatial patterns in the physical environment and the influence of these patterns on important environmental resources. Landscape ecology is different from traditional ecology in several ways. First, it takes into account the spatial arrangements of the components or elements that make up the environment. Second, it recognizes that the relationships between ecological patterns and processes change with the scale of observation. Finally, landscape ecology includes both humans and their activities as an integral part of the environment.

There are many applications for landscape ecology and broad-scale information in regional assessments. For example, we can identify the areas that are most heavily impacted today by combining information on population density, roads, land cover, and air quality. In the Tensas River Basin, we already have good information (from the U.S. Census Bureau) about which areas are most urbanized. But which areas have only a small proportion of stream length bordered by adjacent forest cover? Which areas are characterized by a high degree of forest fragmentation? What percentage of forest loss occurred on wet soils? What about information for watersheds instead of areas? Broad-scale measurements can be taken in order to make relative comparisons of these indicators over the entire region.

Another use of this approach is to identify the most vulnerable areas within the watershed. Vulnerable areas are not yet heavily impacted, but because of their circumstances they are in danger of becoming so.



One example might be an area that has a relatively high percent of forest cover, but that is also experiencing rapid gains in human use of the land. Such an area might be more vulnerable to forest fragmentation than a similar area with less human use or less forest area.

A third application of this approach is to place localities into a watershed and/or regional context. Some individual towns and rural areas in the Tensas River Basin may seem isolated, perhaps within a large forested area. However, all are connected by physical features and by ecological processes. Water flows from one place to another, roads provide a connecting infrastructure, and land cover patterns of forest and agriculture form a connected backdrop for all of our activities. While land management decisions are made and implemented at a local scale, a watershed perspective can guide our decisions and make us better stewards of our environment. By placing our homes, farms, neighborhoods, and government organizations into a watershed landscape picture, we can begin to make informed decisions that consider not only our goals and actions, but our neighbor's as well.

What are Landscape Indicators and How Do They Help to Understand Environmental Conditions?

Figure 1.2 illustrates how a single community is linked to the landscape at several different scales and across different mapping units (watersheds and parishes in this example). Tallulah is highlighted in the middle of the figure. At this scale we concentrate on individual land parcels and roads, and our decisions are based on a local perspective. Broader-scale perspectives emerge as we follow the lines up either side of the figure. We see that the community is part of both a subwatershed (left) and a parish (right), which, in turn, are components of groups of watersheds and parishes. These larger groups are components of the entire region. This is an important concept because local environmental issues can have regional impacts.

An indicator is a number that is calculated by summarizing data. The indicator calculations may also consider related data or use a model to improve reliability. Well known economic indicators include the seasonally-adjusted unemployment percentage and number of housing starts, both of which indicate overall economic condition. In these indicators, seasonal adjustment is made with a model, and most economists look at several indicators together instead of just one at a time. Similarly, landscape indicators can be measurements of ecosystem components (such as the amount of forest) or processes (such as net primary productivity), and models can be used to help interpret the measurements in order to understand overall ecological conditions.

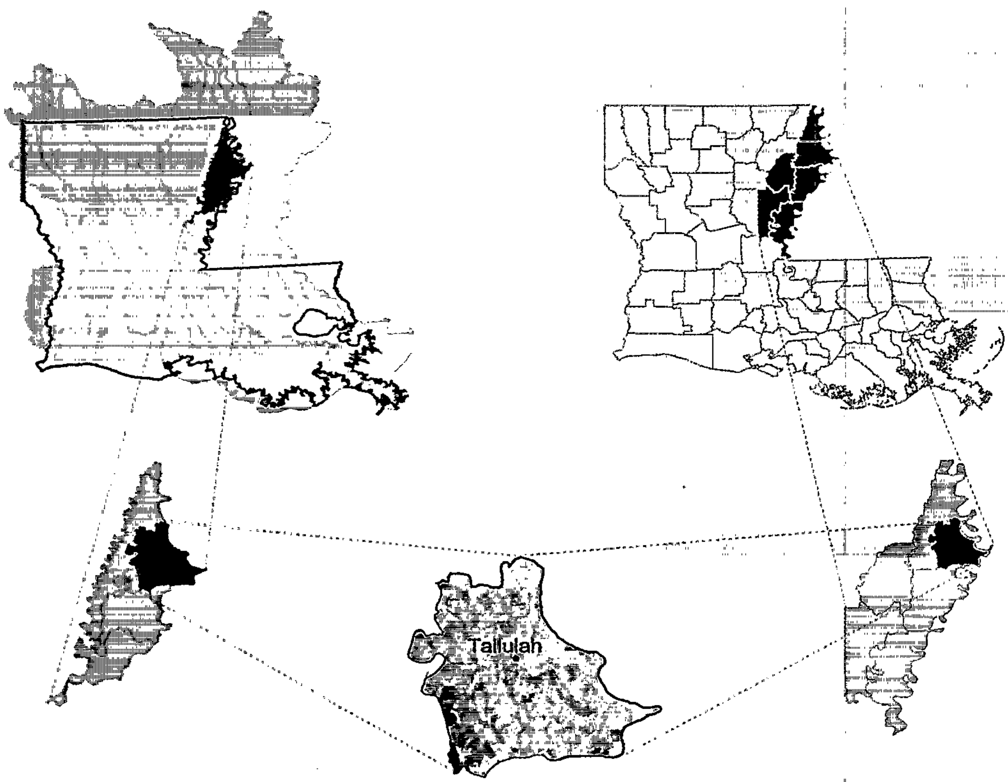


Figure 1.2

This figure may help to understand how a city (bottom center) fits into a larger context of either watersheds (left branch) or parishes (right branch).

Figure 1.3 shows an example of measuring spatial patterns as an indicator of stream conditions. The distribution of streamside land cover has been mapped for the same subwatershed that is shown in Figure 1.2. Stream segments that are green have adjacent forest; orange indicates that streams are next to agriculture or urban land covers. The pattern of streams in relation to land cover is an indicator of conditions within the stream. Forests often filter pollutants, preventing them from reaching the water, whereas agricultural and urban landuse often contribute pollutants to streams. They also dissipate energy associated with major precipitation events; this reduces nutrient loading and the severity of flooding. A simple summary indicator might be the percentage of stream length in the parish that is adjacent to forest land cover. To refine this indicator, a model might help to account for "natural" conditions, for example whether or not forest was the natural land cover for the parish.

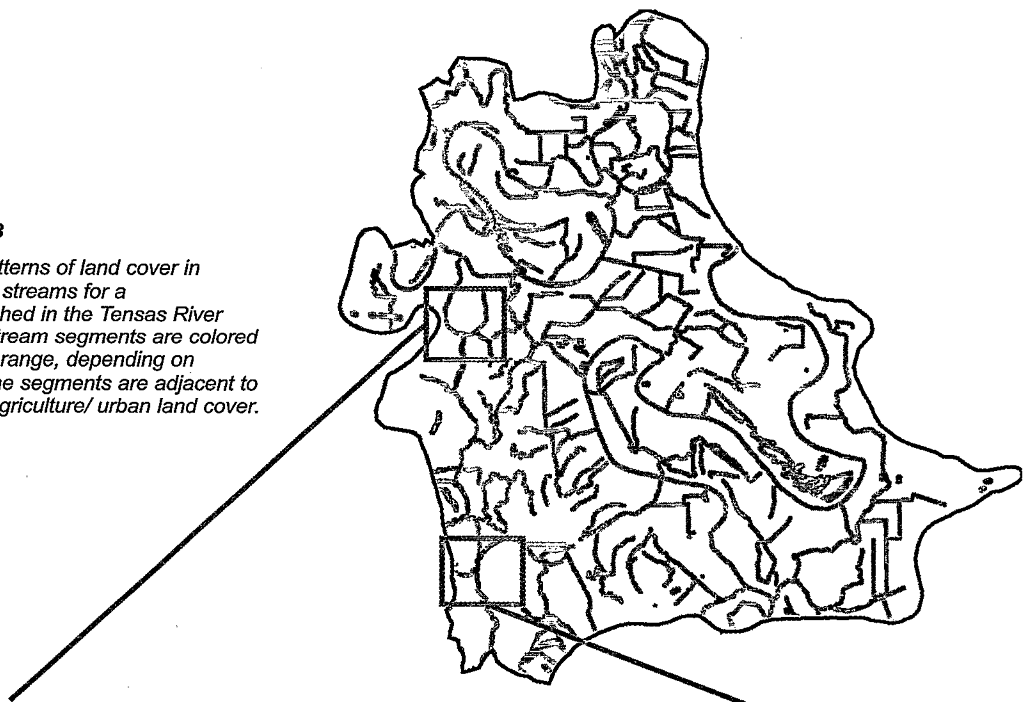
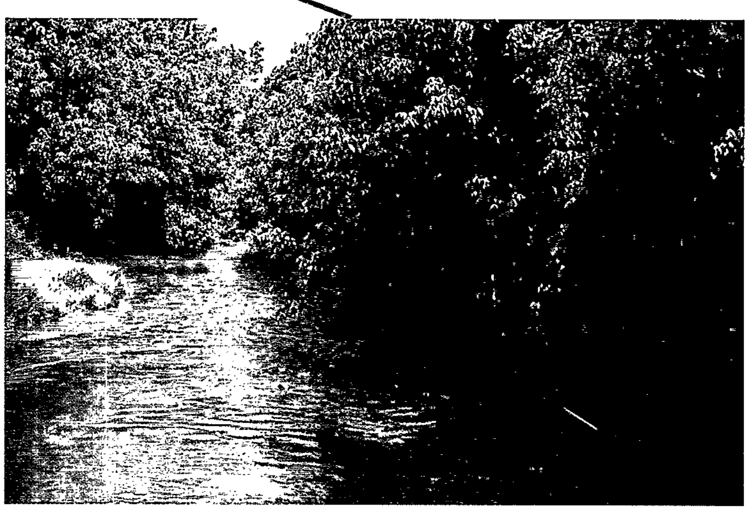


Figure 1.3

Spatial patterns of land cover in relation to streams for a subwatershed in the Tensas River region. Stream segments are colored green or orange, depending on whether the segments are adjacent to forest or agriculture/ urban land cover.



How Were the Landscape Indicators Selected?

The starting point for selecting indicators was what people in the area said they cared about. These concerns were then matched to our ability to make meaningful measurements, recognizing that some things just can't be measured very well given the available data or models. As a result of workshops and advice from people who live in the Tensas River Basin, three general environmental themes were identified--human use, forest and water. These three themes and the indicators measured within each theme are discussed in detail in Chapter 3.

Figure 1.4 shows an example of a landscape indicator. In this example you can see that if forest patches are not connected, the forest is more vulnerable to the disturbance. Figures 1.5 and 1.6 are pictorial representations of key landscape attributes that affect the sustainability of environmental condition across broad scales.

Figure 1.5 shows some key landscape components that sustain a high quality environment, and Figure 1.6 shows some human modifications of the landscape that can reduce the sustainability of natural resources. These figures, although not of the Tensas River Basin, illustrate some of the important landscape indicators analyzed in this atlas.

Landscapes are very complicated, and the generality of the conceptual models is an accurate reflection of the level of scientific understanding of landscape dynamics. Scientists who study landscape ecology are trying to improve our ability to interpret landscape indicators relative to environmental values. The improvements will help to interpret the information that is contained in this atlas, and will also suggest new landscape indicators or new ways to measure the ones that are included here. In the meantime, it is worth exploring how much is known about regional conditions, and what can be said by using state-of-the-art landscape indicators.

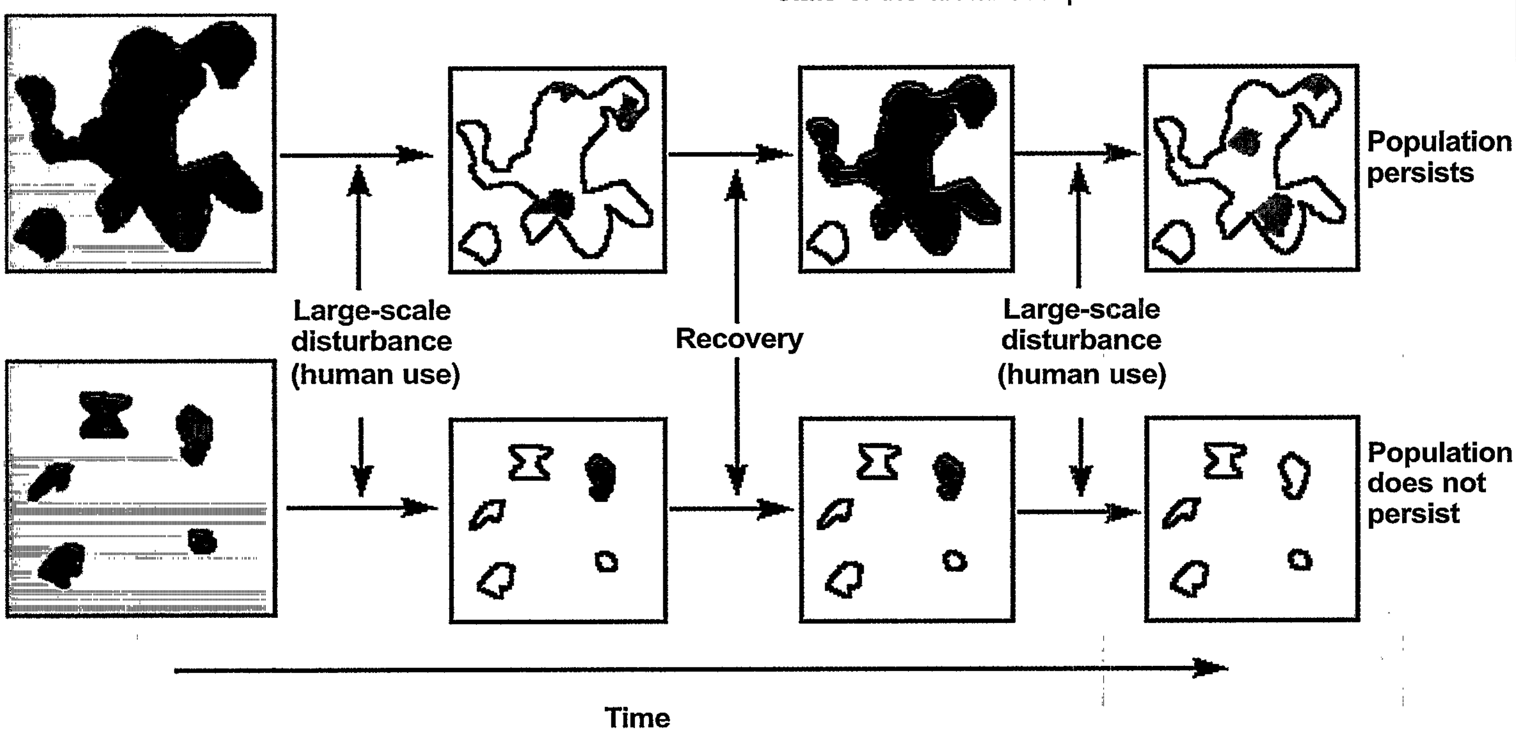


Figure 1.4

Forest fragmentation can result in the loss of a species due to natural disturbance. In this example larger, more connected forest sustains the species over time, whereas smaller, more isolated habitat loses the species over time. (In this example, tan is non-forest, red is occupied forest, and white is unoccupied forest.)

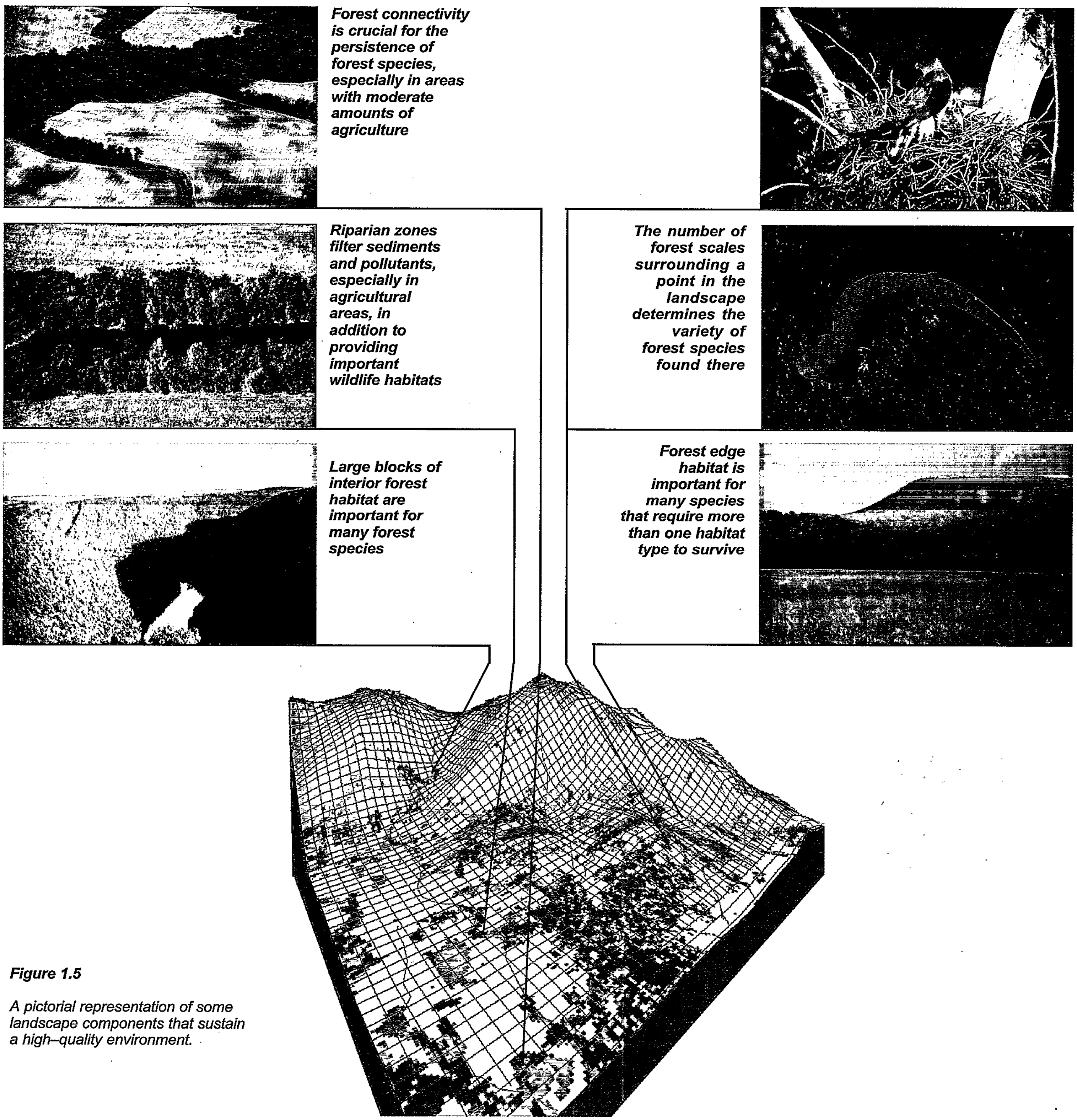
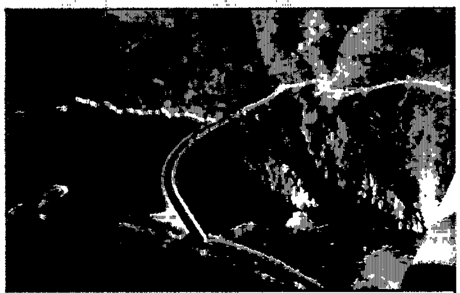


Figure 1.5

A pictorial representation of some landscape components that sustain a high–quality environment.



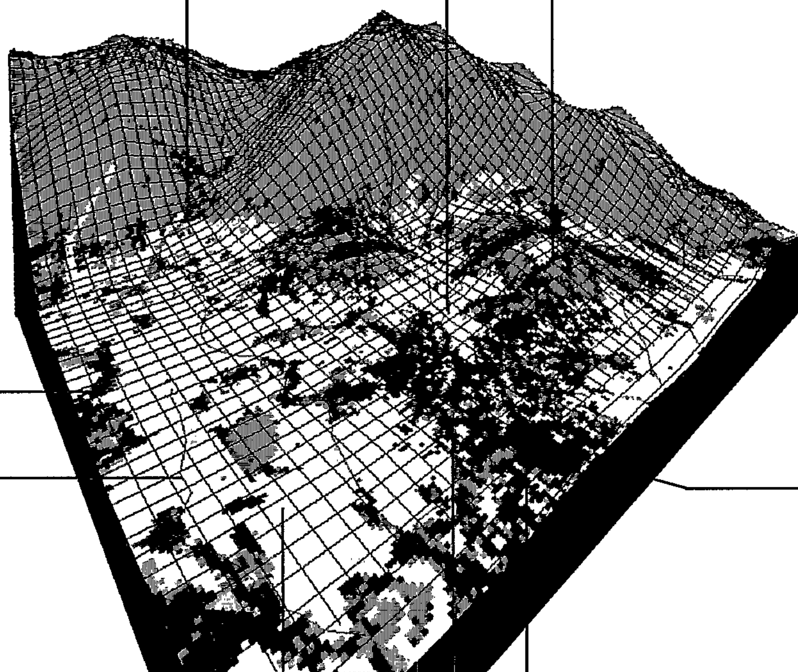


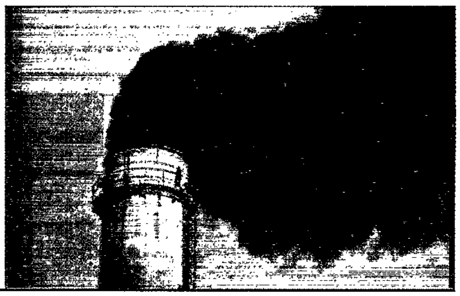
Figure 1.6

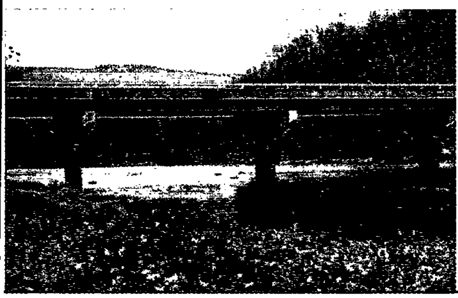
A pictorial representation of some human modifications of the landscape that reduce the sustainability of natural resources

Humans reduce riparian cover along streams, which decreases filtering capacity

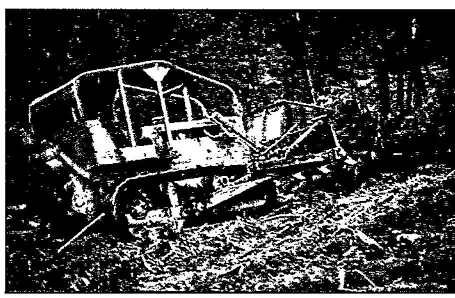
Forest harvest practices influence forest connectivity and patch sizes

Air pollution spreads across the landscape, affecting regional air quality





Roads near streams increase sediment and pollution loads by increasing surface runoff



Population growth results in loss of forest and changes in overall watershed landscape pattern

How Were the Landscape Indicators Measured?

Many kinds of data were used to prepare the indicators shown in this atlas. Federal agencies were the primary source for data, including maps of elevation, watershed boundaries, road and river locations, population, soils, and land cover. Sources included the U.S. Geological Survey (USGS), the U.S. Environmental Protection Agency (EPA), the U.S. Department of Agriculture (USDA), the U.S. Census Bureau, the U.S. Fish and Wildlife Service, the Louisiana Department of Environmental Quality, The Mississippi Alluvial Plain Project of The Nature Conservancy, and the North American Landscape Characterization (NALC) Program.

Data collected by satellites were used to map land cover and its change over time. The sensors carried on satellites measure the light reflected from the Earth's surface. Because different surfaces reflect different amounts of light at various wavelengths, it is possible to identify land cover from satellite measurements of reflected light. Figure 1.7 illustrates the differential reflectance properties of water, sediments suspended in water, and land surfaces for a typical satellite image. Examples of land cover maps derived from satellite images appear later in this atlas.

In a typical digital map, data are stored as a series of numbers for each theme. These maps can be thought of as checkerboards, where each grid square (or pixel, which is an abbreviation of "picture element") represents a data value for a particular landscape attribute (for example soils, topography, or land cover type) at a specific location.

Figure 1.7

Illustration of differential light reflectance properties for water, sediments suspended in water, and land surfaces over a portion of Vancouver, British Columbia -These images can be manipulated in various ways to extract information about the Earth's surface.
Source: North American Landscape Characterization Program

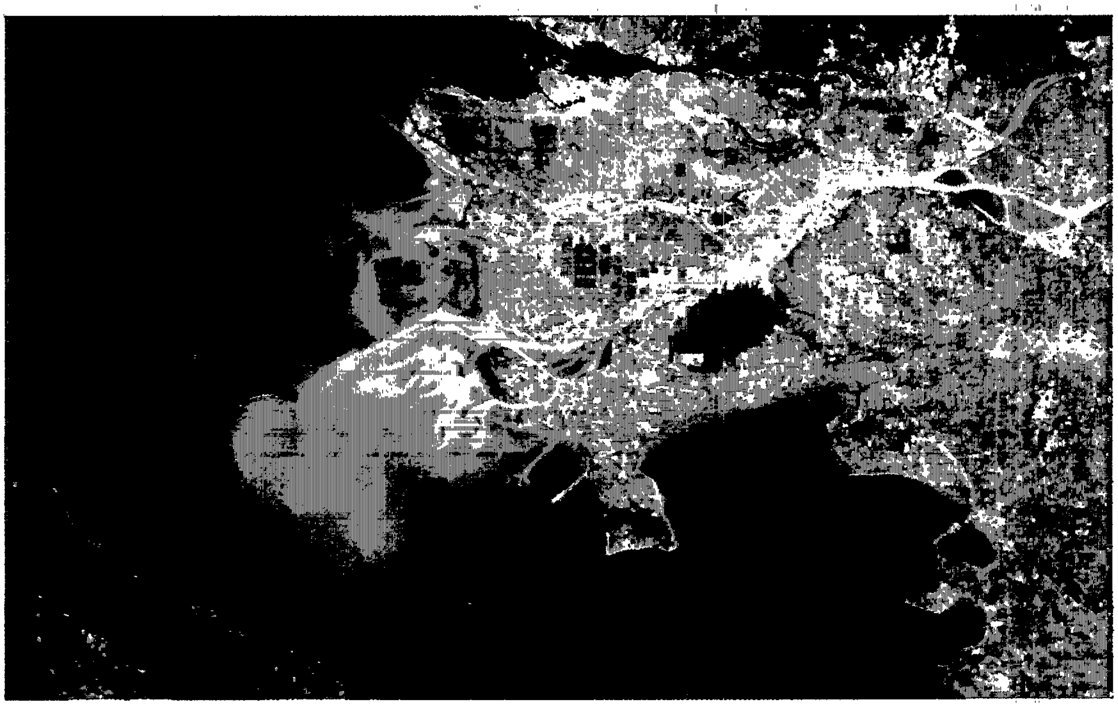


Figure 1.8 illustrates one method of measuring a landscape indicator. This method ("overlaying") simply overlays maps of different themes in order to extract information about spatial relationships among the themes. These relationships are then stored as a new map which combines the information from the original set of maps.

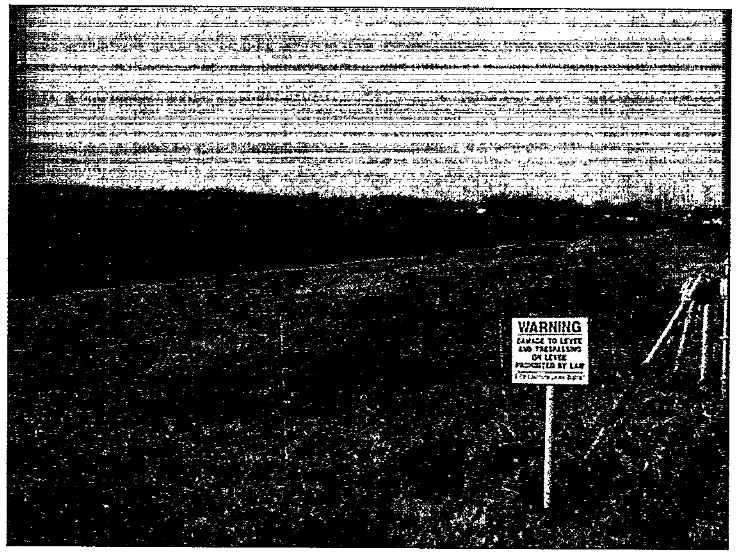
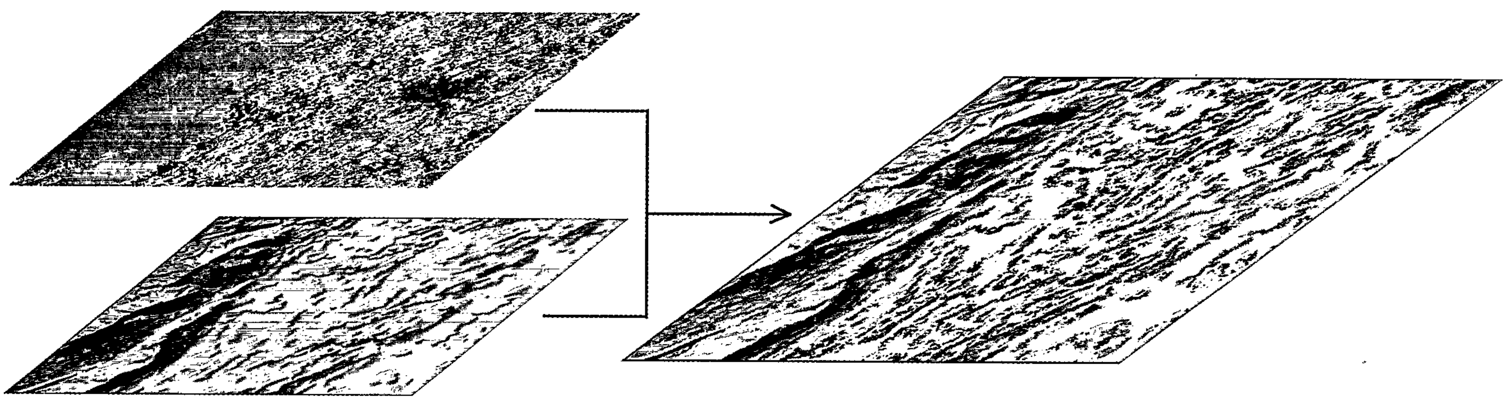


Figure 1.8

Land cover (with agriculture in red) is combined with topography to indicate agriculture on steep slopes. The combined map shows agriculture on slopes greater than 3%.

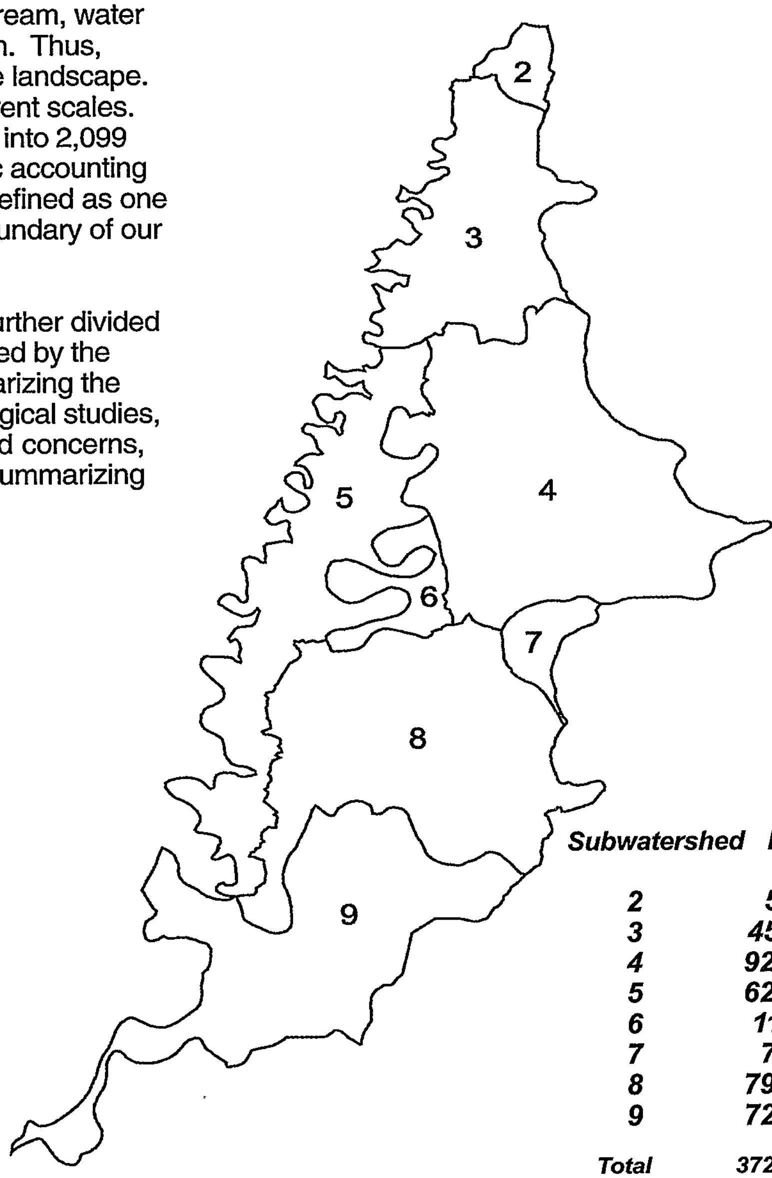


How Were the Landscape Indicators Summarized?

Usually, a watershed is defined as a catchment area that is drained by a single stream or river (i.e., the Mississippi watershed consists of all the area drained by the Mississippi river system, including all tributaries). The dividing lines between watersheds are formed by ridges. Water on one side flows into one stream, water on the other side flows into a different steam. Thus, watersheds are a natural unit defined by the landscape. Watersheds can be defined at several different scales. The USGS has divided the contiguous U.S. into 2,099 watershed units known as 8-digit hydrologic accounting units (HUCs). The Tensas River Basin is defined as one of these 8-digit HUCs and serves as the boundary of our study area.

The Tensas River Basin 8-digit HUC was further divided into 11-digit HUCs or subwatersheds (defined by the USDA) as a basis for analyzing and summarizing the landscape data (Figure 1.9). In many ecological studies, especially those which assess water-related concerns, subwatersheds are an appropriate unit for summarizing data.

The next chapter will look at the landscape from a national perspective. As you read about the national landscape, see how the Tensas River Basin compares to other watersheds in the United States.



Subwatershed	*Hectares*
2	*5625*
3	*45532*
4	*92534*
5	*62012*
6	*11136*
7	*7353*
8	*79748*
9	*72365*
Total	*372000 (Hectares)* *930000 (Acres)*

Fig 1.9

Tensas River Basin divided into subwatersheds. Each subwatershed was given a unique number (2-9) for this report.

Chapter 2: The National Context

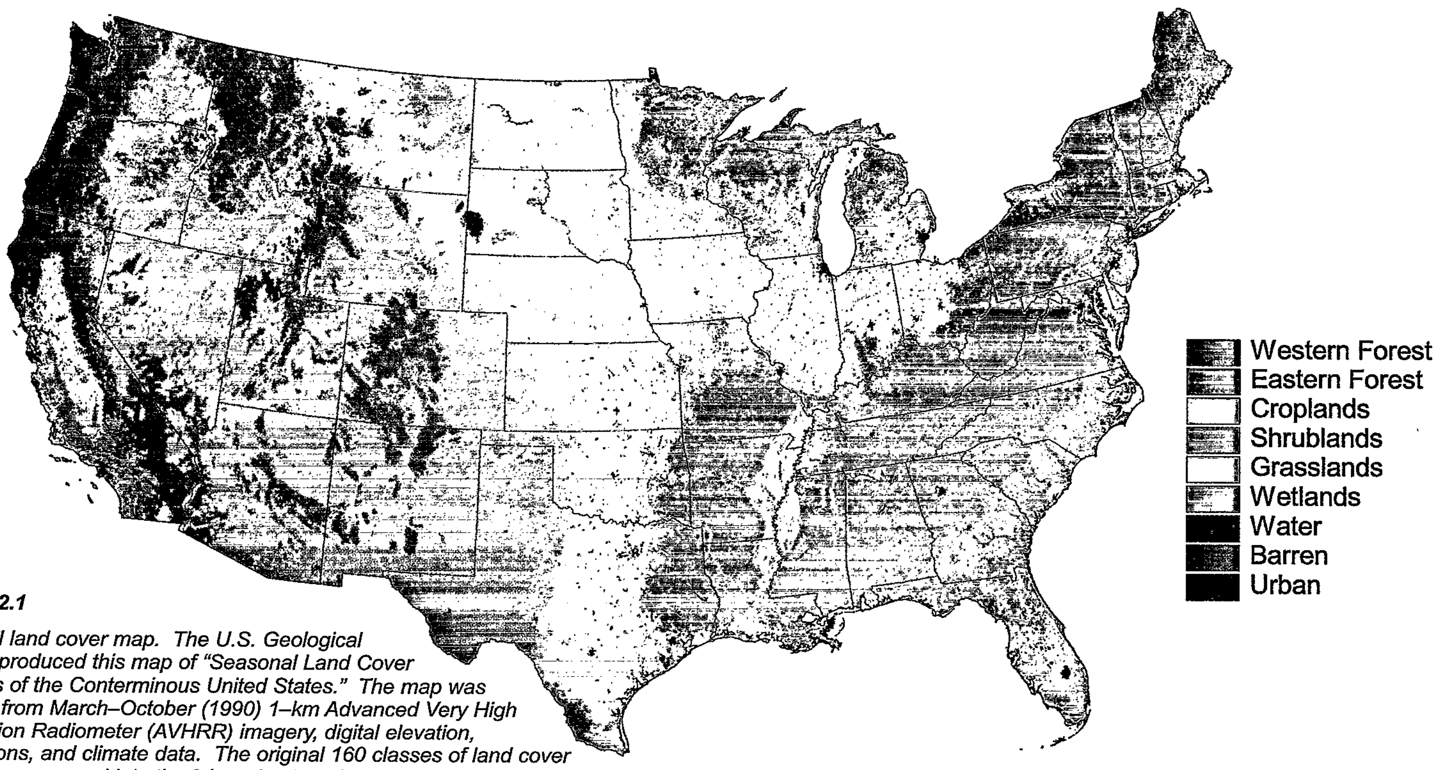
Before looking in detail at the Tensas River Basin, it is helpful to place the Basin within a national perspective. This chapter paints a picture of the lower 48 United States, showing differences and patterns among watersheds at a continental scale. A national context helps us interpret the overall condition of the Tensas River Basin, relative to the rest of the country. It also helps to determine if conditions like those found in the Tensas River Basin are likely to exist elsewhere.

While it would be desirable to look in great detail over the entire nation, in practice only a few aspects of environmental condition can be described in a consistent fashion nationwide. The coarse-scale maps in this chapter show watershed rankings based on a variety of landscape indicators. The rankings portray relative conditions across the nation but do not show the absolute values of indicators for each watershed. Indicator values are summarized in the companion bar charts.

Data Sources

Four main data sources were used here. The most important was a national map of land cover (Figure 2.1) which describes the types of vegetation covering an area, whether it is forest, crops or pasture, or covered with water or urban areas. Although the resolution (spatial and land cover) is fairly coarse (1 square kilometer and 9 of the original 160 land cover classes), the familiar national pattern is apparent-forests in the East, grasslands and crops in the Midwest, and shrublands, deserts, and mountain forests in the West. The Tensas River Basin is typical of the alluvial valley of the lower Mississippi River, riverside urban areas, agricultural valleys and plains, and forested wetlands. The variety of the land cover types in the Tensas River Basin, relative to other regions in the United States, can make spatial pattern an important ingredient for making environmental decisions in this region.

Some additional information was used to calculate the indicators of environmental quality nationwide. Figure 2.2 shows the maps of roads, streams, and watersheds. Clearly, not all the roads and streams are included. These maps may be appropriate for a nationwide overview, but much more detailed maps are needed for regional assessments such as the Tensas River Basin analysis described later. The watershed boundaries (Figure 2.2) identify 2,099 individual watershed units across the United States.



igure 2.1

lational land cover map. The U.S. Geological Survey produced this map of "Seasonal Land Cover Regions of the Conterminous United States." The map was erived from March–October (1990) 1–km Advanced Very High Resolution Radiometer (AVHRR) imagery, digital elevation, coregions, and climate data. The original 160 classes of land cover ave been grouped into the 9 broad categories shown here.

For each watershed, the nine indicators (Table 2.1) included in this chapter were calculated from land cover and from the spatial relationships among roads, streams, and land cover.

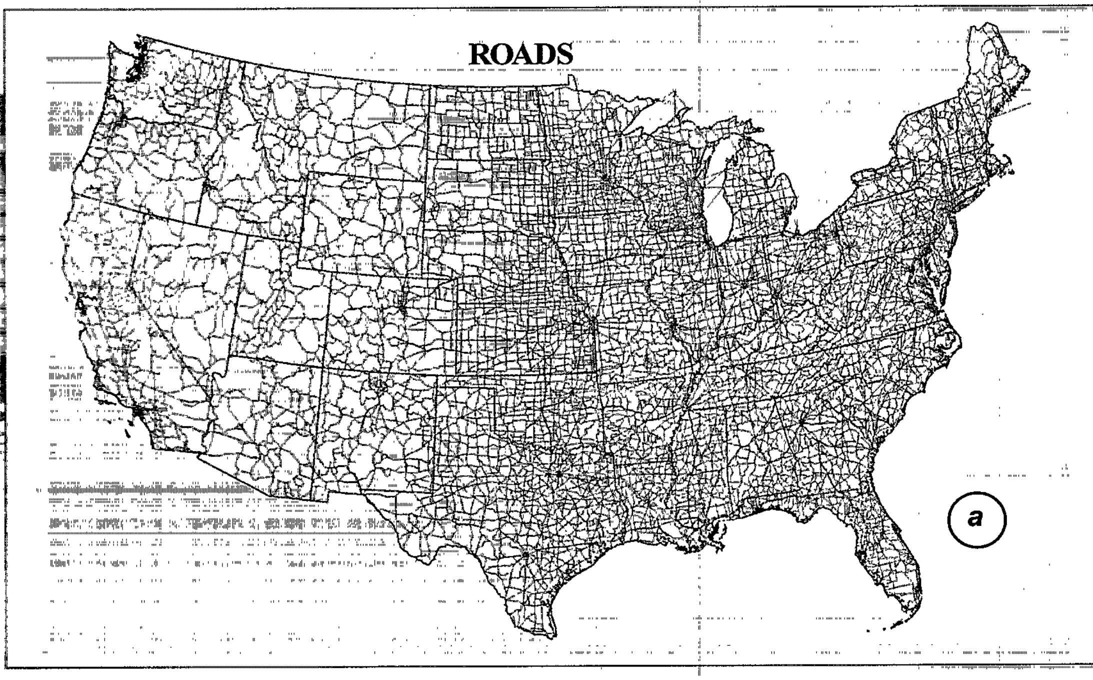
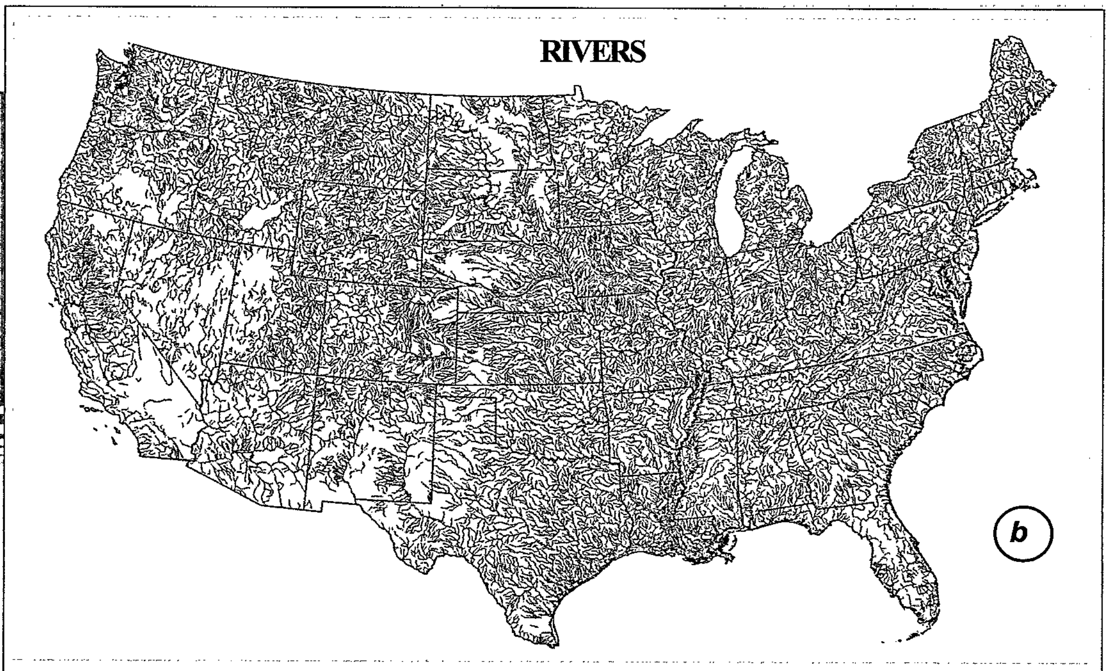


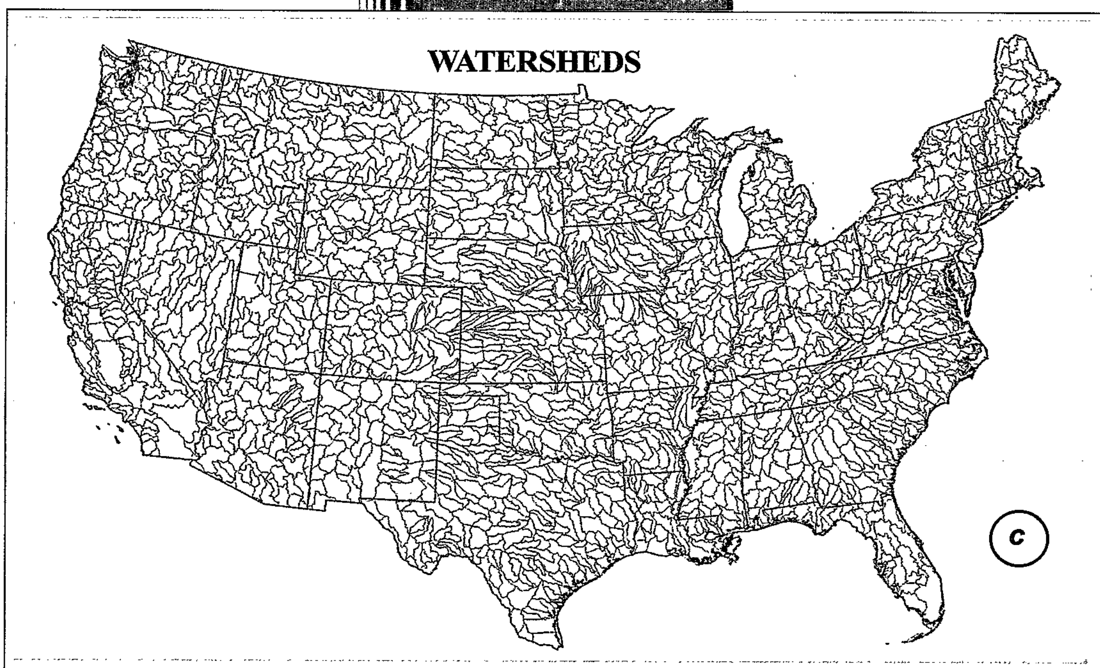
Figure 2.2

National maps of (a) roads, (b) rivers, and (c) watershed boundaries. The maps are from the ArcUSA distribution of the U.S. Geological Survey Digital Line Graph maps of rivers (1973) and roads (1980), and the U.S. Geological Survey map of 8–digit hydrologic accounting units.

Table 2.1 List of landscape indicators used for the national context.

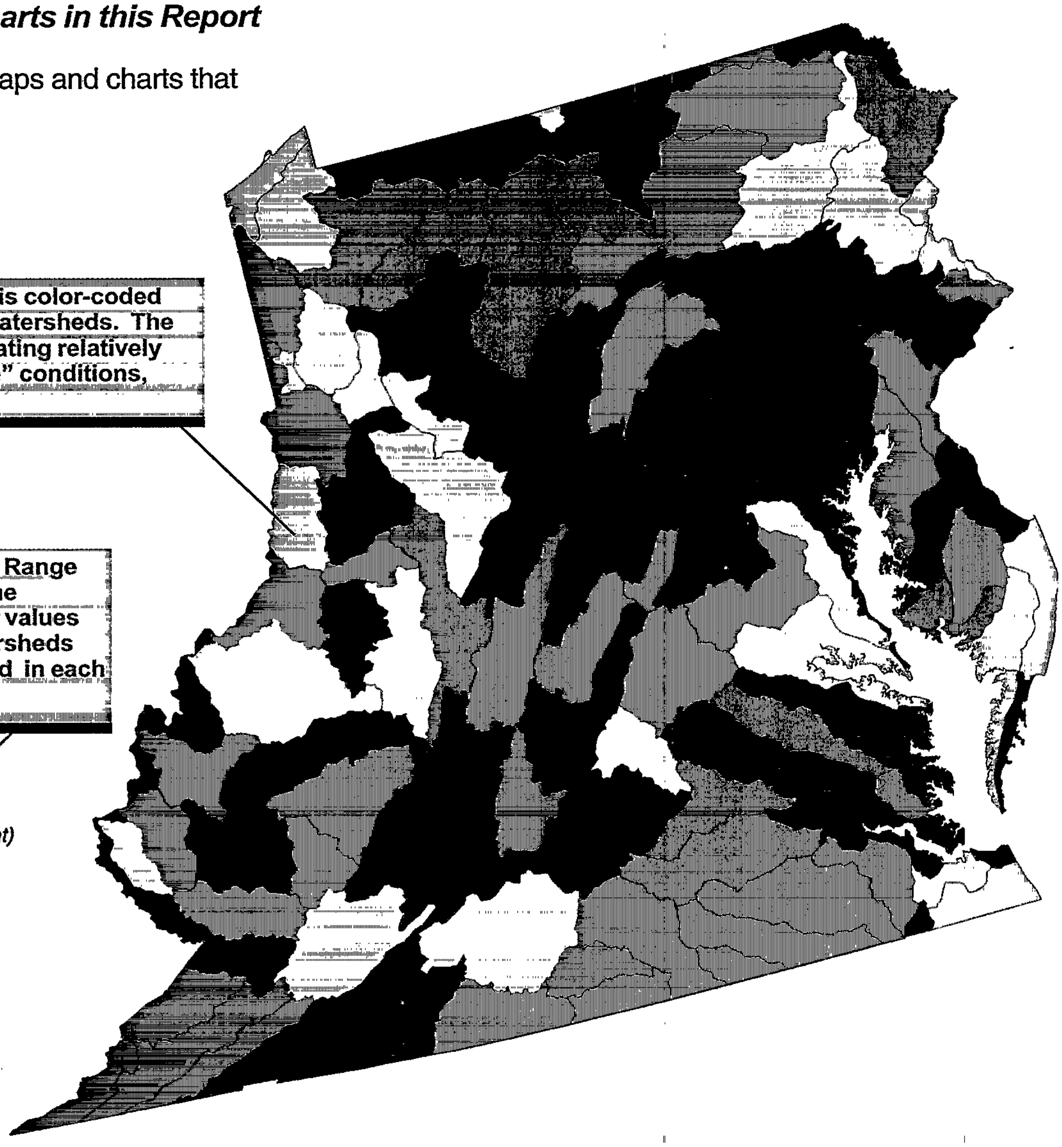
U–Index (proportion of watershed area with anthropogenic land cover)
Agriculture Index (proportion of watershed area with agriculture land cover)
Number of natural land cover types per unit area
Proportion of watershed that has forest land cover
Average forest patch size as a percentage of watershed area
Index of forest connectivity
Proportion of total stream length with forest land cover
Proportion of total stream length with anthropogenic land cover
Number of roads crossing streams per unit stream length

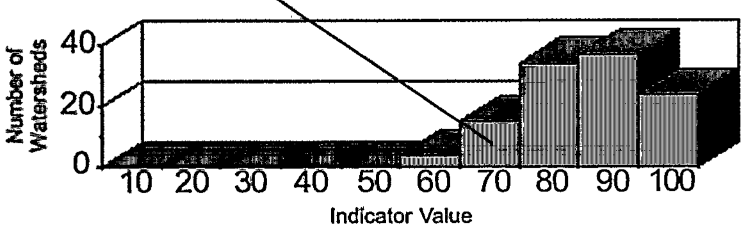

RIVERS
b


WATERSHEDS
c

How to Read the Maps and Charts in this Report

Figure 2.3 illustrates the types of maps and charts that appear in Chapter 2.





A brief explanation of the essential methods is given.

Woody landcover along streams was calculated as the percent of streamlength with forest landcover types. By intersecting a buffer zone around each stream with the landcover, a data set is created which records all landcover types within a specified distance to stream center.
Sources: USGS 1:100,000 River Reach 3 stream data, and MRLC 30 meter Landsat land-cover data.

Figure 2.3

How to read the maps and charts in this report.

Human Use Patterns

One of the simplest and most informative indicators of environmental impact is the extent to which humans have changed the natural vegetation to crops or urban land cover. These indicators are easy to interpret because profound land cover changes influence almost every aspect of the environment from wildlife habitat to soil erosion.

The national maps of human use intensity (Figure 2.4) show watershed rankings for both total human use-agriculture plus urban (Figure 2.4a) and only agriculture (Figure 2.4b). Urban areas are relatively minor in terms of total area, and farming areas are more extensive, so the two maps are very similar. Most of the human appropriation of land has occurred in the central United States and along the eastern seaboard. Higher elevations and the dry southwest appear to have been less impacted by conversion to agricultural or urban land cover. Like most of the south, Louisiana has a complicated pattern of land use that deserves more detailed attention.

The chart gives some details about the distribution of human use intensity among watersheds. You can see that about 40% (800) of the watersheds have had only minor

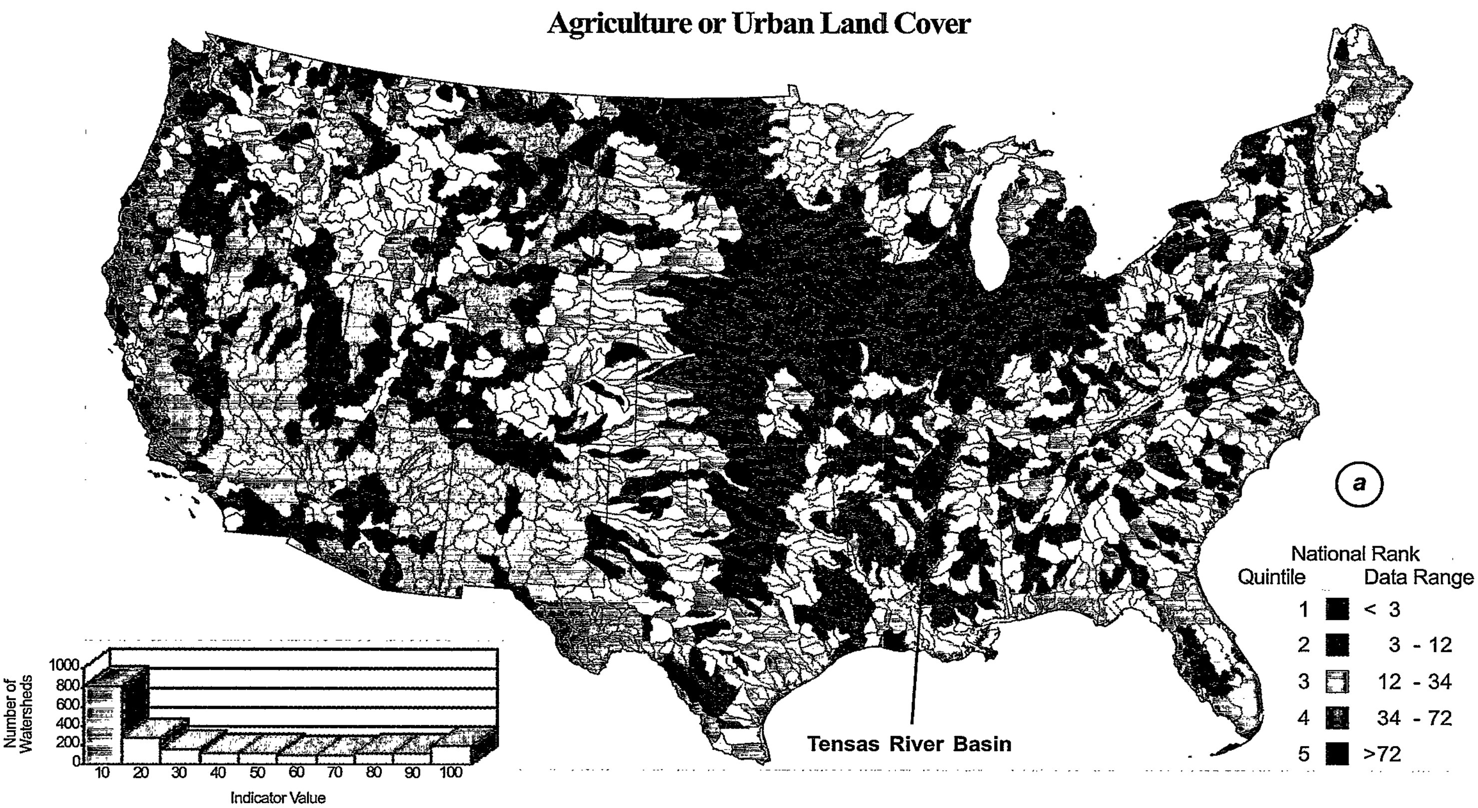


Figure 2.4

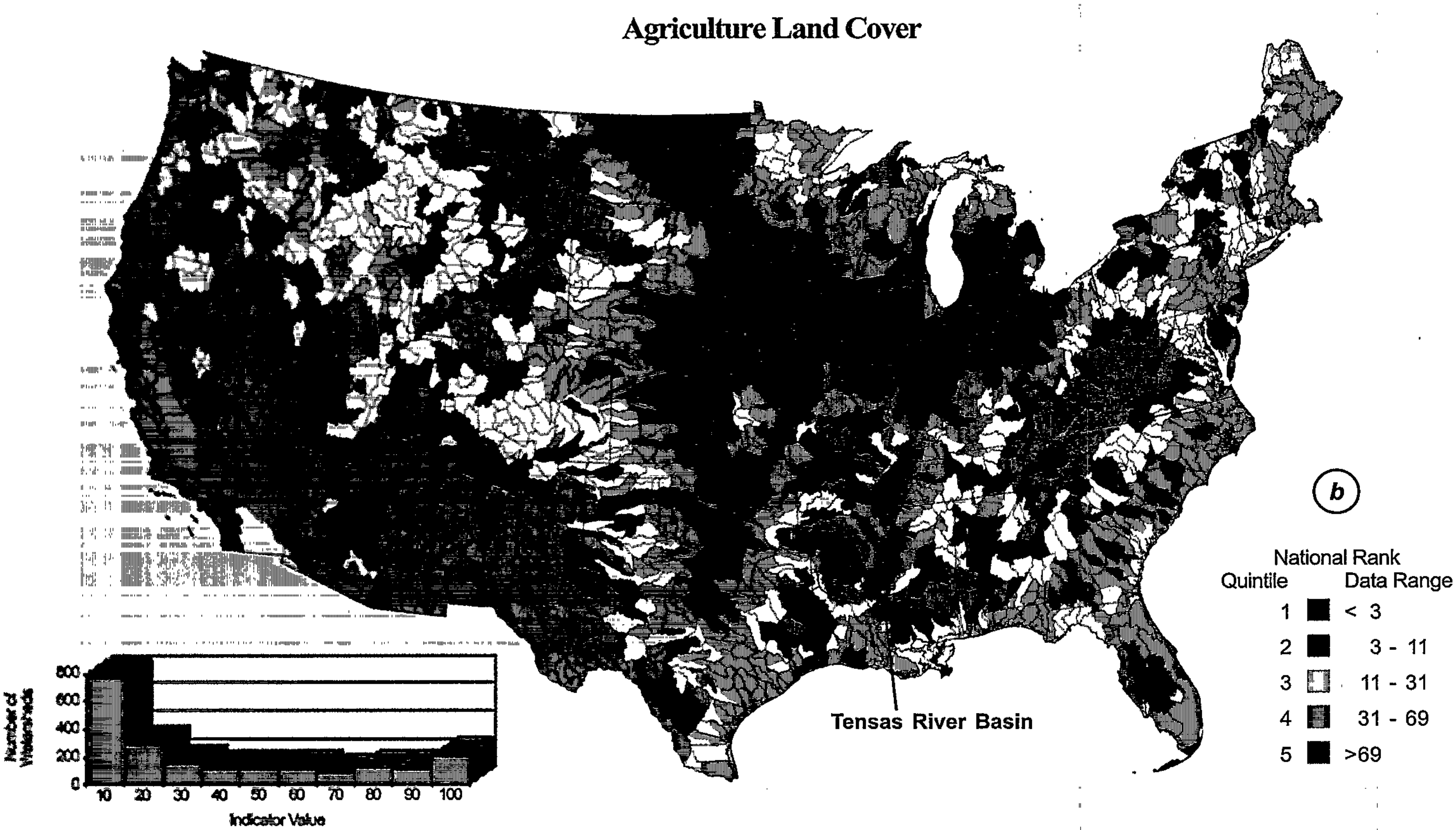
Proportion of watershed area with: (a) agriculture or urban land cover, (b) agriculture land cover.

conversions to agriculture. These watersheds are primarily located in arid and mountainous areas, where grazing, although an important agricultural activity, does not change the grassland cover type at this scale. About 10% (200) of the Nation's watersheds have been almost completely converted to agricultural land; these are located mostly in the fertile central United States.

The Tensas River Basin (Figure 2.4b) is shown in red putting it in the 5th quintile and giving it a data range of greater than 69. This means that there is a very high agricultural land use practice in this watershed.

The complicated spatial patterns in the southern United States are evident in the map of land cover diversity (Figure 2.5). The map shows the watershed ranking for the number of different natural land cover types (anything except urban and agriculture) per unit area. These rankings are based on the original 160-class version of land cover and not the 9-class version shown in Figure 2.1.

The greatest diversity of natural land cover is found in the western United States, where large changes in elevation produce different vegetation types at the top and bottom of the same watershed. But there are also diverse watersheds in coastal areas, including parts of the Mississippi Gulf region.



Forest Patterns

Forest patterns are particularly relevant in the southern United States because forests are the dominant natural vegetation cover. In contrast, natural land cover in the western United States also includes grasslands and shrublands, so forest patterns alone do not describe departures from potential natural vegetation types. We used three different indices of forest pattern in the watersheds: amount of forest, average forest patch size, and forest connectivity. The resulting national rankings of watersheds for these forest indices are shown in Figure 2.6.

The first map (Figure 2.6a) shows the watershed rankings of forest area, expressed as the percentage of total watershed area. The chart indicates that about 20% (400) of the nation's watersheds are almost completely forested, and that about 30% have little forest cover. About 100 watersheds have no forests at all when measured at this scale. Forest cover is the most common vegetation type in nearly all of the watersheds east of the Ohio River. Many western watersheds are only forested at higher elevations.

The two other maps are different ways of looking at whether the forests that do occur in a watershed are continuous or fragmented into smaller patches. Figure 2.6b shows watershed rankings of average forest patch area or size, expressed as a percentage of total watershed area. Figure 2.6c shows watershed rankings of forest connectivity, defined as the probability that a randomly selected forested spot on the map is adjacent to another forested spot.

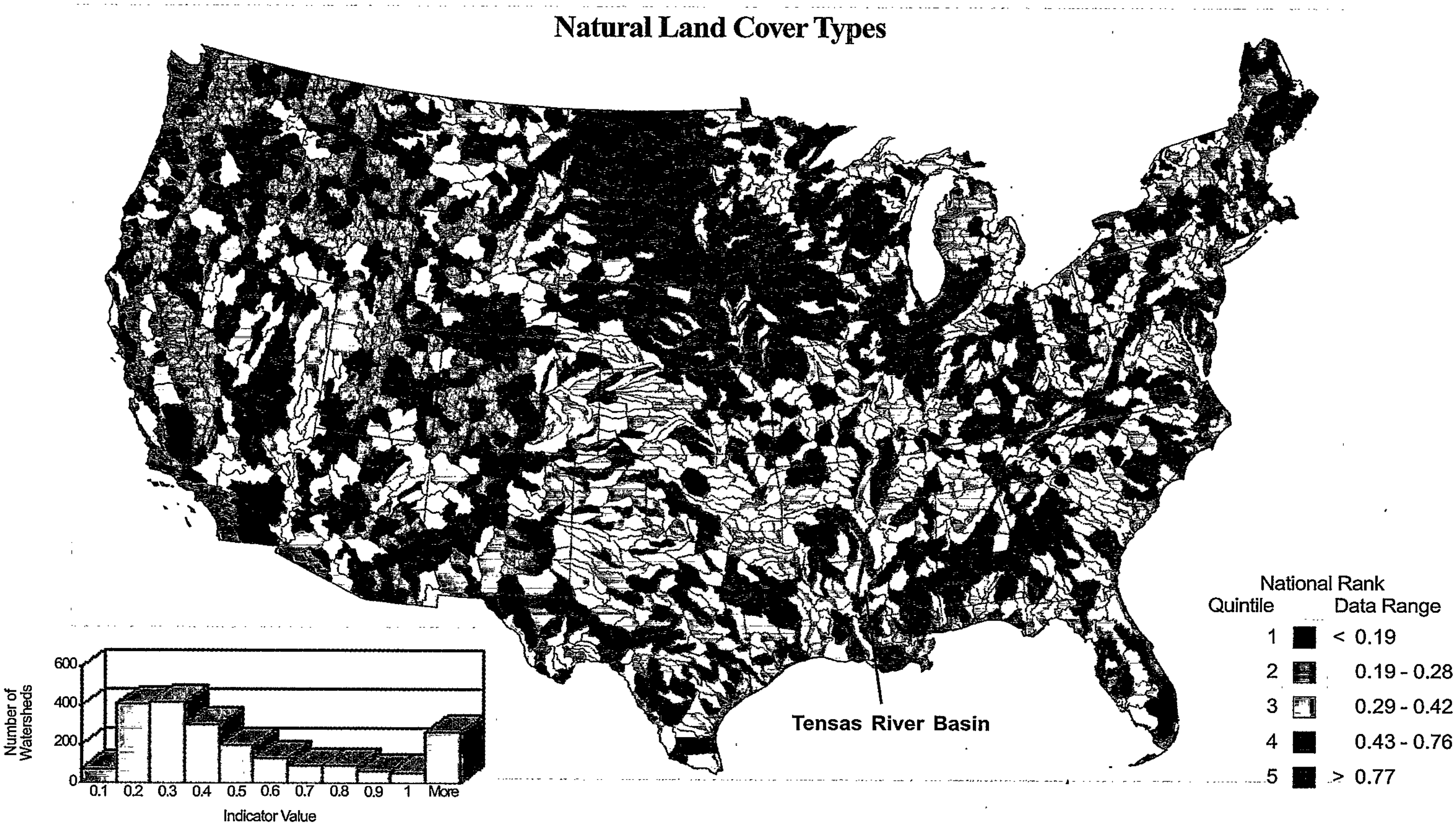


Figure 2.5

Number of natural land-cover types per 100 square kilometers of watershed area.

All three maps have a similar pattern. Forest cover is usually continuous where most of the watershed is forested. In other cases, such as some watersheds in the southwest, forest cover is a minor component overall, and yet is still continuous where it does occur. Compared to potential natural cover conditions, forest loss and fragmentation of the remainder is significant in the northeast United States, along the east coast, and in the Mississippi River valley. The patterns in Louisiana are typical of those found in other places in the southern part of the country.

Although the three maps have a similar pattern, the charts illustrate different views obtained by using different indicators. The distribution of watersheds is more or less uniform for the indicator based on percentage of forested area. The charts for the other two indicators suggest that in most watersheds, the average forest patch is a small percentage of total area, but that forest cover tends to be connected in whatever amount actually exists.

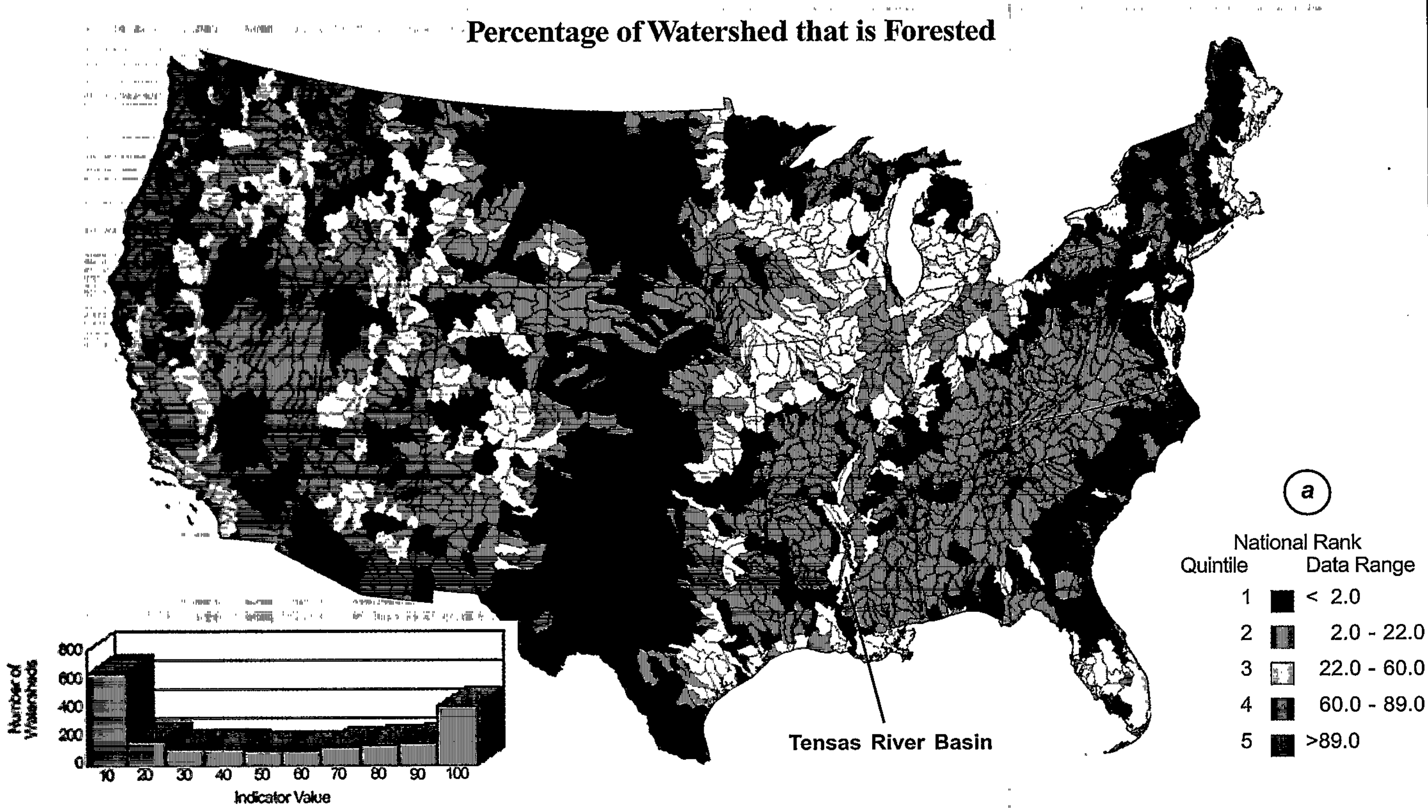
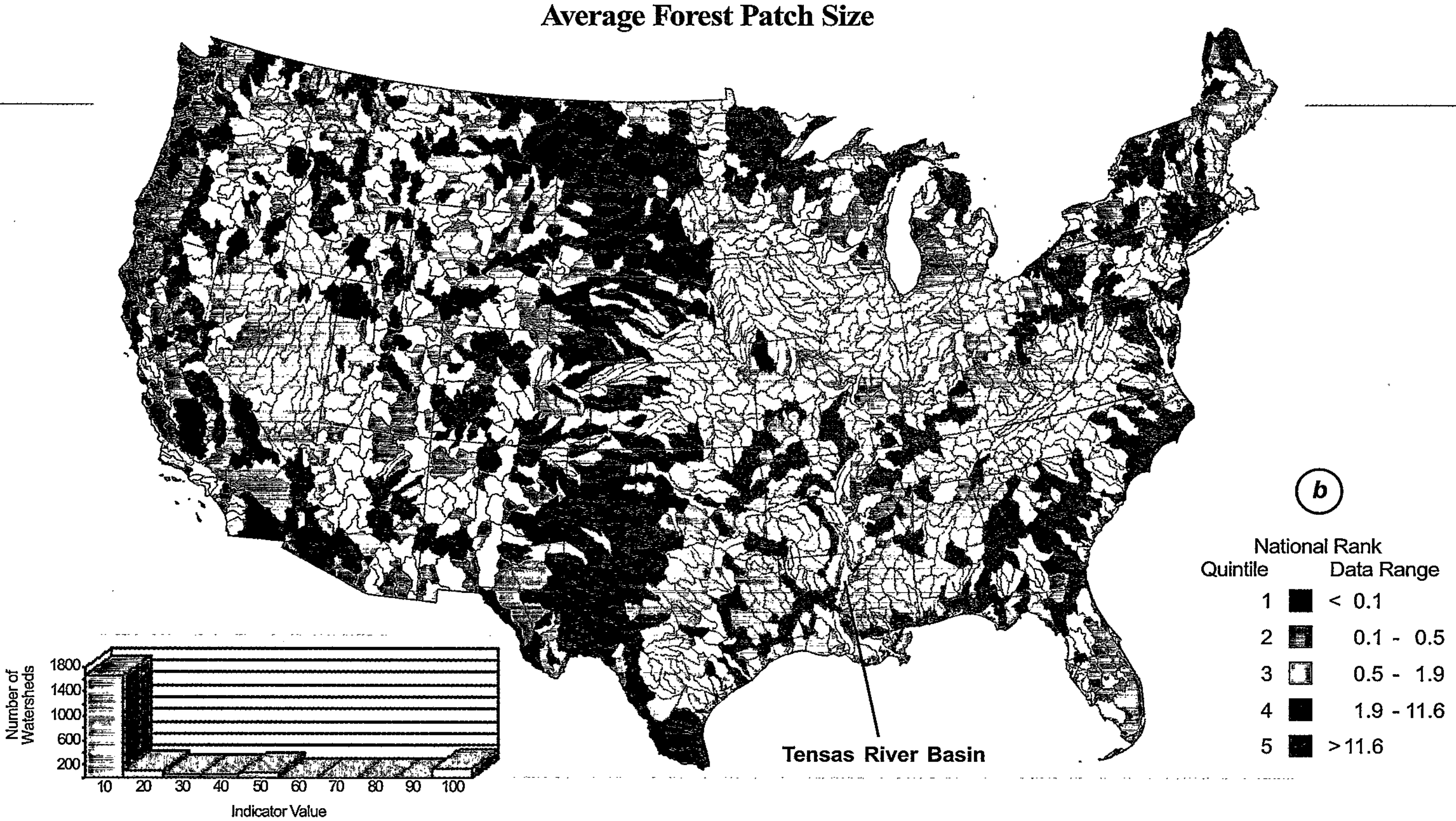


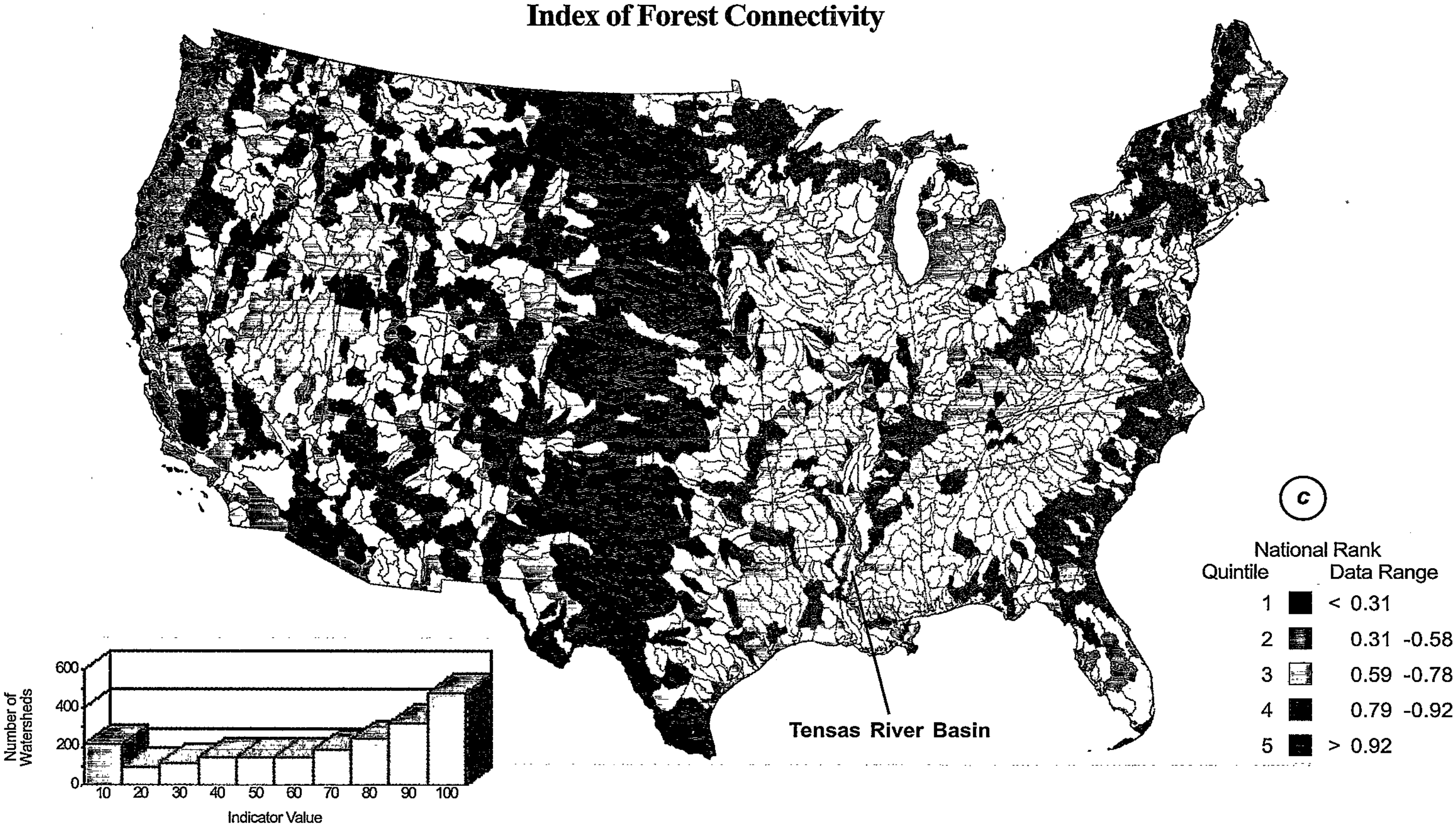
Figure 2.6

Three forest pattern indicators: (a) percentage of watershed that is forested, (b) average forest patch size as a percentage of total watershed area, and (c) index of forest connectivity.

Average Forest Patch Size



Index of Forest Connectivity



Patterns Affecting Water Quality

Water quality and aquatic life are intimately related to land cover near streams. The vegetation near streams is referred to as riparian vegetation. It forms an important buffer zone protecting water quality. Natural vegetation absorbs agricultural nutrients, slows the rate of water movement, and is a settling zone for soil particles suspended in runoff. Riparian conditions are often evaluated within a few meters of a stream, but the larger landscape context is also important.

One way to measure environmental conditions is to look at whether streams flow through predominantly forested or developed landscapes within a watershed. If there are no large urban areas or agricultural zones anywhere near streams, then it is less likely that water quality is being affected by these land uses. If forest cover dominates in the vicinity of streams, then there is greater opportunity for forests to buffer the conditions within streams.

Watershed rankings of the proportions of stream length dominated by different land cover types are shown in Figure 2.7. These proportions are based on forest cover (Figure 2.7a) or urban and agriculture cover (Figure 2.7b) within about one-half kilometer of streams in each watershed. Along the Mississippi River, the rankings for forested riparian zones show a sharp contrast between the area near the river and the forested areas to the east and west. The Tensas River Basin is one of the areas near the Mississippi River.

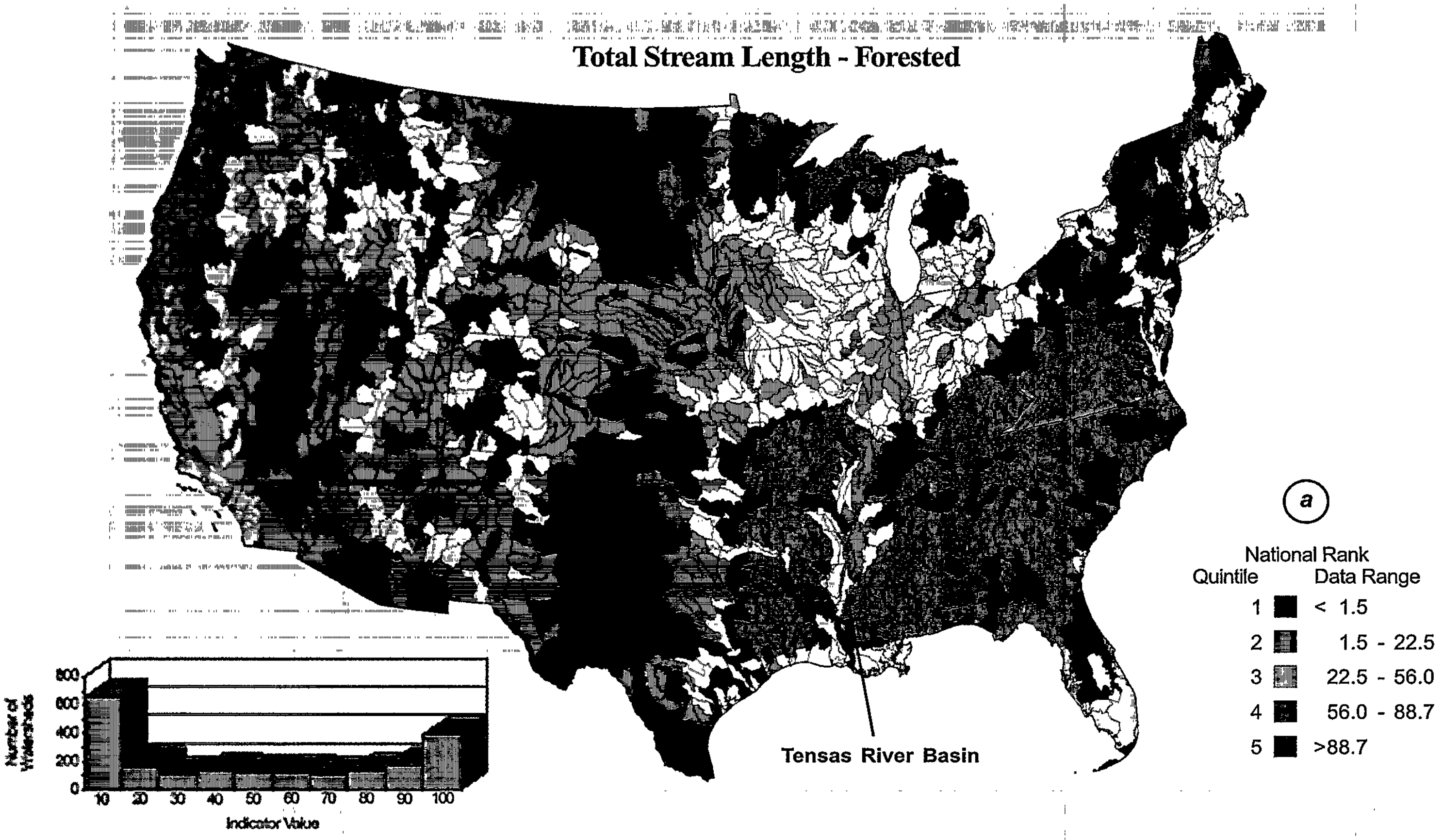


Figure 2.7

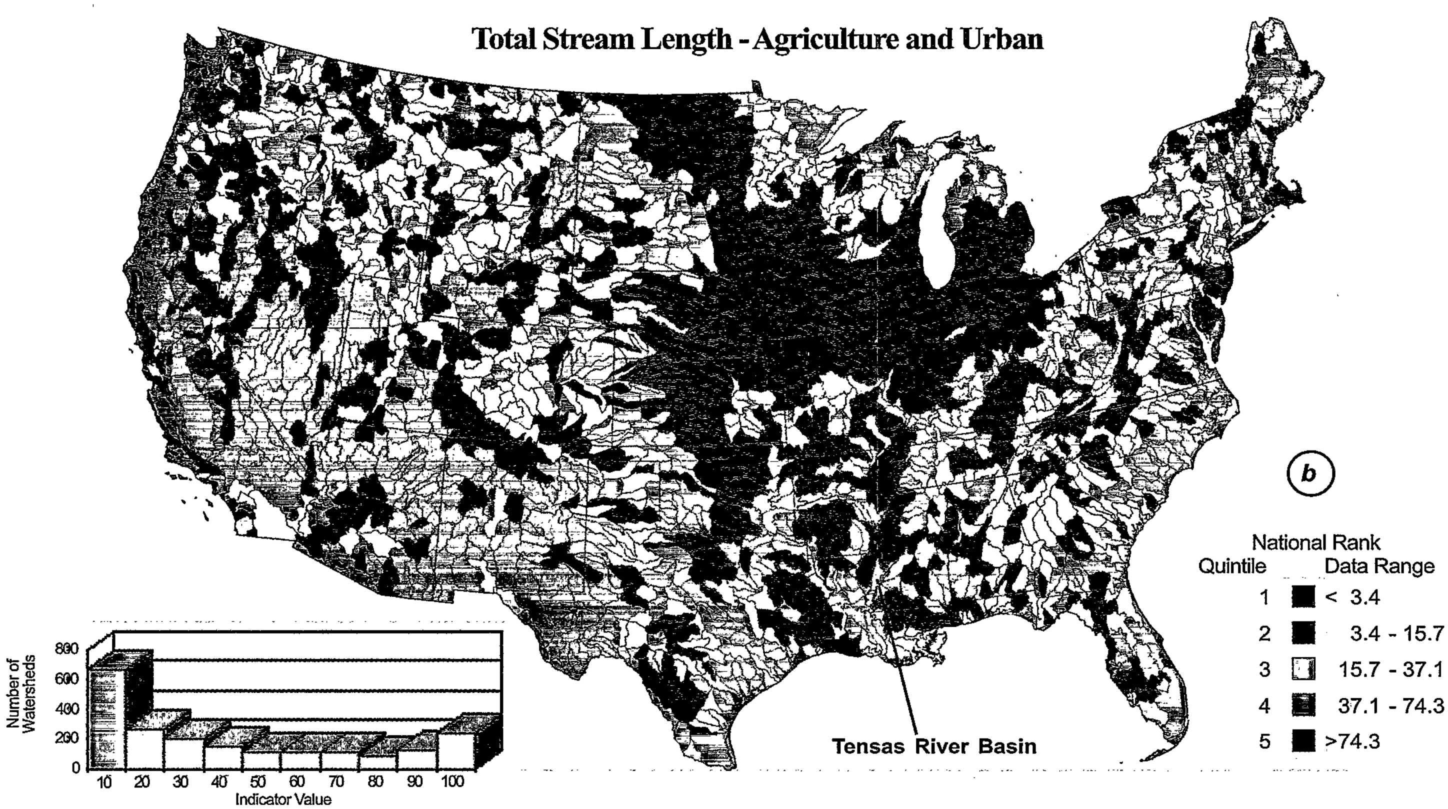
Proportion of total streamlength that is: (a) forested, or (b) agriculture and urban.

The rankings based on the proportion of agriculture or urban land cover in riparian zones show similar patterns in the southern United States. The differences are more complicated in the western United States because nonforested vegetation may also be shrublands or grasslands.

Nationwide, the charts indicate that about 40% of the watersheds have riparian landscapes that are at least 70% forested, but an equal number of watersheds have very little forest cover in riparian landscapes. About 10% (200) of the watersheds have riparian landscapes that are nearly all agriculture or urban, and about the same number are almost completely undeveloped.

Water quality is also related to larger patterns of land use over entire watersheds. For example, roads near streams affect water quality not only as direct pollution sources, but also because they represent paths for rapid runoff. The frequencies of roads crossing rivers were expressed here as the number of road crossings per unit river length in each watershed. This expression helps to adjust for differences in the total length of rivers between watersheds.

The map of watershed rankings for this indicator (Figure 2.8) is complicated, and it does not closely resemble the national patterns found earlier when looking at land cover. The Tensas River Basin, like most of the Southeast and Midwest United States, has extensive road networks. Low lying areas are built-up to make roads thus changing the way water flows in the watershed.



National Context Summary

Several important features of the Tensas River Basin can be identified by placing the region into a national context. The Tensas River Basin certainly has complicated spatial patterns of land cover, and the finer-scale analyses shown later in this Atlas seem warranted. In fact, the Tensas River Basin should be an excellent case study area because of the variety of conditions that it contains.

Some patterns in the Tensas River Basin are typical of other areas along the southern agricultural belt. This means that what is learned in the Tensas may be applicable in other regions in the lower Mississippi Valley. Because the Tensas is also a transition zone between regions of more or less impact to the east and west, further studies here may also be relevant to environmental monitoring in these other areas.

The Tensas River is not the most highly impacted watershed in the south, but it is different from the less impacted areas that are found at slightly higher elevations in the east and west. The patterns in the watershed creates an opportunity to consider a full range of environmental strategies from restoration of the more developed areas to protection aimed at forests and wetlands. This brief look at the Tensas River Basin in a national context has confirmed that many aspects of the broad-scale view of environmental quality can be usefully explored here.

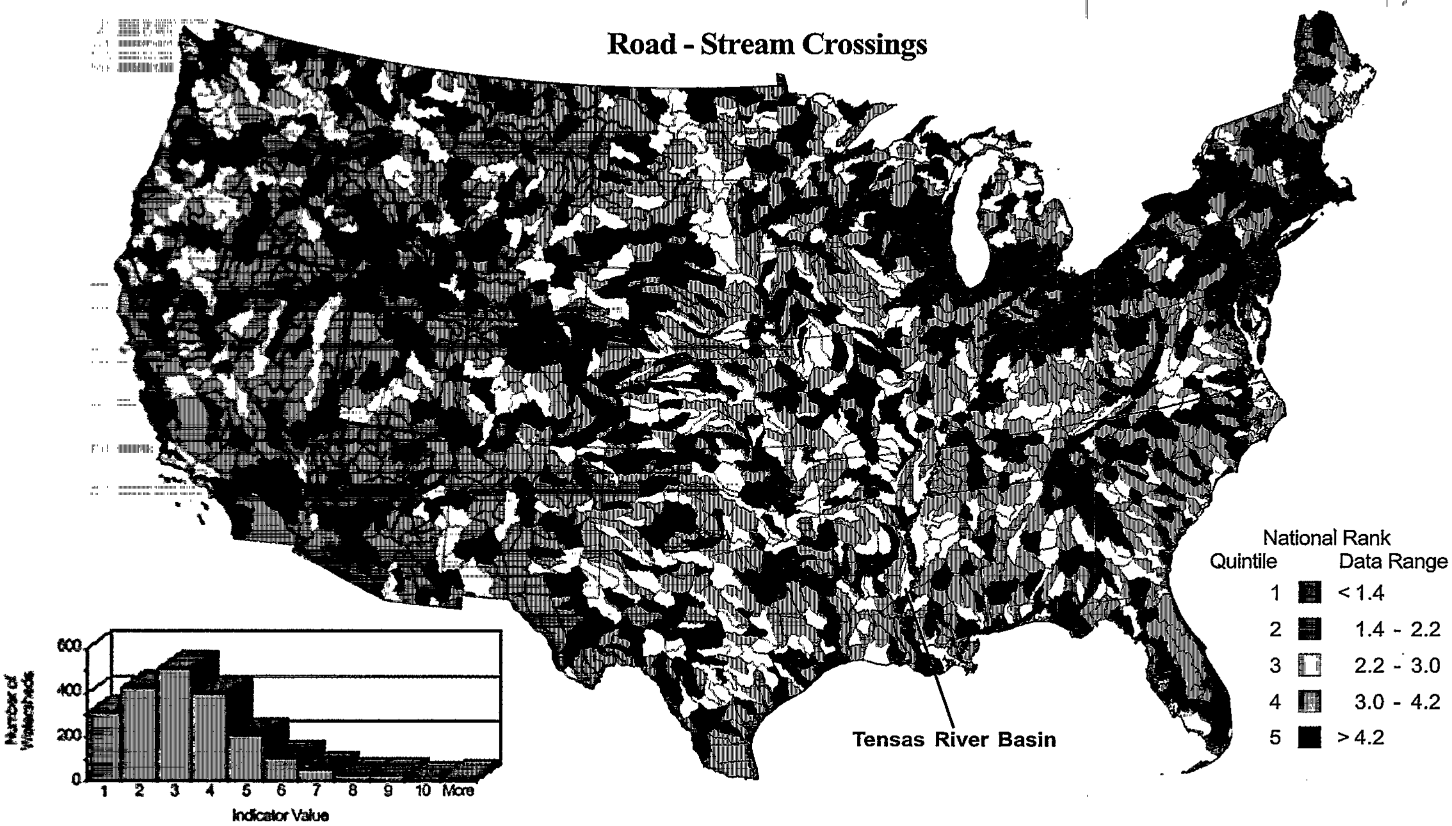


Figure 2.8

Number of road–stream crossings per 100 kilometers of streams.

Chapter 3: The Tensas River Basin Landscape Assessment

This chapter illustrates the landscape indicators used to assess watershed conditions in the Tensas River Basin. Each indicator is discussed separately; maps illustrate the relative rankings of subwatersheds and charts show the distributions of indicator values.

We begin with a brief look at the biophysical setting of the Tensas River Basin including maps of the data used to calculate indicator values. Included are regional pictures of topography, rivers, watershed boundaries, and land cover. An important criterion when choosing digital data was consistency across the watershed. Consistency is essential because the goal is a sub-watershed comparative assessment.

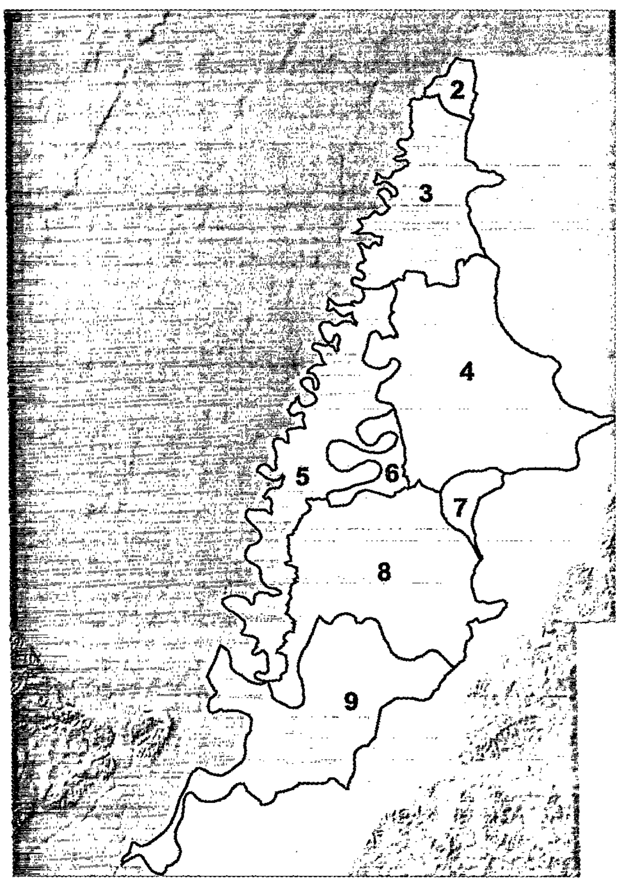


Figure 3.1

Shaded relief map of the Tensas River Basin. Source: U.S. Geological Survey, Digital Elevation Model, 3 arc–second.

The landscape indicators are grouped according to three themes: human use, forests, and water. The following discussions introduce each theme and a number of analyses pertinent to the Tensas River Basin are applied to each theme. The interpretation of indicators are not exhaustive. In addition, these groups are subjective since any given indicator could be relevant to more than one theme and each affect water quality, the subject of Chapter 4. For example, a discussion of an indicator of forest change along streams or riparian corridors appears in both the analysis of forest change and the analysis of water.

The concluding section in this chapter describes a current program that focuses on restoring wetlands. Based on analyses presented in this chapter, a GIS illustration of areas of potential restoration gives land managers an example of a powerful decision tool.

Biophysical Setting

The Tensas River Basin encompasses approximately 375,834 hectares (930,000 acres) of Mississippi River alluvial flood plain in Northeast Louisiana. The Tensas River is now hydrologically connected to the Atchafalaya River which is a major distributary of the Mississippi River. Historically, most of the Basin was covered with bottomland hardwood forested wetlands. The bottomland hardwoods of the Tensas River Basin have been described as some of the richest ecosystems in the country in terms of diversity and productivity of plant and animal species. At the same time, these lands are recognized as some of the nation's most productive farmland for grain and fiber. The result is a conflict of land use between traditional row crop agricultural interests and concern for a healthy, diverse, and stable ecosystem.

The alluvial flood plain of the region forms the backdrop for all of the physical and biological processes that shape the watershed. Generally when you look at a map of a watershed, whether it is a physical map, a vegetation map, or even a socio–political map, the most striking features of the landscape are created by topographic features. In the Tensas River Basin (Figure 3.1) a lack of topographic variety encourages a variety of different landforms including point-bars, abandoned river courses, abandoned channels, natural levees, and backswamps. The Tensas River Basin is unique in that natural levees along the riparian vegetation lie on the highest ground in the Basin. This causes drainage water to run parallel to streams for many miles before actually entering the stream and river water channels. Wetlands and backswamps then become the vegetation filtering areas for pollutants and nutrients. These landforms create a diverse physical and ecological region. Bayous, channels, streams, and rivers direct the flow of water across the landscape and are dominant features in the Tensas River Basin (Figure 3.2). In the previous chapter we looked at the Tensas River Basin in the context of a watershed within the lower 48 contiguous states. In this chapter, we further divide the watershed into topographically relevant subwatersheds or zones and examine landscape indicators based on these subwatersheds. These subwatersheds, known as 11-digit hydrological accounting zones, were defined by combining the USGS 8-digit HUC boundary with the NRCS 11-digit boundaries and are shown in Figure 3.3.

Note that Zones 2, 7, and 9 were not defined as 11-digit hydrologic accounting units by NRCS but do fall within the boundary of the 8-digit USGS HUC boundary. Subwatersheds 2 and 7 may be parts of other subwatersheds or contain most likely, bayous in which water could flow in many directions.

Therefore, these areas are included in the combined 11-digit boundary but may not actually be totally hydrologically linked to the Basin. Subwatershed 9 appears to be linked to the Basin through a major tributary. The indicator values calculated for zones 2 and 7 are probably not as reliable as the values for those zones in which an entire subwatershed was in the assessment area.

Figure 3.2

1991/92 NALC Image
60-meter False Color Composite

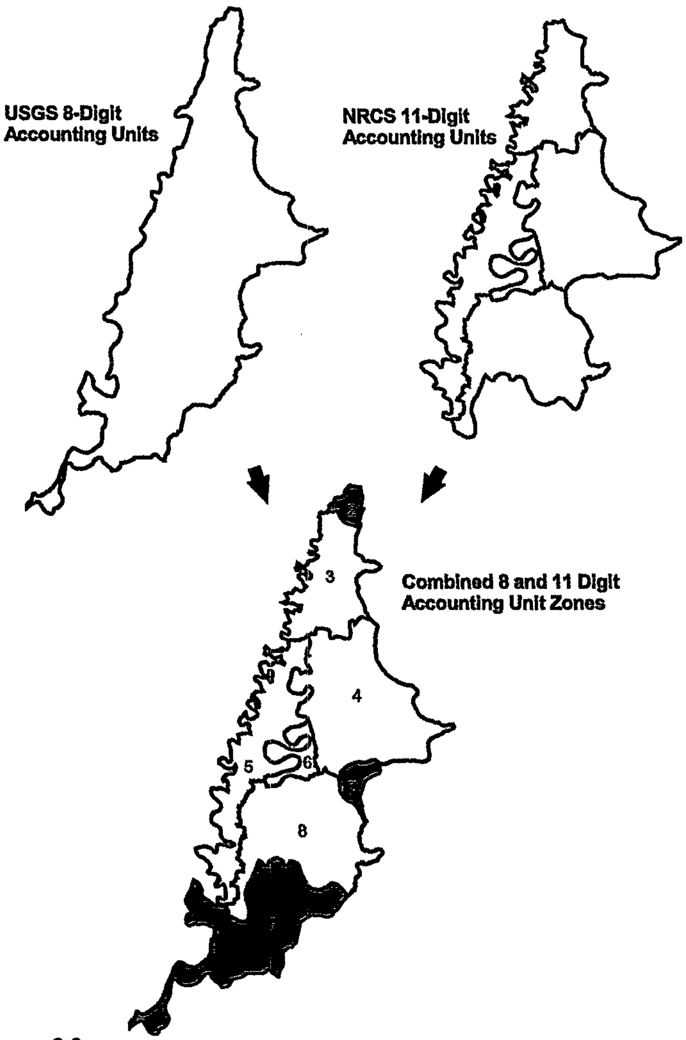


Figure 3.3

Combination of USGS 8-digit HUC boundaries with NRCS 11-digit boundaries. Zones 2,7, and 9 are shown in red.

Land Cover

Land cover is the product of past land uses on the backdrop of the biophysical setting. A map of land cover is essentially a picture of the dominant vegetative, water, and urban cover in an area. Figure 3.4 illustrates the land cover of the Tensas River Basin.

This land cover map was jointly prepared by the USFWS, the USGS Biological Research Division (formerly known as the National Biological Service) and the University of Arkansas at Fayetteville. They used Landsat Thematic Mapper 30-meter satellite imagery to derive the 17 classes displayed in the map. Although individual pixels are far too small to be rendered accurately here, the visual impression of broad-scale watershed patterns is readily apparent.

This Land Cover map can be used for many types of landscape analyses and assessments. For our assessment of the land cover we started with only three classes: forest, human use, and water. Later on in this chapter we explain in much more detail how these were derived.

The two most dominant land cover types in the Tensas River Basin are forest and human use, which presently cover about 22% and 77% of the area, respectively. Some of the subwatersheds are primarily forested and approach 60% forest cover. Some subwatersheds have less than 5% forest cover. Where forests have been removed, agriculture and urban land covers become more dominant. The median amount of urban land cover per watershed is about 2%. Agriculture is an extremely important land use in the region; four subwatersheds have more than 60% of agriculture land cover.

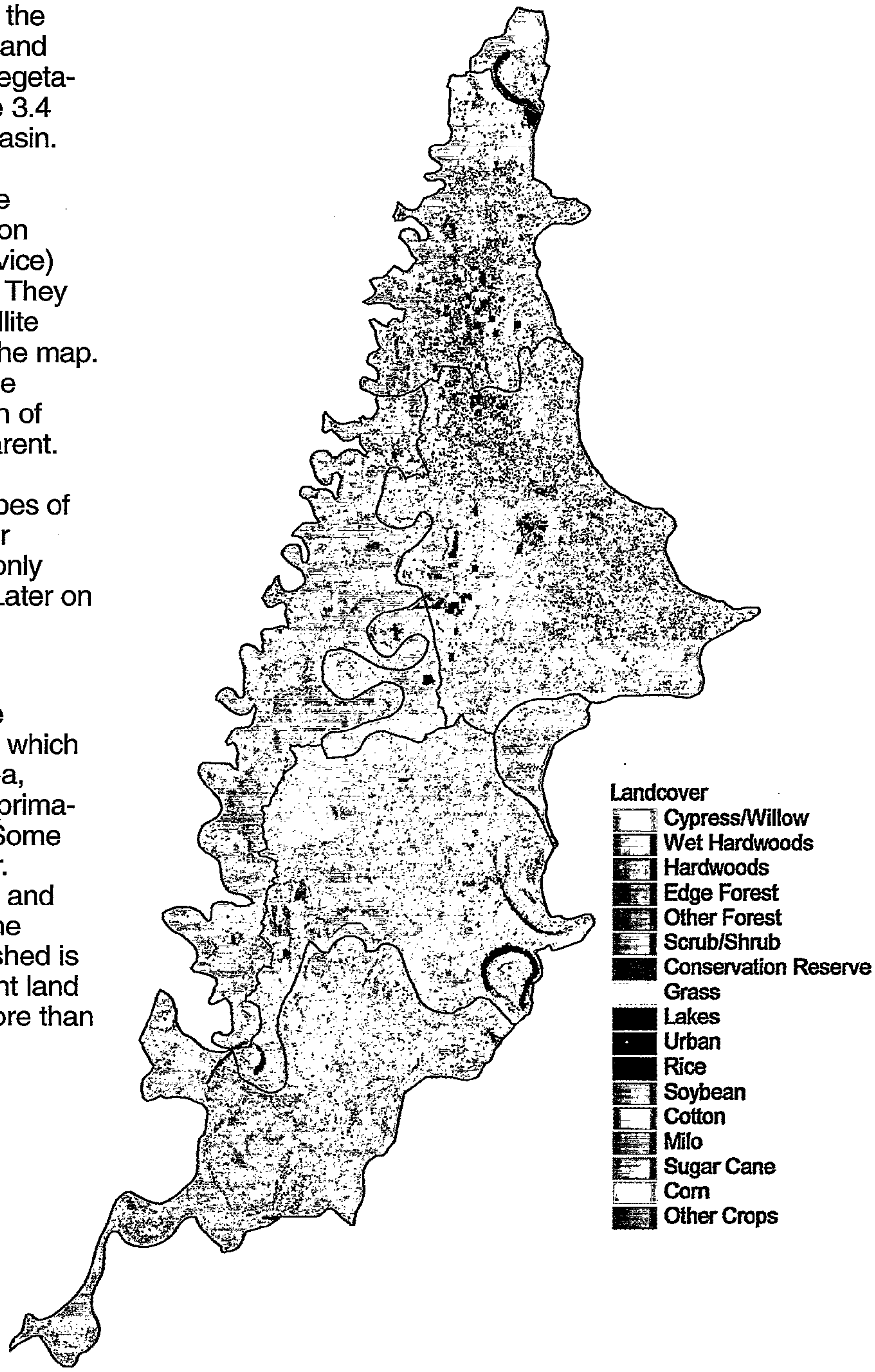


Figure 3.4

Land Cover in the Tensas River Basin. Source: USFWS, BRD, and the University of Arkansas at Fayetteville. Landsat TM 30 -meter satellite imagery, June 1992.

Humans in the Landscape

Humans structure the landscape for their purposes, and landscapes structure human activities. For example, humans may decide the shapes and sizes of individual agricultural fields, but watershed-scale patterns of topography, soils, and geology determine whether or not there can be fields at all. Because human-dominated landscapes are used for different purposes which impose different patterns, land use history is always important for understanding local landscapes. The interplay between humans and landscapes has created a tapestry of multi-scale patterns in the Tensas River Basin, and combinations of these two factors influence the sustainability of ecological processes.

Population Density and Change

According to the U.S. Census Bureau, the population of the Tensas River Basin in 1990 was about 29,300 people, which represents about 0.0001 of the total population of the United States. With a population of 29,300 covering an area of 3,763 square kilometers, the average population density of the Tensas Basin is about 7.8 people per square kilometer.

Between 1970 and 1990, the total population in the Tensas Basin (East Carroll, Madison, and Tensas parishes) decreased from 37,680 to 29,300. Thus, the average population density decreased from about 10 people per square kilometer to 7.8 people per square kilometer. Figure 3.5 shows the population of the Tensas River Basin by parishes and the populations of three cities in the Basin.

Human Use Index

The proportion of an area that is used for agriculture or urban land use is a measure of human use known as the U-index. We often assume that humans tend to simplify their environment. At landscape scales, however, the map of human land use displays complicated patterns (Figure 3.4, Land Cover). The scale at the transition from simple to complicated patterns might be a measure of the scale to which humans have structured a landscape or, conversely, the scale at which geophysical processes constrain human activity. By looking at watershed patterns of the U-index, it is possible to identify those areas which have experienced the greatest land cover conversion from the natural cover of vegetation.

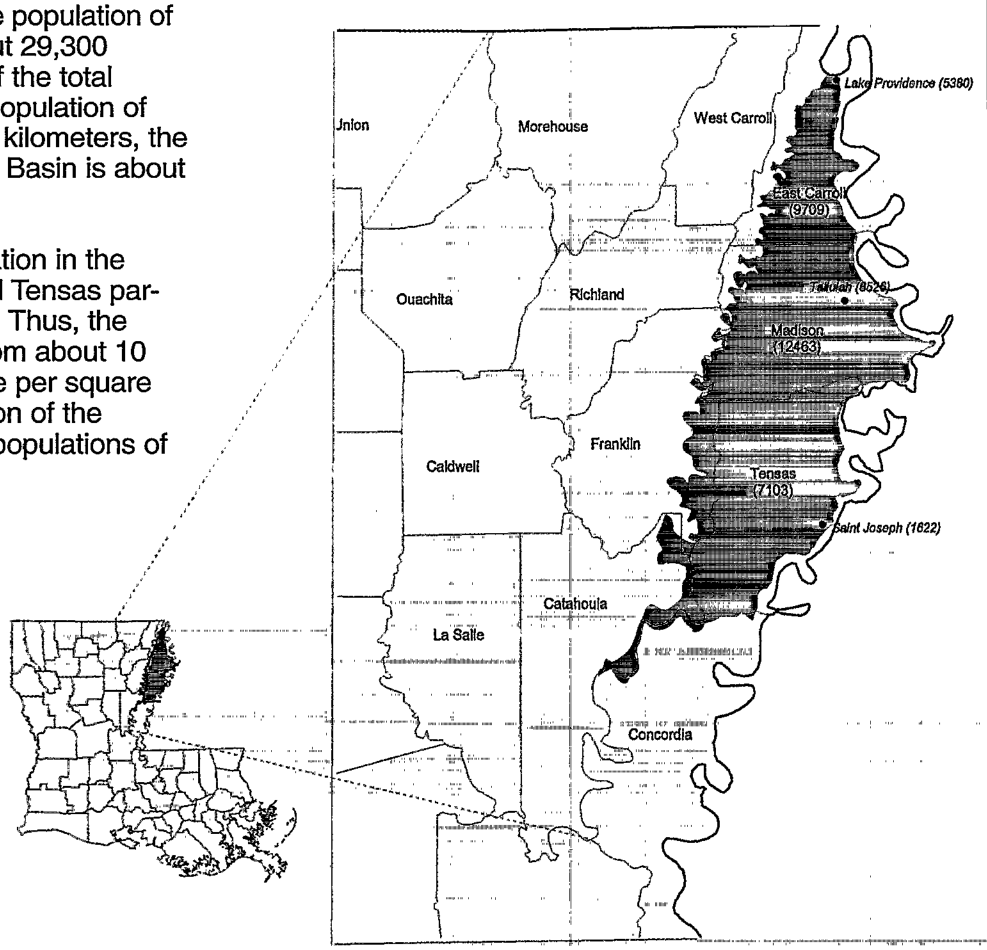
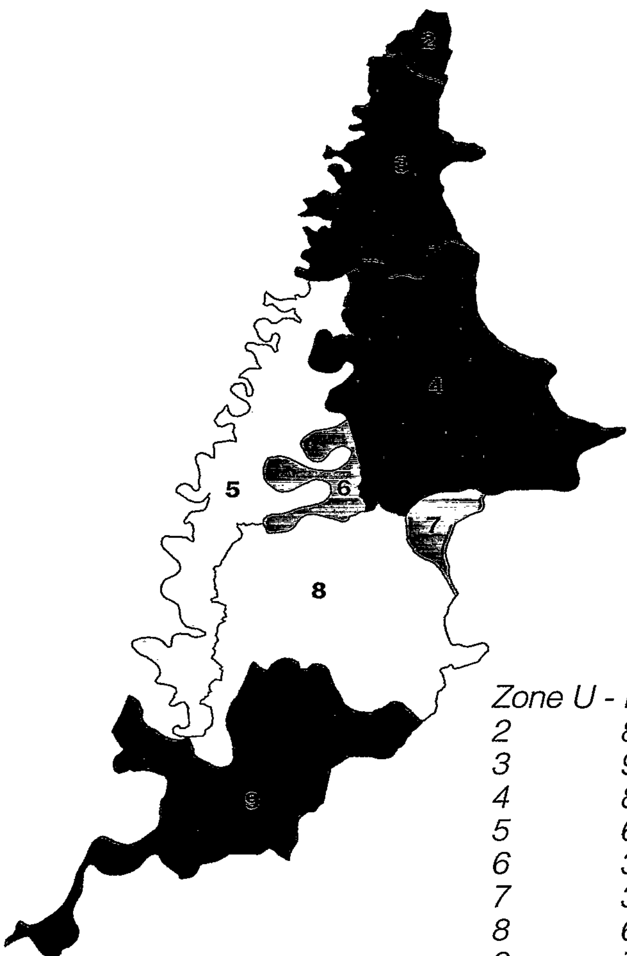


Figure 3.5

Population (1990) of Louisiana Parishes within the Tensas River Basin.

The watershed pattern of human use in 1991/92 is reflected in the subwatershed rankings over the region (Figure 3.6). The highest U-index value for a subwatershed is about 96.7%, which means that 96.7% of that watershed has agricultural or urban land cover. The lowest value is 38.9%, and the average value is 77.3%. Compared to the national human use maps in Chapter 2, this is a very high human use index.



Zone	*U - Index*
2	*82.3%*
3	*96.7%*
4	*87.6%*
5	*66.0%*
6	*38.9%*
7	*39.0%*
8	*69.6%*
9	*78.9%*
Total	***77.3%***

Figure 3.6.

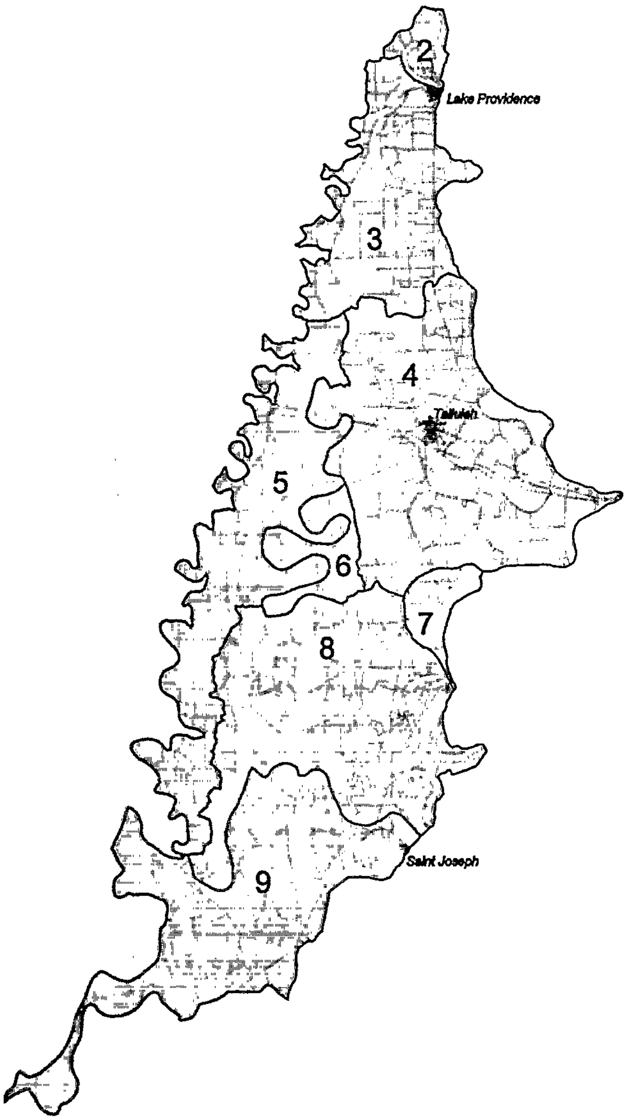
Human Use (U) Index, Tensas River Basin.

Roads

Roads and other transportation corridors are designed to connect the human-dominated elements of a landscape. The network of roads in the Tensas River Basin permits access, commerce, and communication throughout the region. Roads are also important for connectivity among ecological communities. Sometimes roads restrict ecological communities, as in the case of animals that are unable to cross roads. Sometimes roads enhance ecological communities, such as for plant species that spread along disturbed roadsides. In some cases, areas remote from roads may better accommodate wildlife, e.g., Louisiana black bears. The influence of a given road extends for some distance, depending on such things as road size and surface type, traffic volume, and type of use. There are few places in the Tensas River Basin that are entirely free of their influence.

According to the road maps used for this atlas, there are about 3,666 kilometers of roads in the Tensas River Basin. This data set (U.S. Census TIGER) includes all types of roads--interstates, U.S. and State highways, county roads, and city streets. This works out to an average of 125 meters of road per person in the region. It is no wonder that roads are one of the most important human features in the Tensas River Basin landscape today.

Figure 3.7 illustrates the road network within the Tensas River Basin. It is immediately apparent, with the exception of road concentration in the urban areas of Lake Providence, Tallulah, and Saint Joseph, that roads are uniformly distributed throughout the Basin. Figure 3.7 also breaks out kilometers of roads by zone.



Zone	Kilometers	Ha	Ratio of Km/Ha
2	83.5	5,601	1.49
3	485.0	45,387	1.07
4	949.9	92,471	1.03
5	491.4	61,742	0.80
6	46.7	11,126	0.42
7	63.6	7,345	0.87
8	778.4	79,713	0.98
9	767.1	72,212	1.06
Total	3,666.0	375,807	0.98 (Avg)

Figure 3.7

Roads in the Tensas River Basin. Source: US Census TIGER.

Roads Along Streams

Roads affect stream water in many ways and roads in close proximity to streams have the most potential for adverse effects on stream water quality. Figure 3.8 shows road intersections with streams by sub-watershed in the Tensas River Basin. Since roads have an impervious surface, and ditches are built to channel water off roads and into streams, the rate of water runoff is higher where there are more roads. Although large spills of polluting materials are rare and often quickly contained, small spills of petroleum products, antifreeze, and other vehicle-related chemicals happen every day on every mile of road in the region. These small spills eventually go somewhere, usually into streams. Road construction near streams is a temporary stress on water quality, but after construction, the roads remain, and routine maintenance can contribute to poorer water quality. For these and other reasons it is important to consider how the proximity of roads to streams might influence regional water quality.

Forests in the Landscapes

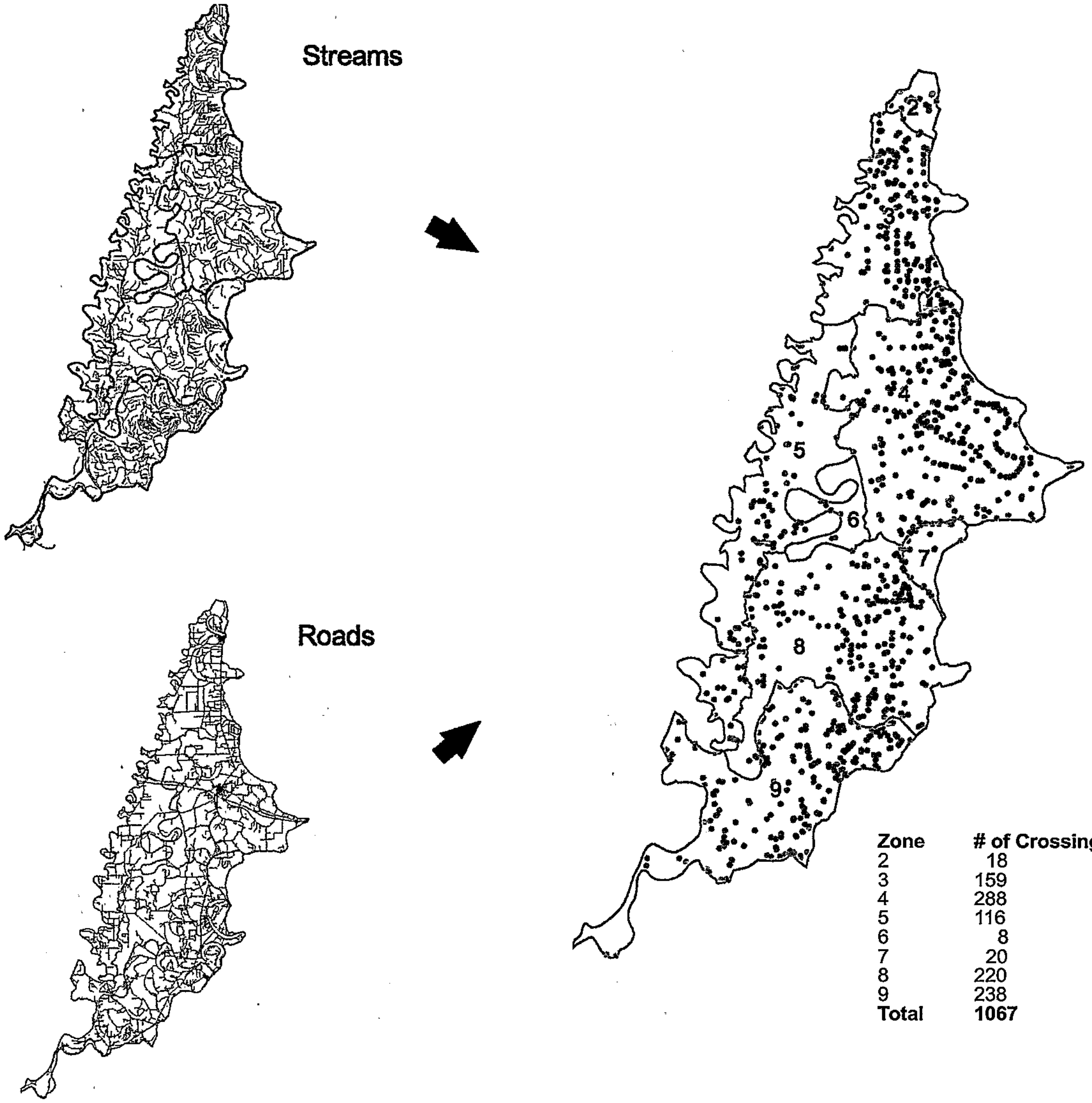
Forests are important elements of both natural and human-dominated landscapes. Forests provide many benefits including wood fiber, outdoor recreation, wildlife habitat, and regulation of some watershed hydrologic functions. Historic patterns of land use and development have created the present distribution of forests from what once was essentially all forest. There have also been changes in the plant and animal species which live in forested environments. In this section, the pattern of the existing forest cover is described as it affects various environmental values, particularly wildlife habitat.

Percentage of Forest Cover

At one time, nearly all parts of the Tensas River Basin were forested. Today, the amount of remaining forests helps to indicate the probable condition of streams within each watershed. The proportion of watershed covered by forest is indicative, but not conclusive, of stream conditions because the specific types of non-forest land cover (such as urban or crop) are also important.

Figure 3.8

Roads Crossing Streams.



Zone	# of Crossings	Ha	Xings/Ha
2	18	5,601	0.32
3	159	45,387	0.35
4	288	92,471	0.31
5	116	61,742	0.19
6	8	11,126	0.07
7	20	7,346	0.27
8	220	79,713	0.28
9	238	72,212	0.33
Total	**1067**	**375,807**	**0.28**

The forest cover map of the Tensas River Basin (Figure 3.9) is based on the North America Landscape Characterization (NALC) satellite imagery data. NALC satellite data, available since the early 1970s, is a Federal effort to create similar data sets for the entire country. The resolution of the NALC data is 60 meters; thus, each pixel (picture element) represents an area about the size of a football field. Compare the land cover map shown in Figure 3.4 (30-meter pixels) to the NALC data (Figure 3.9).

Although individual pixels are far too small to be rendered accurately here, the visual impression of broad-scale regional patterns is readily apparent. Forest vegetation shows up on the NALC image as red in color, agriculture shows up as light red, grey, light blue and white. When the NALC Image is enlarged the agriculture almost always shows a pattern of rows or right angles typical of farm fields.

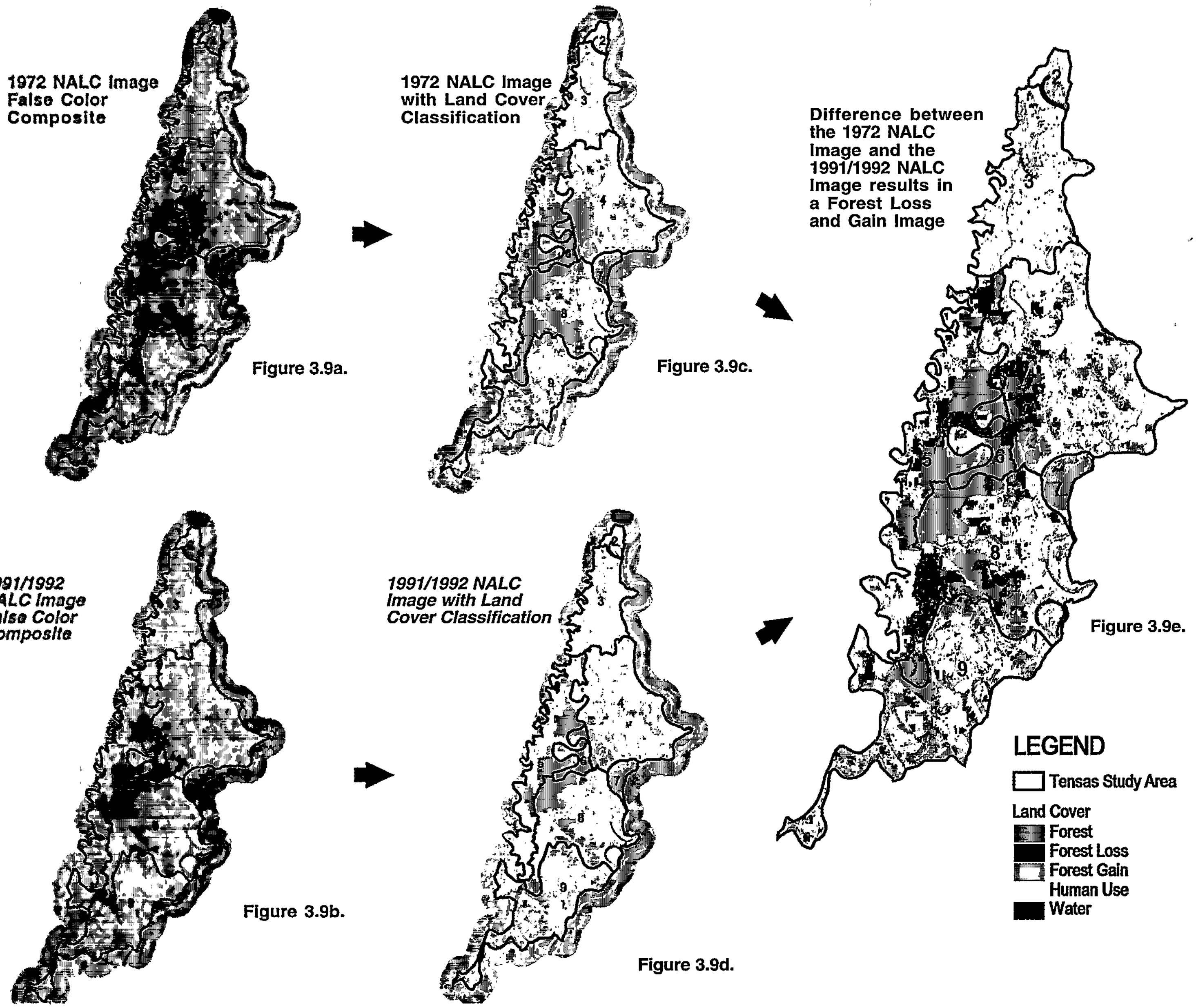


Figure 3.9

Forest Cover in the Tensas River Basin.

The NALC images (Figure 3.9a and 3.9b) were classified to show landuse (Figures 3.9c and 3.9d). The classifications were forest, human use (urban and agriculture), and water. The 1972 image was compared to the 1991/92 image and changes in forest areas and human use areas were calculated. The forest cover changes are shown in Figure 3.9e. As the figure shows, there was significant forest loss during that time period. Subwatersheds, 4, 5, 8, and 9 have had substantial forested loss. The northern subwatershed, 2 and 3, have had little forest loss because they had been converted to agriculture long before 1970. Where forests have been removed over the last 20 years, agriculture land cover has become more dominant, as can be seen by comparing Figures 3.9c with 3.9d.

Forest Fragmentation

As in other regions of the United States, forest fragmentation is an important issue in the Tensas River Basin. Although the word has several meanings, the general concept is that what was once a large continuous forest has been broken up into smaller pieces. In the eastern United States, forest loss is generally associated with agriculture and urban uses which remove some forest and leave the remaining stands in smaller, isolated blocks. The pattern of forest loss can be important as the amount lost. For example, a checkerboard pattern exhibits more fragmentation than a clumped pattern of the same amount of forest.

Forest fragmentation was assessed by using the forest and non-forest data classification shown in Figures 3.9c and 3.9d. The fragmentation statistic measures the probability that a randomly selected forested spot is adjacent to another forested spot. High values indicate low fragmentation. This statistic was calculated for 1972 as 88% and 1991/92 as 84%. These are relatively high values which indicate that much of the forest area in the Tensas River Basin is interconnected. Forest fragmentation will be discussed in more detail later in this chapter.

Percent of the Watershed in the Largest Forest Patch

About 30 years ago, A.W. Kuchler made maps of potential natural vegetation, that is, the vegetation that would occur if vegetation was only influenced by natural processes such as weather and fire. In the Tensas River Basin, Kuchler's maps show that the potential natural vegetation is almost exclusively forest.

Previous discussion introduced the concepts of forest loss (Figure 3.9) and forest fragmentation. Consider a watershed with some given amount of forest cover. If the forest is in one continuous stand, then the largest forest stand equals the total forest cover. If the largest stand is smaller than this expected value, then fragmentation has occurred and the remaining forest cover is discontinuous.

The largest forest patch in the Tensas River Basin in 1972 was 54,939.2 hectares compared to the largest forest patch in 1991/92 of 37,997.3 hectares. This is a loss of 16,941.9 hectares from the largest patch. The average forest patch in 1972 was 38.9 hectares and in 1991/92 was 23.1 This is a loss in average forest patch size of 15.8 hectares throughout the Tensas River Basin.

These forest patch size statistics may be used to determine where local reforestation would best improve forest connectivity regionally. A significant increase in the size of the largest forest patch could be made by joining the two largest patches. More information on Wetland Forest restoration is given later in this chapter.

Detailed Forest Analysis of the Tensas River Basin, 1970s to 1990s.

The landscape analysis began with taking the 1972 classified data and running computer programs which calculate the various landscape statistics. The landscape statistics for the 1972 and 1991/92 data are given in Tables 3.1 and 3.2 (all tables are found at the end of Chapter 3). Figures 3.10 and 3.11 show the classified images of the Tensas River Basin for 1972 and 1991/92 respectively. The Tensas River Basin was classified into three categories: forest, human use (urban and agriculture), and water. The water statistics are not presented in the tables.

In 1972 the data show the amount of forest area in the Tensas River Basin as 126,298 hectares and the human use as 244,522 hectares. These represent 33.6% and 65.1% of the total Tensas River Basin area. In 1991/92 the amount of forest area is 80,807 hectares and human use is 290,336 hectares. These represent 21.5% and 77.3% of the total Tensas River Basin. The net forest loss for this period is 45,491 hectares (112,463 acres) or 12.3% of the land area. These data indicate a substantial decrease in forest and an increase in human use over the years. The totals and percents are given for each subwatershed (Tables 3.1 and 3.2). The landscape analysis for percent forest change which includes the entire Tensas River Basin is shown in Table 3.3. The classified data which show the forest vegetation change is given in Figure 3.12. These data were also analyzed by subwatershed and presented in Table 3.3.

Forest patch statistics are also given in Tables 3.1 and 3.2. A high same-type forest edge percentage indicates low forest fragmentation. In 1991/92, subwatershed number 6 has a same-type edge percentage of 94.9. This is a very high value showing that the forest in subwatershed number 6 is highly connected. The Tensas River National Wildlife Refuge is located in subwatershed number 6 which accounts for the high value as connected forest patches are needed for wildlife management. The largest forest patch size and the average patch size are also given in these tables.

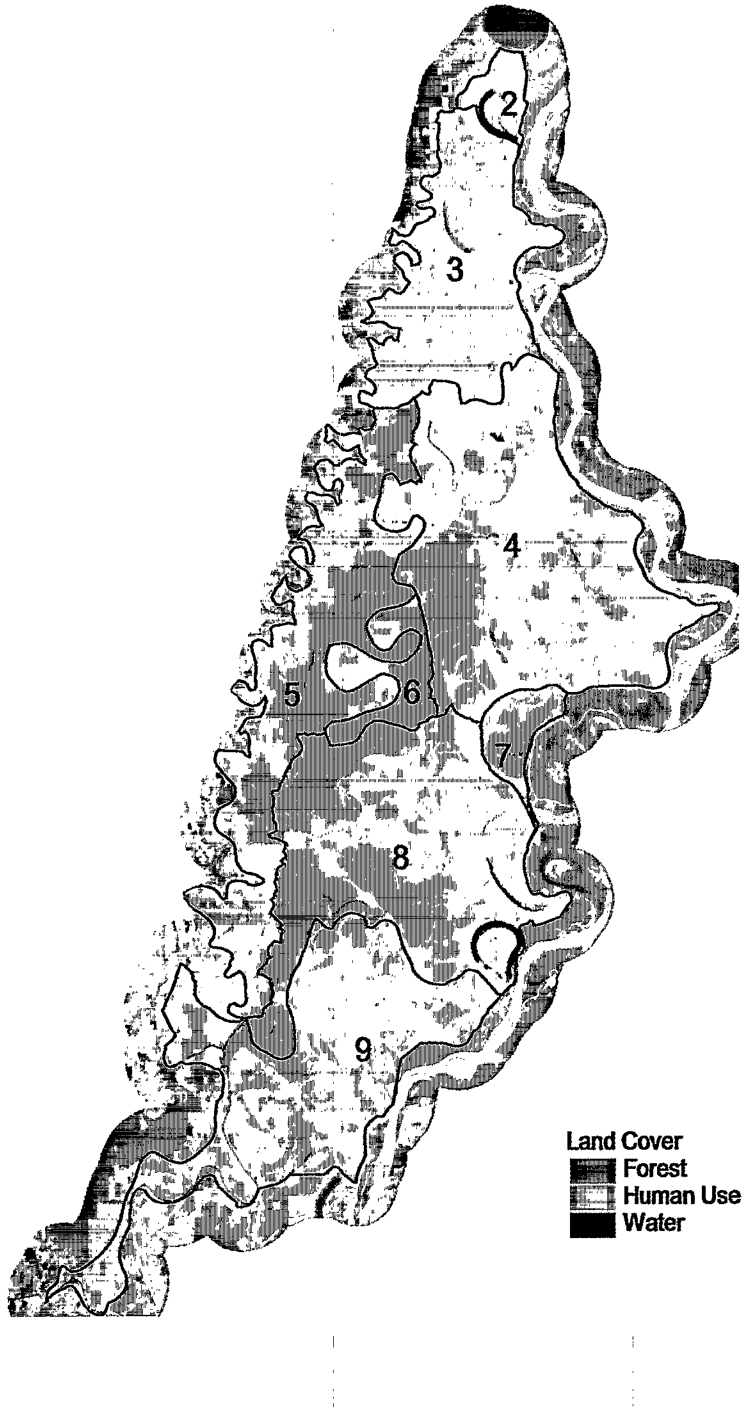
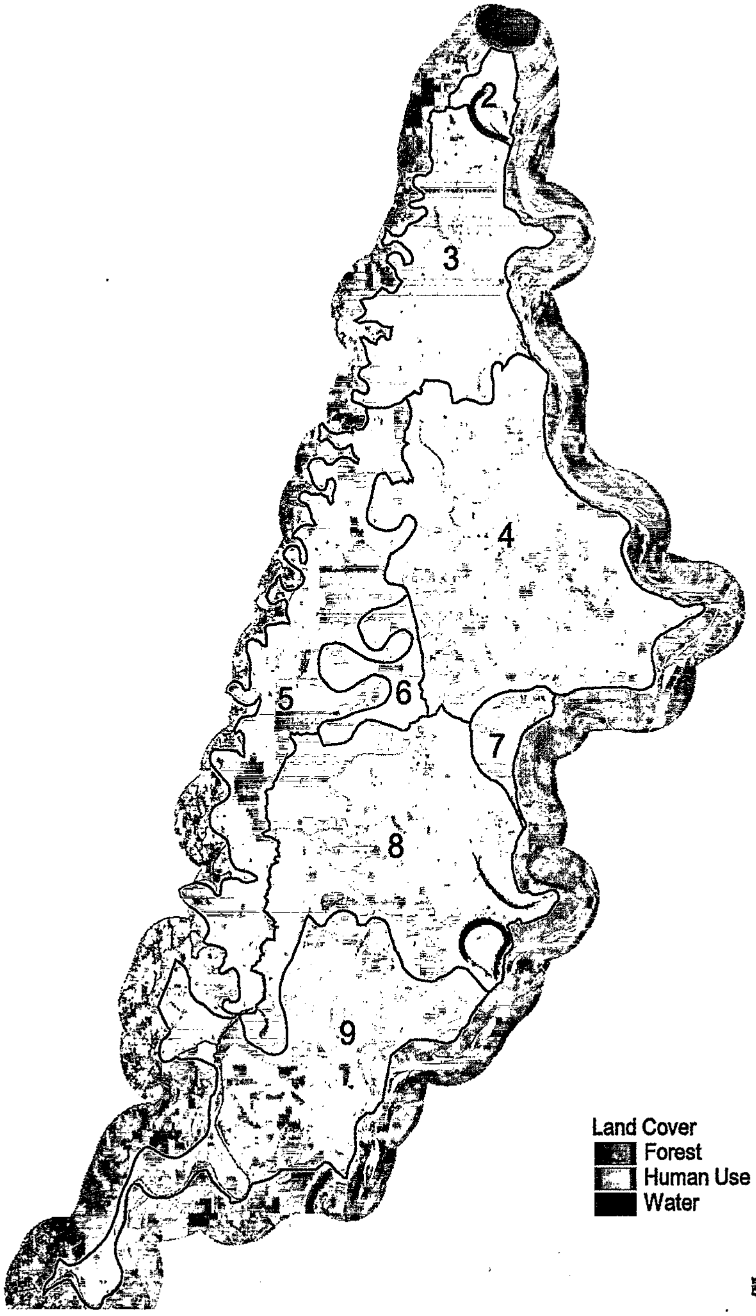


Figure 3.10

1970s Classified Image, Land Cover.



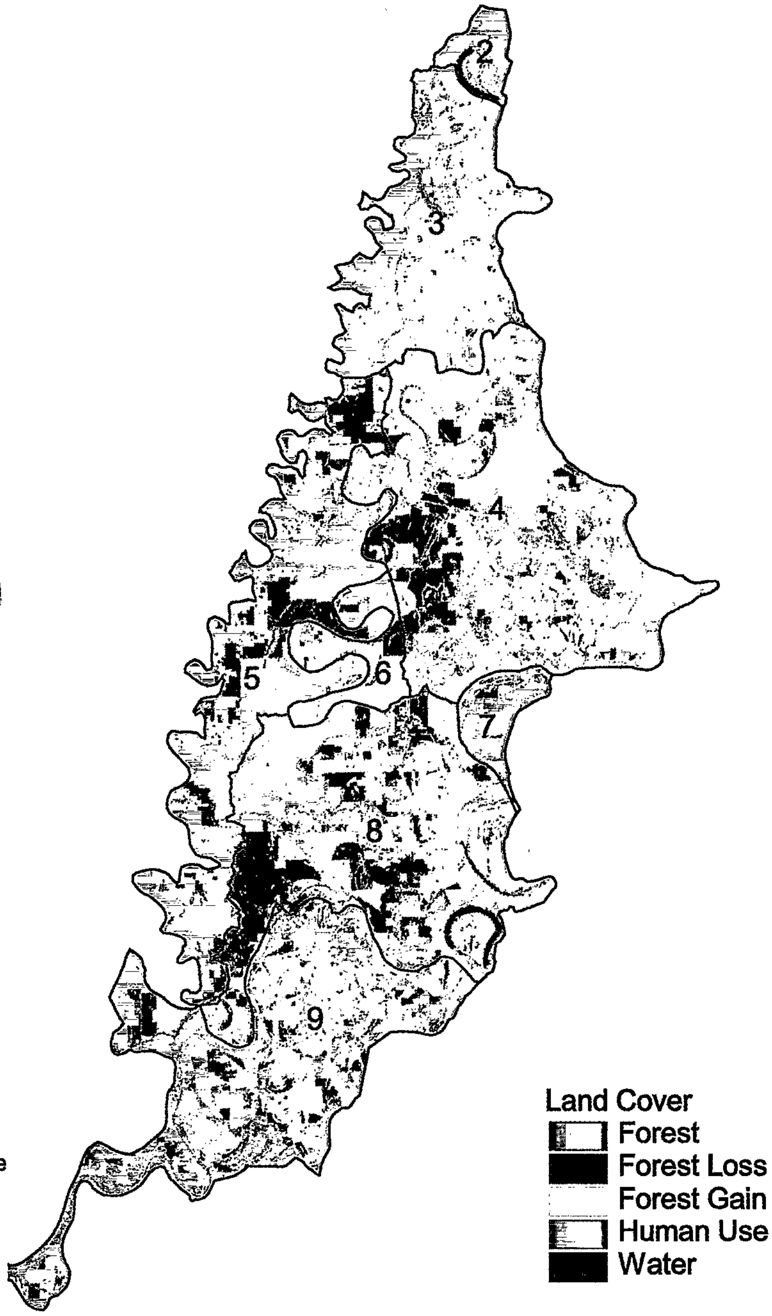


Figure 3.11

1990s Classified Image, Land Cover.

Figure 3.12

Classified Image, Vegetation Change 1970s to 1990s.

Vegetation Change

In the previous sections, we discussed landscape change based on NALC images that had been classified. Another method is to calculate indices directly from the satellite imagery. It is interesting to compare the results of the preceding landscape change analysis with those presented in the following discussion.

A common perception is that patterns of forest and agriculture and urban areas remain constant over time. In this section we present patterns of vegetation change measured by comparing satellite images from 1972 and a composite of 1991 and 1992. The change is determined by using a vegetation index called Normalized Difference Vegetation Index (NDVI) which was calculated for each pixel on each of the two dates. When the NDVI values are essentially the same at both dates, then there has been no change. When the value is greater in 1972 than 1991/92, we interpret this as vegetation loss. When the value in 1972 is less than 1991/92, we interpret this as vegetation gain. Total vegetation change is taken to be the sum of loss and gain on an area basis.

The NDVI can be derived from satellite images because the near infrared band produces a large reflectance compared to the visible red band when looking at vegetation. The formula for NDVI is:

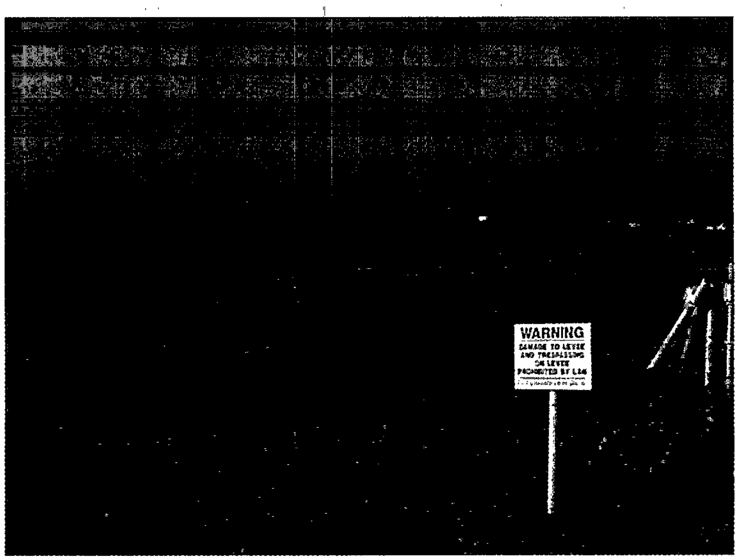
$$\text{NDVI} = \frac{\text{Infrared Band} - \text{Visible Red Band}}{\text{Infrared Band} + \text{Visible Red Band}}$$

The NDVI also has the advantage of compensating for changing illumination conditions like surface slope, aspect, and other factors. Indexes derived by NDVI range from -1.0 to 1.0, where negative index values represent clouds, water, and snow. Index values near zero represent barren soil and rock, and positive index values are indicators of the variation in vegetation.

Comparison of temporal changes in reflectance measures from satellites, such as NDVI, can be useful for gaining insight into land cover changes when land cover maps from two different dates are not available. Interpreting the measurements relative to land cover change is not straightforward though because some changes in reflectance are not changes in land cover. Crop rotation is a good example. Change in NDVI measurements may be the result of seeing a field in production on one date and fallow on the other. Interpretation of these measurements for actual land cover change requires a lot of additional work beyond calculating their difference over time.

Despite the complications, the amount and spatial pattern of NDVI change is important. For example, many of the decreases in NDVI turn out to be associated with road improvements, new residential developments, urbanization projects, and construction of reservoirs. Gains in NDVI may be the result of crop rotation or maturing vegetation in residential developments. Gains in NDVI appear to be associated with both natural and anthropogenic processes, whereas non-crop rotation NDVI losses appear to be more consistently associated with anthropogenic activities.

These examples show that, after calibration, NDVI changes over time can help answer several ecologically important questions such as: (1) how much change has occurred? (2) is vegetation change evenly distributed over all the watersheds in the region, and (3) is vegetation change concentrated in the headwater regions of streams? Figure 3.13 shows the vegetation change from 1972 through 1991/92.



Tensas River Basin Agriculture Field.

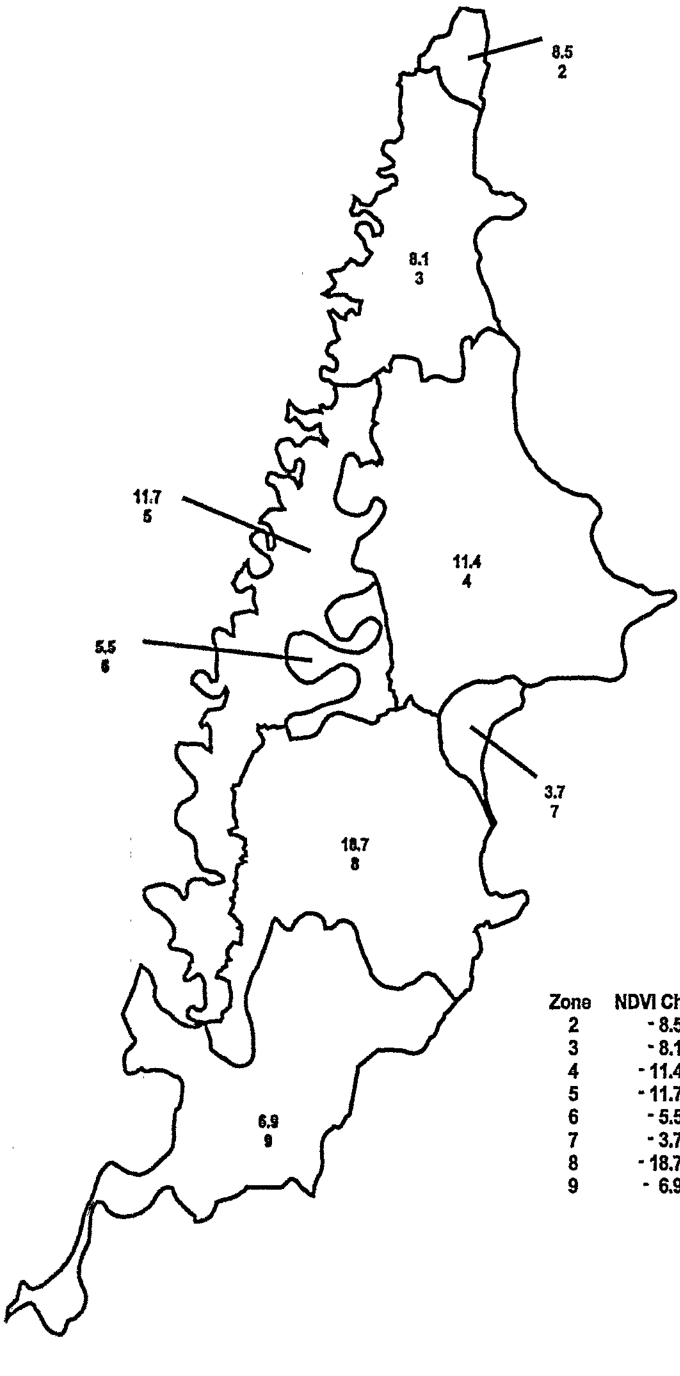
Vegetation Change by Subwatershed

Figure 3.14 shows the percentage of total NDVI change for all subwatersheds in the Tensas River Basin. All of the changes observed represent losses in vegetation. Vegetation loss shows a general pattern with the highest rate of change in subwatershed 8. Vegetation changes in subwatersheds 2, 3, and 4 are most likely due to farming practices of rotating crops. Lower vegetation changes can be noted in subwatersheds 6 and 7 due to the relative stability of the forests in those areas. The high loss in vegetation in subwatershed 8 is most likely due to forest loss in that area since 1972. Table 3.4 contains the numerical data of gains and loss by pixels and the percentage for each subwatershed. Similar patterns of vegetation changes were observed in Figure 3.9 which showed forest losses and gains based on classified NALC images.

Tensas River Basin, Bottomland Hardwoods.

Figure 3.13

NDVI Change between 1972 and 1991/92 in the Tensas River Basin. Red = Loss and Green = Gain.



Zone	NDVI Change
2	- 8.5
3	- 8.1
4	- 11.4
5	- 11.7
6	- 5.5
7	- 3.7
8	- 18.7
9	- 6.9

Figure 3.14

Net percentage of change in the NDVI for the Tensas River Basin from 1972 to 1991/92 by subwatershed. All changes represent net losses.

Forest and Crop Land Along Streams

The strip of vegetation along streams is known as the riparian vegetation zone. It is commonly described by the types of vegetation it contains. In an ideal situation, many pollutants and fertilizers will be intercepted or absorbed by the riparian vegetation, and this process helps to keep the streams clean. Bank erosion is also mitigated by intact riparian vegetation. The Tensas River Basin is unique in the natural levees along with the riparian vegetation lie on the highest ground in the Basin. This causes drainage water to run parallel to streams for many miles before actually entering the streams and river water channels. Wetlands and backswamps then become the vegetation filtering areas for pollutants and nutrients.

Forested riparian zones are a natural part of the healthiest stream ecosystems in the southern United States. They provide an effective barrier to runoff of water, pollutants, and excess fertilizer and support a variety of valuable plant and wildlife species. Conversely, when riparian forests are replace by agriculture, the riparian zone not only loses its natural buffering capacity but now becomes a potential source of pollution and excess fertilizer. Agricultural practices usually employ fertilizers, pesticides, and other chemicals that are essential to crop growth and yield. These chemicals can more readily be moved into streams which flow through agricultural fields, in comparison to streams which flow through forests. The maps on these pages illustrate differences among watersheds in the length of stream that has either forest or crop cover in the riparian zone.

Figure 3.15 shows the relative amount of forests and human use land cover within a 360-meter buffer riparian zone along the Tensas River and its major tributaries. Figure 3.16 shows the amount of forests and human use land cover within a 120-meter buffer zone on either side of all the stream reaches of the Tensas River Basin. Subwatersheds 2 and 3 have the least percentage of forest in riparian zones. Subwatersheds to the south have the greatest amount of forested riparian cover. All of the sub-watersheds have stream length with some cropland cover. The watersheds with the highest potential for negative impacts are in subwatersheds 2, 3, and 4.

Whereas the distribution of riparian forests is an indicator of natural buffering capacity, the distribution of crop land cover in riparian zones is an indicator of potential problems. Figure 3.17 zooms in on stream length between subwatersheds 5 and 8 and shows cropland cover (human use) and forested areas in the riparian zone. All of the areas shown in red were historically forested and are now cropland cover.

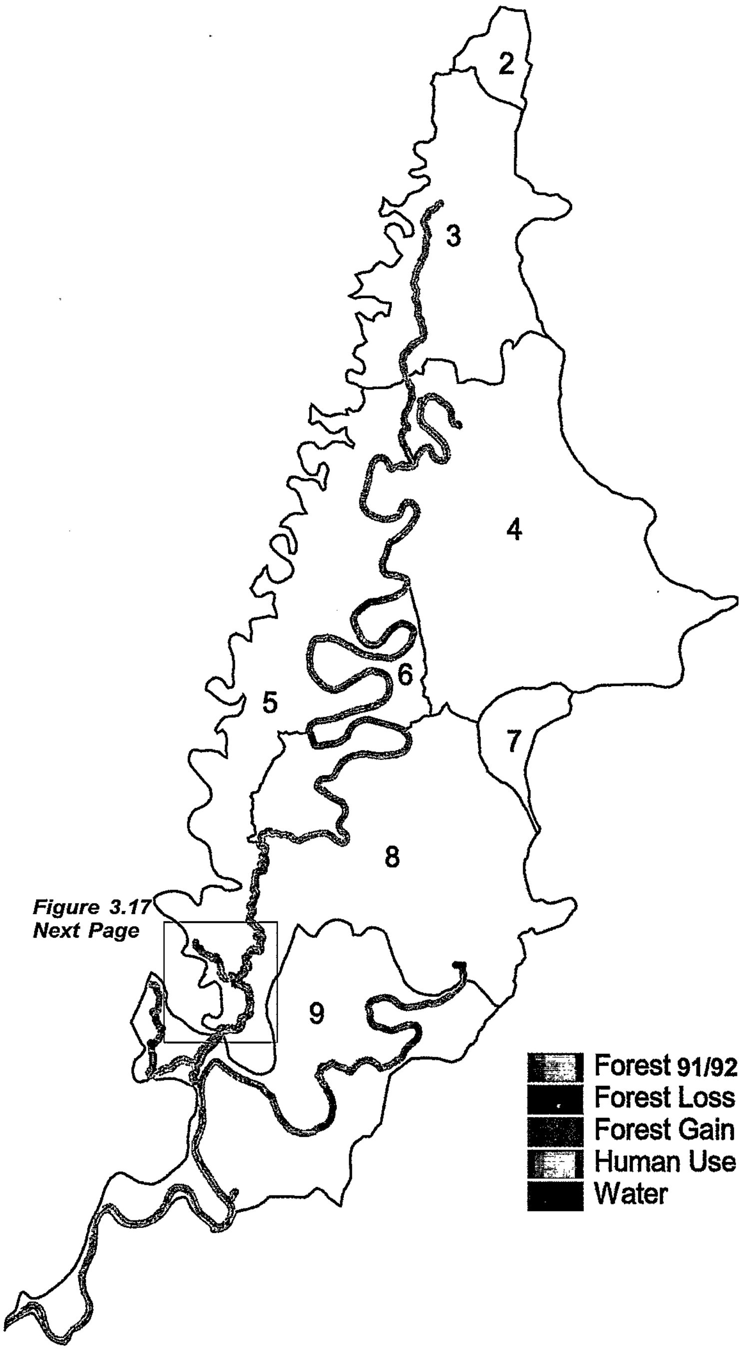


Figure 3.15

Riparian Zone of Tensas River and its Major Tributaries (360-meter buffer).

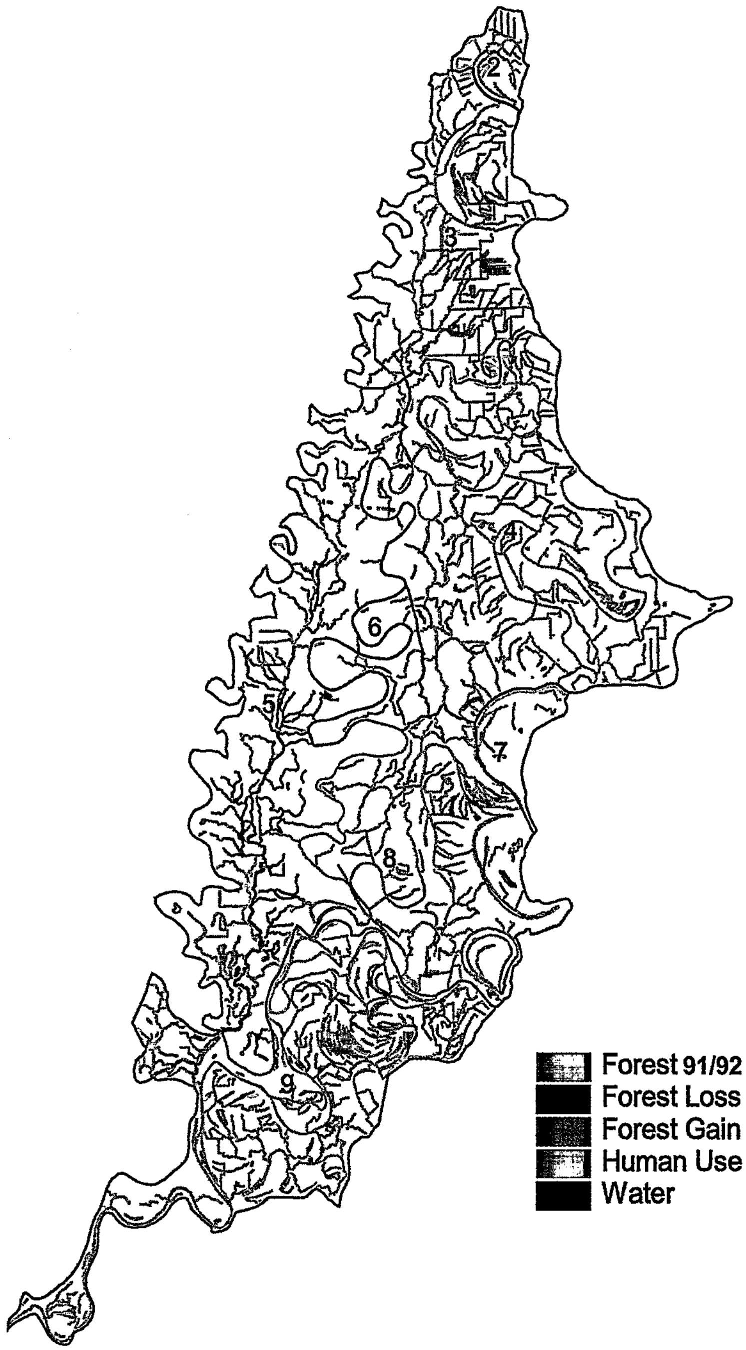


Figure 3.16

Riparian Zone of all Stream Reaches (120-meter buffer).

Forest
Forest Loss
Forest Gain
Human Use
Water

Figure 3.17

Enlargement of Riparian Zone with 1992 NALC Image.

Water and the Landscape

Everyone knows the importance of water. But many people do not realize how much its quality depends on the surrounding landscape. Water quality, like landscape condition, is the cumulative impact of environmental stress and land management practices at broad scales. Changes in the distribution and pattern of ecological resources and human activities can alter fundamental water processes including flow and balance, nutrient and sediment loading, and chemistry. These changes can, in turn, influence the water quality and quantity that are valued by society. Figures 3.16 and 3.18 illustrate the stream network within the Tensas River Basin.

This section presents landscape indicators that are related to water quality in the streams of the Tensas River Basin. "Riparian" indicators describe landscape conditions near streams and "watershed" indicators describe conditions over entire watersheds. The riparian indicators include measures of human activities (agriculture and roads) near streams and the amount of wetland area. The size and amount of riparian buffers along streambanks is an important determinant of soil loss and sediment movement, which in turn affect water quality.

The group of watershed indicators presented here primarily measure the potential for soil and nutrient losses from surrounding landscapes which would ultimately be deposited in streams. Put simply, watersheds covered by natural forests are more likely to be in good condition than watersheds with high percentages of intensive human land uses. Because intact riparian areas buffer streams from the potentially adverse effects of watershed-scale events like erosion, both types of indicators need to be evaluated when considering overall landscape influences on stream condition and water quality.

Watershed Indicators

While streamside conditions are important, it is also important to have indicators of potential impacts on water quality from sources throughout the watershed. It was mentioned earlier that the watershed indicators presented here are primarily concerned with soil erosion and runoff processes. These indicators are relatively easy to determine from existing databases. In any case, erosion processes are extremely important. The results of increased erosion may include reduced agricultural productivity, increased water treatment costs, introduction of pesticides and fertilizers in the water supply, loss of habitat for fish and other species, and reduced recreation potential.

In years past the freshwater marshes, stream bank areas, and bottomland swamps of the Tensas River Basin were under strong development pressures. Large portions of forest near streams and in backwater swamp areas were converted to agriculture. This loss of forested areas interfered with the soil and water interactions in forested wetlands that removes pollution (excess nutrients) before it enters streams, lakes, and estuaries. Wetland forests also dissipate peak flows during floods and release the waters slowly, reducing damage to downstream farms and cities. Preserving or restoring wetland forests has other economic benefits including wetland-based recreation such as hunting and harvesting wetland plants. Residents of the Tensas River Basin realize that the vegetation along a stream and in backswamp areas can influence the condition of both the stream bank and the water in the stream. They began restoration efforts in the early 1990s.

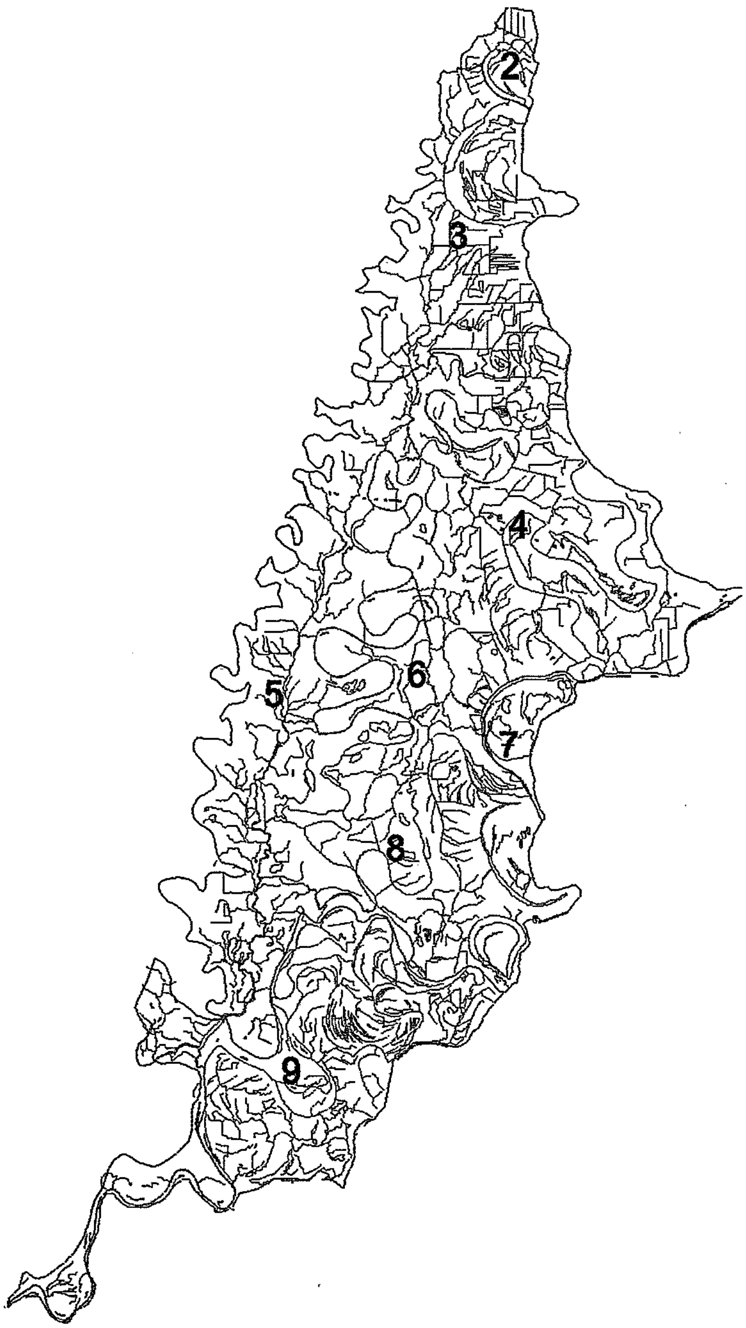


Figure 3.18

Stream network in the Tensas River Basin. Source: EPA RF3.

Riparian Analysis

The conditions of the riparian ecosystem over a whole watershed can be studied in order to learn where, for example, a restoration project would most improve water quality. Similarly, a characterization of riparian conditions over the entire Tensas River Basin can help to identify which areas of the Basin are most likely to see improved water quality as a result of riparian vegetation improvements.

The forest change data for the riparian areas of the Tensas River Basin are given in Table 3.6. This analysis was done by taking the forest change data and applying it to all the streams in the watershed in areas 120 meters on either side of the stream. This is shown in Figure 3.11. Each subwatershed was also analyzed so a comparison can be made between the different subwatersheds.

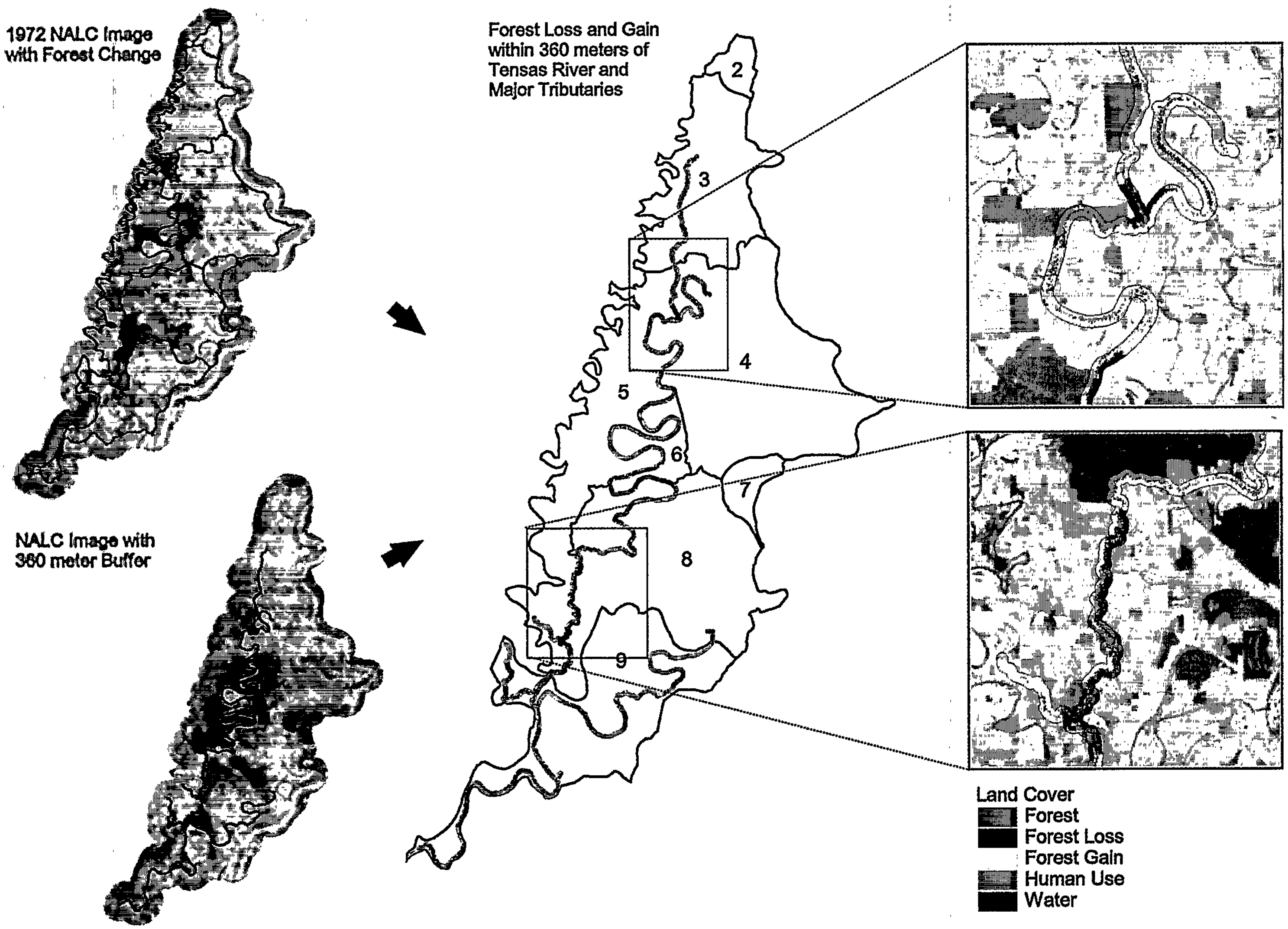


Figure 3.19

Vegetation Change within 360 meters of Tensas River and Major Tributaries.

This comparison can be seen in Table 3.6. Riparian areas have undergone changes in the Basin. In most cases, the forest change tends to be higher near streams. The highest forest change in the riparian areas was in subwatershed 8 where there was a 23.7 percent loss in forest vegetation. This data shows us where land use practices can be changed to help improve water quality. Improvements could be made in subwatershed 8 if the land owners are willing to convert the riparian strip of land back to forest vegetation.

Vegetation Change along the Tensas River Reach

The vegetation along a stream affects the condition of the stream and the water in the stream. This analysis includes the area 360 meters on either side of the main channel of the Tensas River and the same distance on either side of the major tributaries of the Tensas River. The results are shown in Table 3.5 and illustrated in Figure 3.19.

Compared to the overall Tensas River Basin which had a 21.3% overall loss in forest vegetation the data show that loss in the immediate area of the river and its tributaries was only 7.5%. Although the loss of forest vegetation was 7.5%, it shows that more vegetation was left within 360-meters of the main portion of the Tensas River and should help prevent stream bank erosion and excess nutrient loading to the river.

Backswamp Area Analysis

The backswamp areas of the Tensas River Basin play a very important role in the ecology of this water system. The land is very flat which means that water can move into stream channels and it can also collect in low-lying areas. These areas, which can hold water for months at a time after big rain events, make up lakes, swamps, and wetland forests. Figure 3.20 shows the location of Tensas River Basin backswamp areas. Information about changes to and locations of the backswamp areas will be an indicator of water quality in this watershed.

The backswamp areas in the Tensas River Basin are very important in terms of using the excess nutrients found in the water and holding water during heavy rain events. The combination of these flood areas with the forest change landscape indicators is shown in Table 3.7 and Figure 3.21. Forest change in backswamp areas is somewhat different that in other areas. A higher percentage of backswamp area was lost in subwatershed 4 (around the town of Tallulah) than in the entire Tensas watershed. A complete comparison between the Tensas subwatersheds is given in Table 3.7.

Backswamps in the Tensas River Basin.

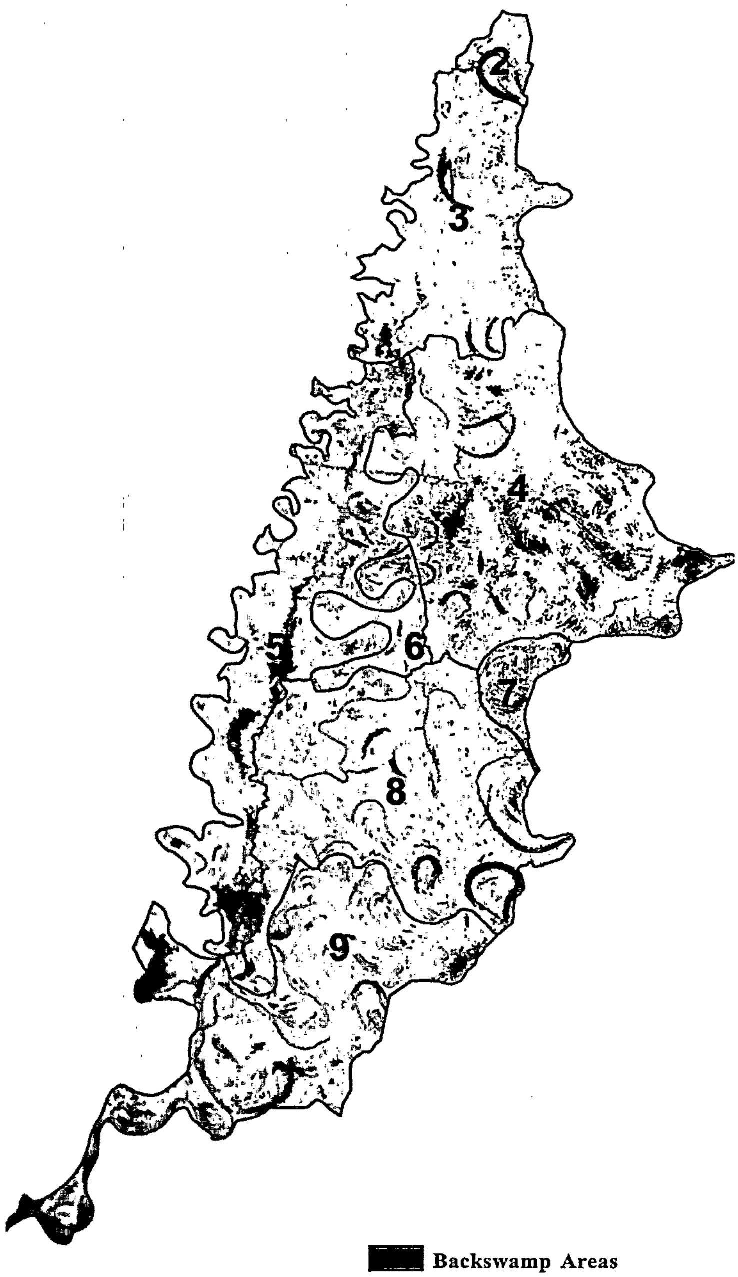


Figure 3.20.

Backswamps in the Tensas River Basin.

Source: The Nature Conservancy and the Biological Resources Division of the USGS

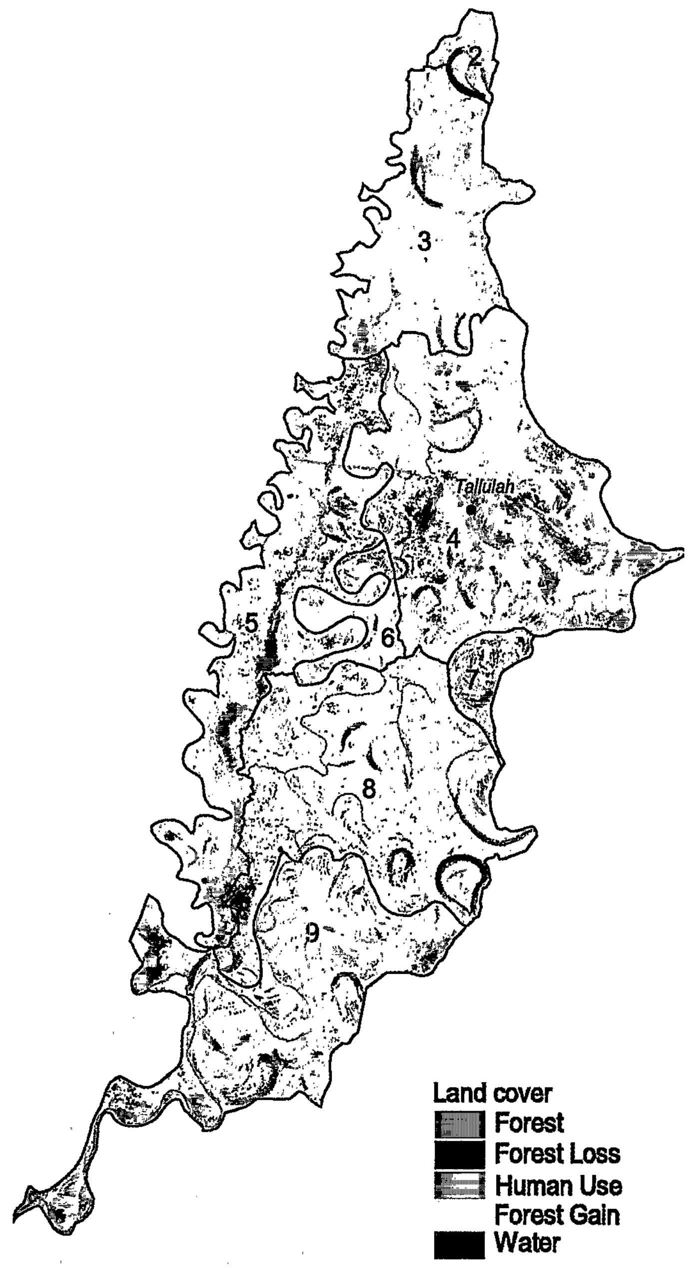


Figure 3.21

Forest Change in Backswamp Areas.

Soil Erodibility Analysis

Soil erosion is important because it reduces productivity of agricultural lands and because eroded soil can be transported to a stream where it becomes sediment. Topsoil is expensive to replace and natural soil-forming processes would require thousands of years to replenish soil already lost from the Nation's farmland. One of the tools developed by agricultural scientists to estimate soil loss from farm lands is the Universal Soil Loss Equation, or USLE. The USLE is intended to demonstrate how agricultural practices contribute to or reduce soil erosion. The USLE is not generally applied to nonfarm land cover types.

Figure 3.22 shows the watershed classes for the different USLE K-factor erodibility values assigned to the surface soil horizons. The K-factor estimates the relative erodibility of a soil with respect to all possible textures (range 0.0 to 0.64). Surface soils in the Tensas River Basin exhibit K-factors ranging from 0.18 to 0.48. As shown in the figure, the most erodible soils seem to occur most commonly in old oxbows and meander channels and are spread evenly throughout the Basin. The least erodible soils occur in backswamp areas adjacent to active stream channels.

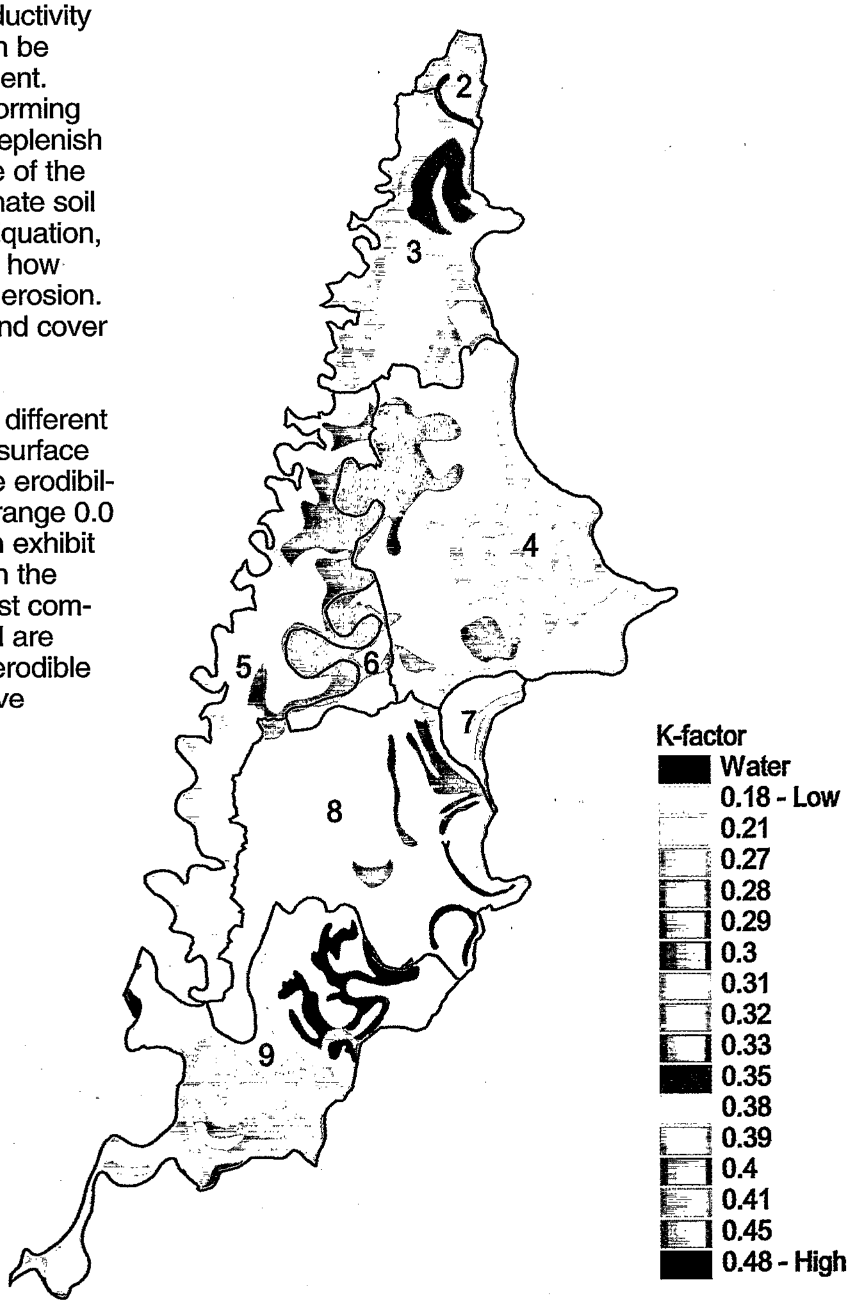


Figure 3.22

Relative Soil Erodibility Map for Tensas River Basin.
Source: NRCS STATSGO.

Wetland Restoration Analysis

Restoration of wetlands and associated processes is a primary objective of many of the stakeholders in the Tensas River Basin. As a result, the Tensas River Basin has been the focus of many environmental studies which provide many types of data to continue our analysis. Many GIS coverages are readily available from groups involved in previous and ongoing studies. These resources provided the opportunity to use this data along with the forest change data to evaluate potential wetland restoration. One of the GIS databases available covers all the areas which are a part of the Louisiana Private Lands Restoration - Wetland Reserve Program. These are areas where land owners have changed land use from agriculture back to forests. Figure 3.23a shows restoration efforts that have been taking place over the past 5 years around the Tensas River Basin. This image shows that the areas previously selected for forest restoration were suitable in terms of restoring forests along riparian areas and connecting existing forests. Figure 3.23b is a view of the forest change, wetland restoration sites and streams to better show how the forest restoration sites are suitable in terms of restoring forest along riparian areas and connecting existing forests.

Displaying GIS databases and remote sensing data together can visually give land managers more information about soils, flood potential, and other types of features to help make the best choices for restoration.

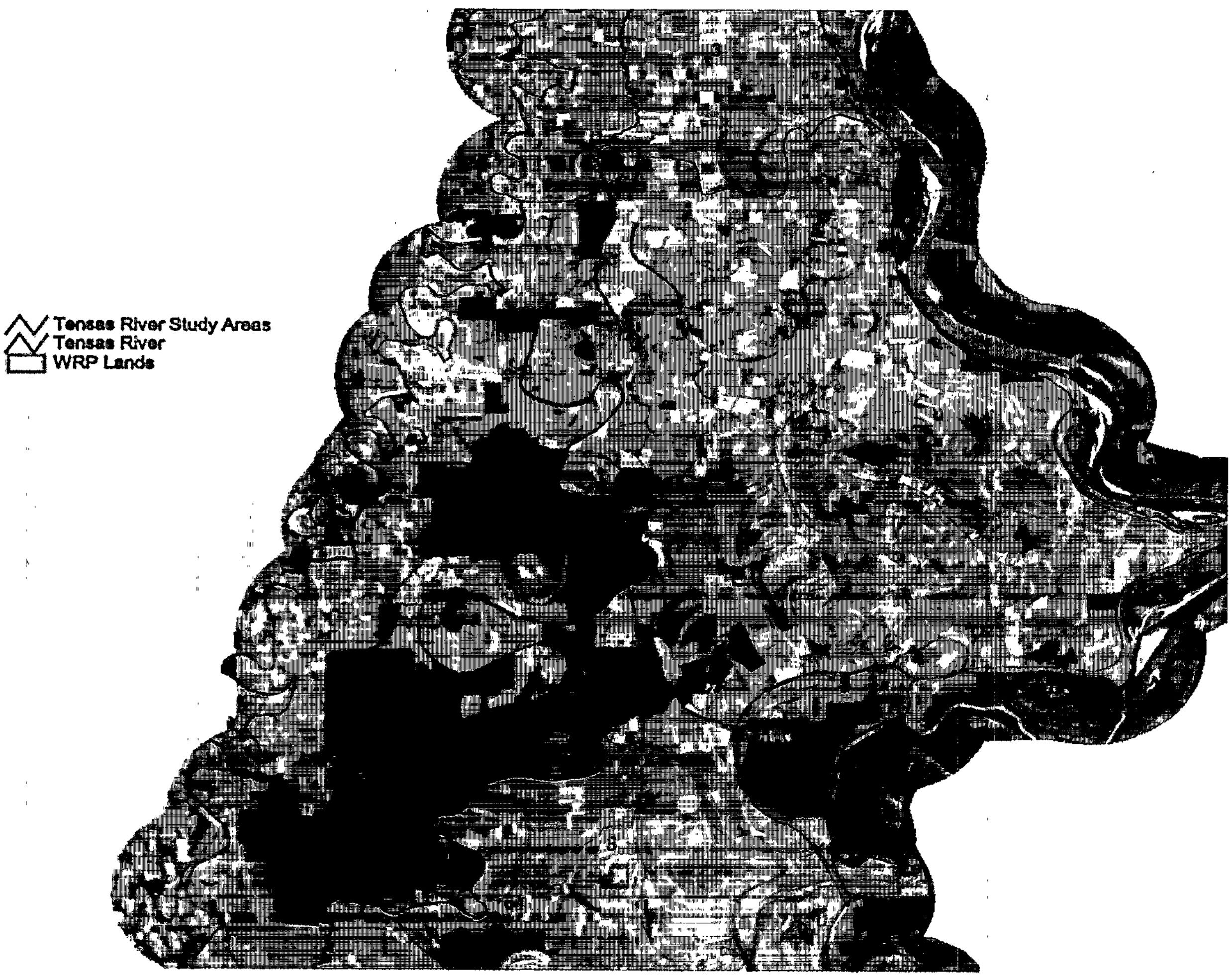


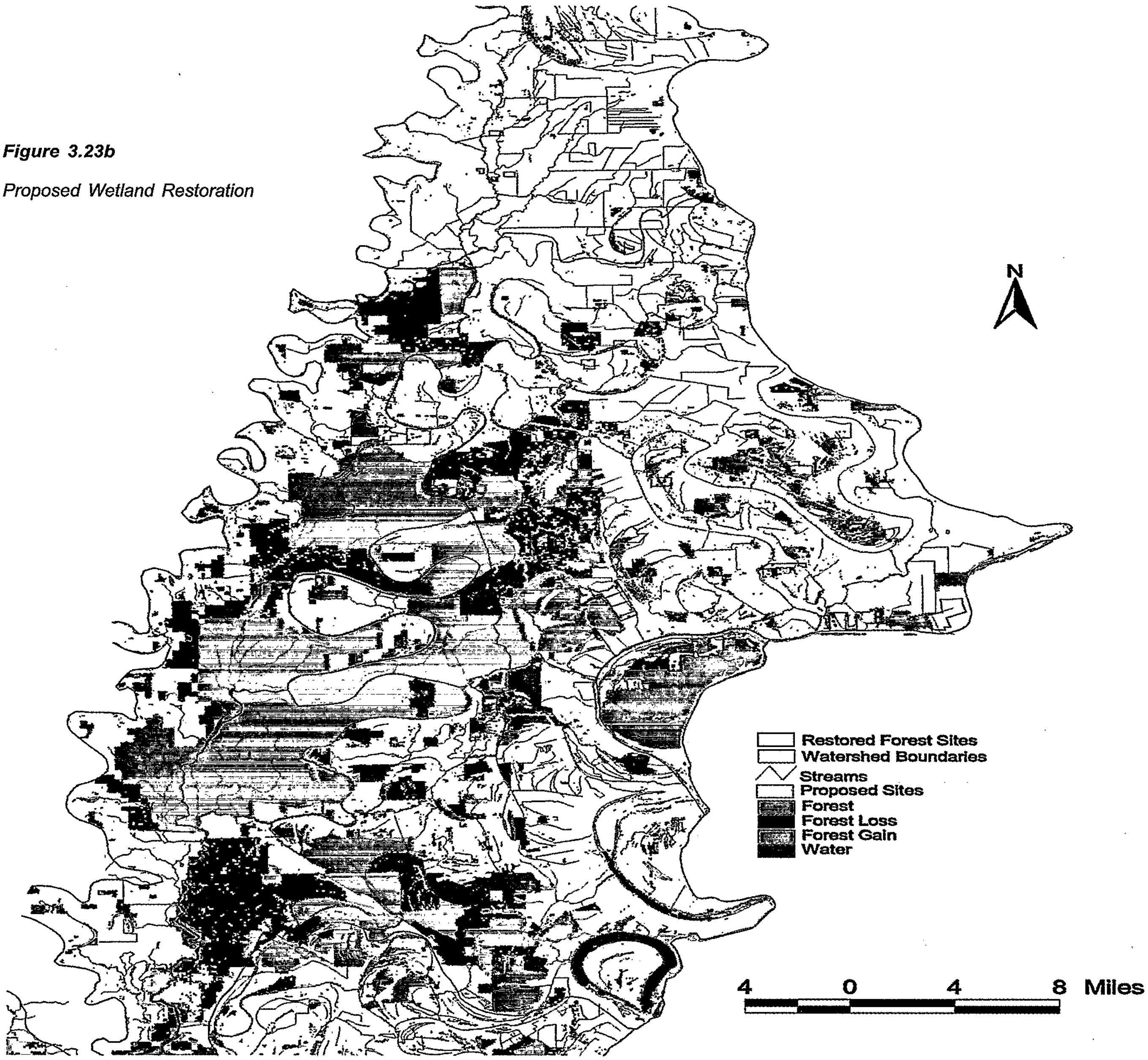
Figure 3.23a

Wetland Reserve Program (WRP). Remote Sensing Image

Using the landscape analysis indicator of percent forest, Table 3.8, we recalculate the landscape statistics to include the Wetland Restoration data. The results of this analysis are shown in Table 3.8. Table 3.8 provides a statistical view of the Tensas Basin in 20 years or when the trees have grown enough to establish a forested area. It is interesting to note that most of the restoration efforts have gone into the subwatersheds 4 and 7. Using the data from this analysis future decisions in selecting restoration sites land managers may want to focus more attention to subwatersheds 8 and 9.

Figure 3.23b

Proposed Wetland Restoration

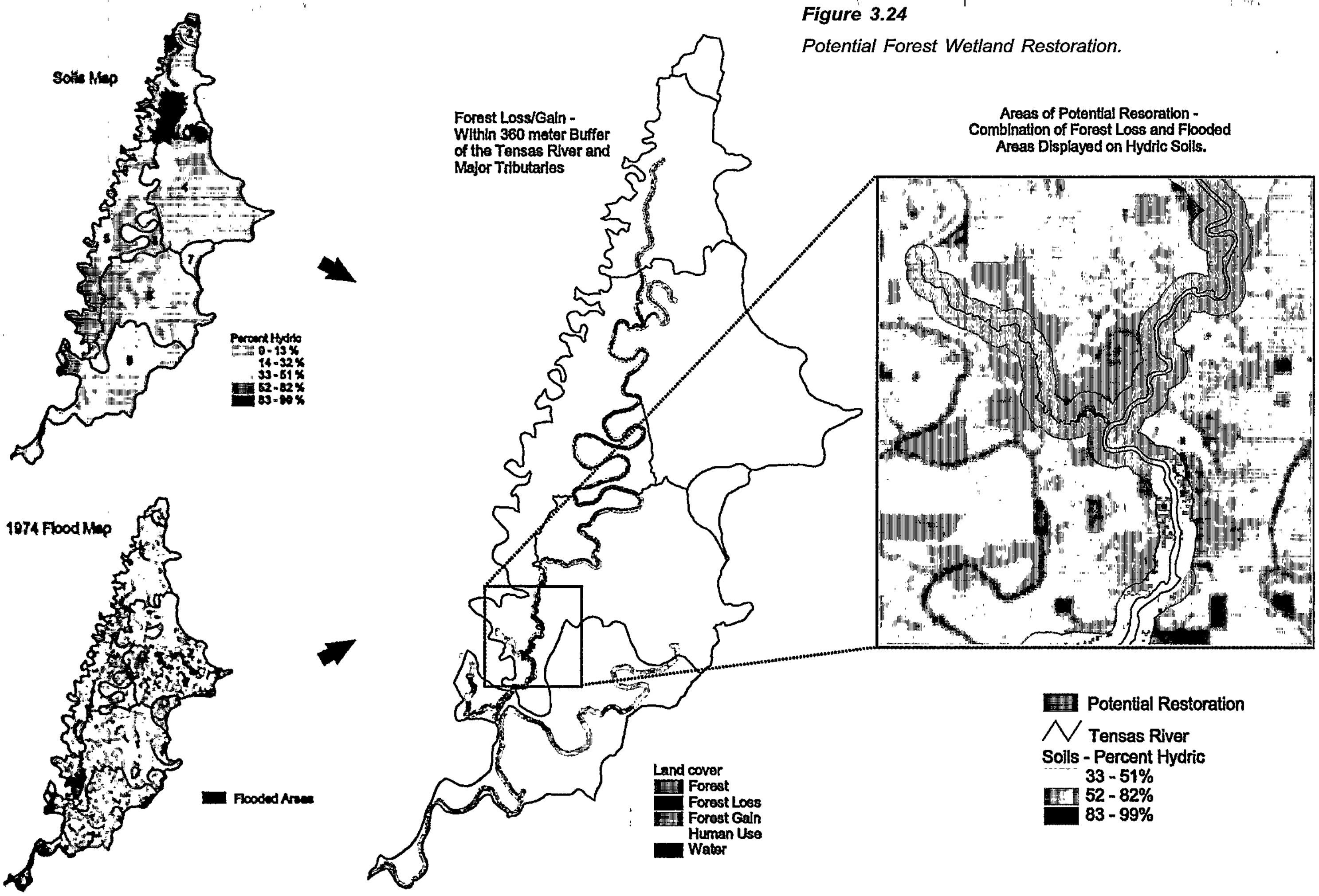


Through landscape analysis we can also locate sites for potential forest wetland restoration. Figure 3.24 shows a combination of a hydric soils map with a flood map and the forest change map along a 360-meter buffer of the main channel of the Tensas River Basin and its major tributaries. Using these maps land managers can make decisions on locating potential restoration sites by factoring in fertile and non-fertile soil types, land which has the potential to flood, and areas which were forest and could easily be forested again in the future. Based on the combinations of these indicators, the best candidates for potential restoration sites are shown in green on the right image of Figure 3.24. Figure 3.24 shows an enlarged map for ease in identifying restoration locations. Figure 3.25 illustrates this technique applied over the entire Basin.

We have also determined the percent of forest change including restoration efforts over the Tensas River Basin and its subwatersheds. Figure 3.26 shows the percent of forest change, the forest change for the whole basin, and the net forest restoration effort to date. Zones 4 and 7 show the most impact from the restoration efforts and Zones 6, 8, and 9 show little change in restoration. Zone 8 shows the most forest loss of all the Zones with a 21.2 percent loss over the 20-year time period. The combination of GIS analysis and these kinds of landscape analysis can give land managers powerful decision tools for improving environmental quality.

Figure 3.24

Potential Forest Wetland Restoration.



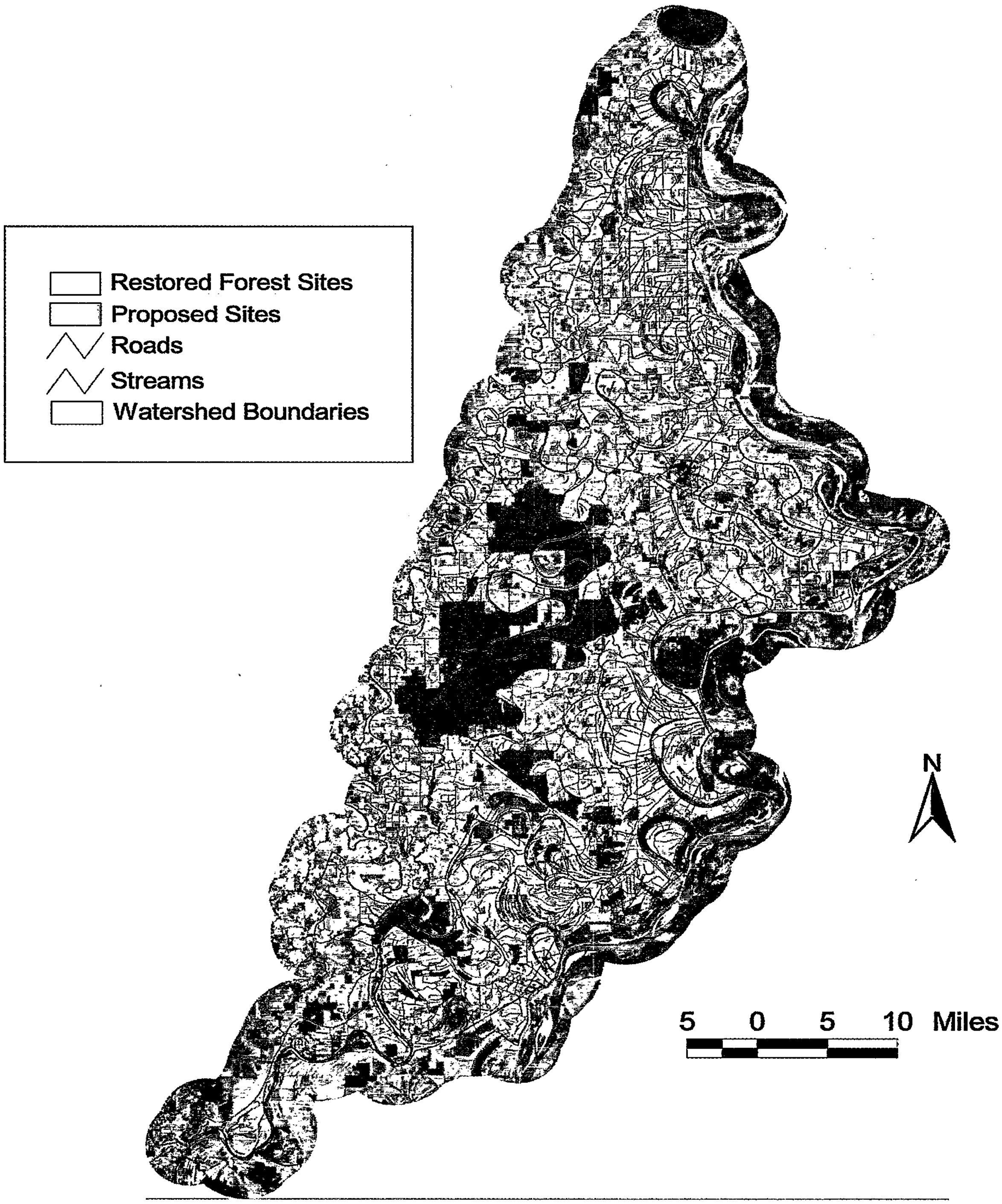
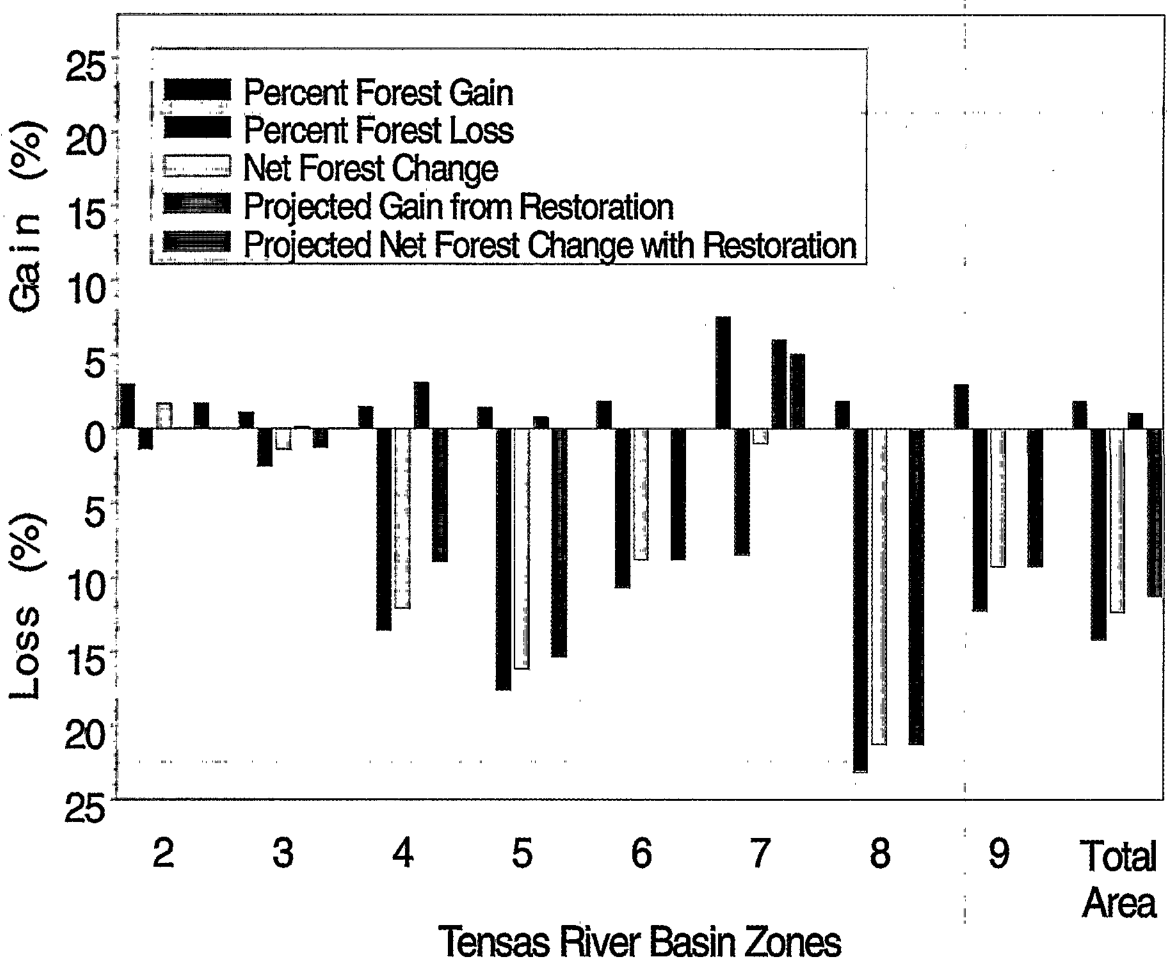


Figure 3.25 *Potential Forest Wetland Restoration for the Entire Tensas River Basin*



Percent Forest Gain
Percent Forest Loss
Net Forest Change
Projected Gain from Restoration
Projected Net Forest Change with Restoration
Gain (%)
Loss (%)
25
20
15
10
5
0
5
10
15
20
25
2
3
4
5
6
7
8
9
Total Area
Tensas River Basin Zones

Figure 3.26

Table 3.1 1972 Forest

Zone	Total # of Pixels	Total (ha)	Forest (pixels)	Forest %	Human Use (pixels)	Human Use %	Same -Type %	Largest Patch (pixels)	Largest Patch (ha)	Avg Patch (pixels)	Avg Patch (ha)
Total	1043984	375834.2	350828	33.6	679228	65.1	88.6	152609	54939.2	108	38.9
2	15569	5604.8	712	4.6	13267	85.2	43.9	101	36.4	7.6	2.7
3	126078	45388.1	5403	4.3	120252	95.4	48.4	864	311.0	7.2	2.6
4	256891	92480.8	61666	24.0	193968	75.5	86.2	36436	13117.0	78.2	28.2
5	171594	61773.8	84382	49.2	85707	49.9	93	49643	17871.5	187.9	67.6
6	30910	11127.6	21398	69.2	9300	30.1	95.2	19442	6999.1	162.1	58.4
7	20411	7348.0	12354	60.5	7811	38.3	87.2	11878	4276.1	99.6	35.9
8	221441	79718.8	108326	48.9	107402	48.5	90.3	53393	19221.5	111.2	40.0
9	200615	72221.4	57279	28.6	140272	69.9	80.9	8394	3021.8	62.3	22.4

Table 3.2 1991 Forest

Zone	Total # of Pixels	Total (ha)	Forest (pixels)	Forest %	Human Use (pixels)	Human Use %	Same -Type %	Largest Patch (pixels)	Largest Patch (ha)	Avg Patch (pixels)	Avg Patch (ha)
Total	1043948	375821.3	224465	21.5	806490	77.3	84.5	105548	37997.3	64.3	23.1
2	15558	5600.9	1056	6.8	12809	82.3	53.8	242	87.1	14	5.0
3	126080	45388.8	3872	3.1	121907	96.7	48.3	368	132.5	7.8	2.8
4	256905	92485.8	31199	12.1	225015	87.6	76.6	11614	4181.0	39.3	14.1
5	171571	61765.6	57244	33.4	113185	66.0	91.8	24872	8953.9	106.9	38.5
6	30923	11132.3	18864	61.0	12025	38.9	94.9	13133	4727.9	136.6	49.2
7	20413	7348.7	12266	60.1	7962	39.0	88.1	11186	4027.0	70	25.2
8	221446	79720.6	61431	27.7	154211	69.6	85.3	28713	10336.7	54.7	19.7
9	200602	72216.7	39231	19.6	158225	78.9	75	6618	2382.5	37.4	13.5

Table 3.3 Forest Change

Zone	Total # of Pixels	Total (ha)	Forest (pixels)	Forest %	Forest Gain (pixels)	Forest Gain %	Forest Loss (pixels)	Forest Loss %	Lost (ha)	Net Lost (ha)	Net Forest Loss %
Total	1043907	375806.5	202203	19.4	19409	1.9	147836	14.2	53221.0	-46233.7	-12.3
2	15559	5601.2	503	3.2	473	3.0	209	1.3	75.2	95.0	1.7
3	126076	45387.4	2210	1.8	1419	1.1	3140	2.5	1130.4	-619.6	-1.4
4	256864	92471.0	26983	10.5	3765	1.5	34739	13.5	12506.0	-11150.6	-12.1
5	171505	61741.8	54148	31.6	2487	1.5	30141	17.6	10850.8	-9955.4	-16.1
6	30906	11126.2	18090	58.5	578	1.9	3294	10.7	1185.8	-977.8	-8.8
7	20405	7345.8	10572	51.8	1531	7.5	1731	8.5	623.2	-72.0	-1.0
8	221426	79713.4	56488	25.5	4261	1.9	51239	23.1	18446.0	-16912.1	-21.2
9	200588	72211.7	32586	16.2	6039	3.0	24496	12.2	8818.6	-6644.5	-9.2

Table 3.4 NDVI Change

Zone	Total # of Pixels	Total (ha)	NDVI (pixels)	NDVI %	NDVI Gain (pixels)	NDVI Gain %	NDVI Loss (pixels)	NDVI Loss %	Lost (ha)	Net Lost (ha)	Net NDVI Loss %
Total	1045254	376291.4	170118	16.3	25605	2.4	144513	13.8	52024.7	-42806.9	-11.4
2	15626	5625.4	1663	10.6	167	1.1	1496	9.6	538.6	-478.4	-8.5
3	126486	45535.0	16243	12.8	3003	2.4	13240	10.5	4766.4	-3685.3	-8.1
4	257020	92527.2	46229	18.0	8442	3.3	37787	14.7	13603.3	-10564.2	-11.4
5	172230	62002.8	31302	18.2	5576	3.2	25726	14.9	9261.4	-7254.0	-11.7
6	30934	11136.2	3149	10.2	730	2.4	2419	7.8	870.8	-608.0	-5.5
7	20420	7351.2	1663	8.1	453	2.2	1210	5.9	435.6	-272.5	-3.7
8	221532	79751.5	46126	20.8	2315	1.0	43811	19.8	15772.0	-14938.6	-18.7
9	201006	72362.2	23743	11.8	4919	2.4	18824	9.4	6776.6	-5005.8	-6.9

Table 3.5 360 Meter Buffer along the Tensas River

Zone	Total # of Pixels	total (ha)	Forest (pixels)	Forest %	Forest Gain (pixels)	Forest Gain %	Forest Loss (pixels)	Forest Loss %	Lost (ha)	Net Lost (ha)	Net Forest Loss %
Total	76659	27597.2	20793	27.1	3100	4.0	8883	11.6	3197.9	-2081.9	-7.5

Table 3.6 120 Meter Buffer along all Stream Reaches in the Basin

Zone	Total # of Pixels	Total (ha)	Forest (pixels)	Forest %	Forest Gain (pixels)	Forest Gain %	Forest Loss (pixels)	Forest Loss %	Lost (ha)	Net Lost (ha)	Net Forest Loss %
Total	691533	248951.9	147034	21.3	13105	1.9	112527	16.3	40509.7	-35791.9	-14.4
2	6071	2185.6	138	2.3	171	2.8	65	1.1	23.4	38.2	1.7
3	67779	24400.4	1282	1.9	992	1.5	1675	2.5	603.0	-245.9	-1.0
4	178889	64400.0	21443	12.0	2677	1.5	30382	17.0	10937.5	-9973.8	-15.5
5	56051	20178.4	25536	45.6	1072	1.9	10188	18.2	3667.7	-3281.8	-16.3
6	30904	11125.4	18088	58.5	578	1.9	3294	10.7	1185.8	-977.8	-8.8
7	4164	1499.0	832	20.0	656	15.8	356	8.5	128.2	108.0	7.2
8	199037	71653.3	55256	27.8	3229	1.6	50401	25.3	18144.4	-16981.9	-23.7
9	148346	53404.6	24001	16.2	4564	3.1	16982	11.4	6113.5	-4470.5	-8.4

Table 3.7 Forest Backswamp Change

Zone	Total # of Pixels	Total (ha)	Forest (pixels)	Forest %	Forest Gain (pixels)	Forest Gain %	Forest Loss (pixels)	Forest Loss %	Lost (ha)	Net Lost (ha)	Net Forest Loss %
Total	125436	45157.0	35286	28.1	4506	3.6	22824	18.2	8216.6	-6594.5	-14.6
2	2616	941.8	115	4.4	124	4.7	26	1.0	9.4	35.3	3.7
3	7005	2521.8	522	7.5	300	4.3	478	6.8	172.1	-64.1	-2.5
4	33623	12104.3	6551	19.5	879	2.6	6909	20.5	2487.2	-2170.8	-17.9
5	23173	8342.3	11259	48.6	551	2.4	3704	16.0	1333.4	-1135.1	-13.6
6	2259	813.2	1717	76.0	71	3.1	160	7.1	57.6	-32.0	-3.9
7	3266	1175.8	1992	61.0	188	5.8	367	11.2	132.1	-64.4	-5.5
8	20543	7395.5	5872	28.6	760	3.7	4544	22.1	1635.8	-1362.2	-18.4
9	32976	11871.4	7172	21.7	1753	5.3	6840	20.7	2462.4	-1831.3	-15.4

Table 3.8 Forest Including Forest Restoration

Zone	Total # of Pixels	Total (ha)	Forest (pixels)	Forest %	Forest Gain (pixels)	Forest Gain %	Forest Loss (pixels)	Forest Loss %	Lost (ha)	Net Lost (ha)	Net Forest Loss %
Total	1043906	375806.2	201389	19.3	30335	2.9	146646	14.0	52792.6	-41872.0	-11.1
2	15559	5601.2	503	3.2	473	3.0	209	1.3	75.2	95.0	1.7
3	126076	45387.4	2210	1.8	1604	1.3	3140	2.5	1130.4	-553.0	-1.2
4	256865	92471.4	26341	10.3	11848	4.6	33844	13.2	12183.8	-7918.6	-8.6
5	171511	61744.0	54134	31.6	3869	2.3	30119	17.6	10842.8	-9450.0	-15.3
6	30904	11125.4	18088	58.5	578	1.9	3294	10.7	1185.8	-977.8	-8.8
7	20405	7345.8	10416	51.0	2764	13.5	1448	7.1	521.3	473.8	6.4
8	221426	79713.4	56488	25.5	4261	1.9	51239	23.1	18446.0	-16912.1	-21.2
9	200588	72211.7	32586	16.2	6054	3.0	24496	12.2	8818.6	-6639.1	-9.2

Chapter 4: Water Quality

Perceived problems with water quality have been an issue in the Tensas River Basin. The approach taken here to examining water quality was to first gather all the stream water quality data available and then to analyze it both temporally and spatially. Initially the hope was to gather enough data to be able to associate water quality with some of the landscape metrics discussed previously.

The major source of the data was STORET, the EPA water quality data base. Not only is the EPA data stored in this data base but so is data from the USGS and various states including Louisiana. All of the existing water quality data for the Tensas River Basin was requested. It was then verified with Louisiana Department of Environmental Quality (LDEQ) and USGS that all existing water quality data for the basin were contained in the storet data base.

The water quality data search yielded a data set that included stream water quality data from 17 stations. However many of these stations included only data from a one-time sampling effort often dating back to the 1970s or the station ceased to operate in the 1970s or early 1980s. The criterion for using a station's water quality data required that it have data from the 1990s or it be located close to a station that had data from the 1990s. This criteria was selected as these would be the most relevant data to current conditions in the Tensas River Basin. This criteria limited the data available for analysis to three sites; Tendal, Winnsboro, and Clayton. The locations of these stations are shown in Figure 4.1. Both Louisiana state and the USGS collect samples from Tendal and Clayton. Unfortunately, with a sample number of only three water quality monitoring stations, it is impossible to make valid associations between the water quality data and any of the landscape metrics that was previously presented. In addition to the three stream monitoring stations, water quality data from Lake Providence were also retrieved. This lake in the Tensas Bayou serves as the headwaters of the Tensas River.

This analysis focused on two variables: total phosphorus and total nitrogen as nitrite and nitrate. In the analysis of the data, significant differences between the three stations were examined as well as seasonal differences and trends over many years.

Figure 4.2 shows the seasonal distribution of the nitrogen and phosphorus data from 1990 through 1996 for all three LDEQ water quality monitoring stations. This type of display is known as a box and whisker plot. The top and bottom edges of the blue box represent the 25th and 75th percentiles of the distribution of the data (i.e., 50% of the data values fall within this range). The vertical lines extend from the blue box down to the 10th and up to the 90th percentile (i.e., 80% of the data values fall within this range).

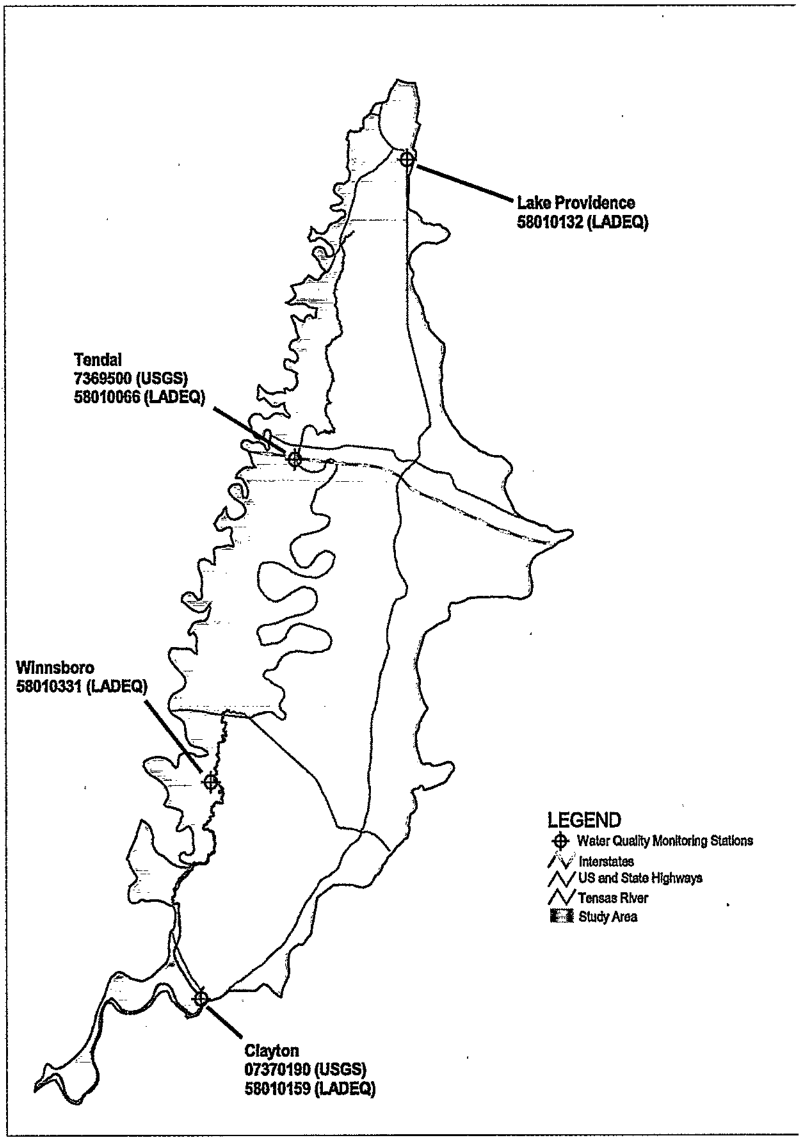


Figure 4.1

Location of Tensas River Basin Water Quality Monitoring Stations.

The small horizontal line drawn within the blue box indicates the median value. Any value outside of the 10th and 90th percentiles is displayed on the graph as a light blue dot. This type of display was chosen rather than a simple mean ± standard deviation plot because a normality test indicated that many of the data distributions for a given station or season were not normally distributed. In part due to the low sample numbers, which are indicated above the box and whisker illustration, a mean value would be heavily influenced by outlier values. One extreme outlier nitrogen value of 5.9 mg/L was omitted from Figure 4.2 for the summer season from the Tendal station. This outlier, omitted for display purposes only, was included in the calculations in the summary statistics given in the Appendix.

Figure 4.2 shows seasonal differences exist for both nitrogen and phosphorus concentrations for all three stations with the exception of phosphorus concentrations from the Tendal station. In general, nutrient concentrations decline from the spring through the fall and then start increasing again in the winter. It is interesting that the Tendal station does not seem to fluctuate seasonally nearly as much as do the other two stations. Perhaps, this phenomenon is due to the proximity of agricultural fields to the water quality monitoring station. Statistical summaries of the water quality data from the LDEQ stations can be found in the Appendix.

To determine whether there were significant differences between the three stations, a Wilcoxon rank-sum (also known as Mann-Whitney U) test was performed. Again, a nonparametric statistic was used because the data are not normally distributed and the sample numbers are low. There were no significant differences between all three stations for total nitrogen. This was true for all seasons combined and for individual seasons. For total phosphorus there were statistically significant differences between Tendal and Clayton and between Tendal and Winnsboro when all seasons were combined. When this analysis was performed on individual seasons, there were statistically significant differences between Tendal and Clayton for the summer and the fall and there were significant differences between Tendal and Winnsboro for the fall. All other comparisons of station and season yielded nonsignificant differences. A summary of this analysis is included in the Appendix.

Figures 4.3 through 4.5 show the historical total nitrogen concentrations for all three locations on separate graphs. Figures 4.6 through 4.8 show the historical total phosphorus concentrations. When there is a LDEQ station collocated with a USGS station, the points are plotted with different color symbols. It would appear that both nitrogen and phosphorus concentrations have increased slightly for the Clayton station when comparing data from the 1970s to the 1990s. It should be noted however that the data from the 1970s were exclusively collected by the USGS while the data from the 1990s were exclusively collected by LDEQ. It may not be appropriate to compare these data directly as there may have been differences in methodology.

It is also interesting to compare the water quality from the three stream monitoring stations to the water quality in Lake Providence (Figures 4.9 and 4.10). Lake Providence serves as the headwaters of the Tensas River and clearly the nitrogen and phosphorus levels are lower than they are at Tendal, Winnsboro, or Clayton.

When evaluating the quality of the water in the Tensas River, one should look at how the data compare with any established criteria. To limit eutrophication potential to downstream waters, the EPA Quality Criteria for Water (1986) advises that total phosphorus levels should not exceed 0.1 mg/ L. This is also the criteria used by the EPA's Surf Your Watershed program. Clearly many of the values from the Tensas River samples exceed that level. We were unable to find a total nitrogen criteria for surface water.

In summary the following can be said about nutrient levels in the Tensas River: They are higher in the stream water than they are in the headwaters, they are generally seasonal in nature, phosphorus levels are at a level where they could contribute to eutrophication, and there are some significant differences in phosphorus levels between Tendal and the other two monitoring stations. To perform a more thorough investigation of the water quality in the Tensas River Basin, a comprehensive water quality study that would characterize the water quality of all the subwatersheds within the basin should be designed and conducted.

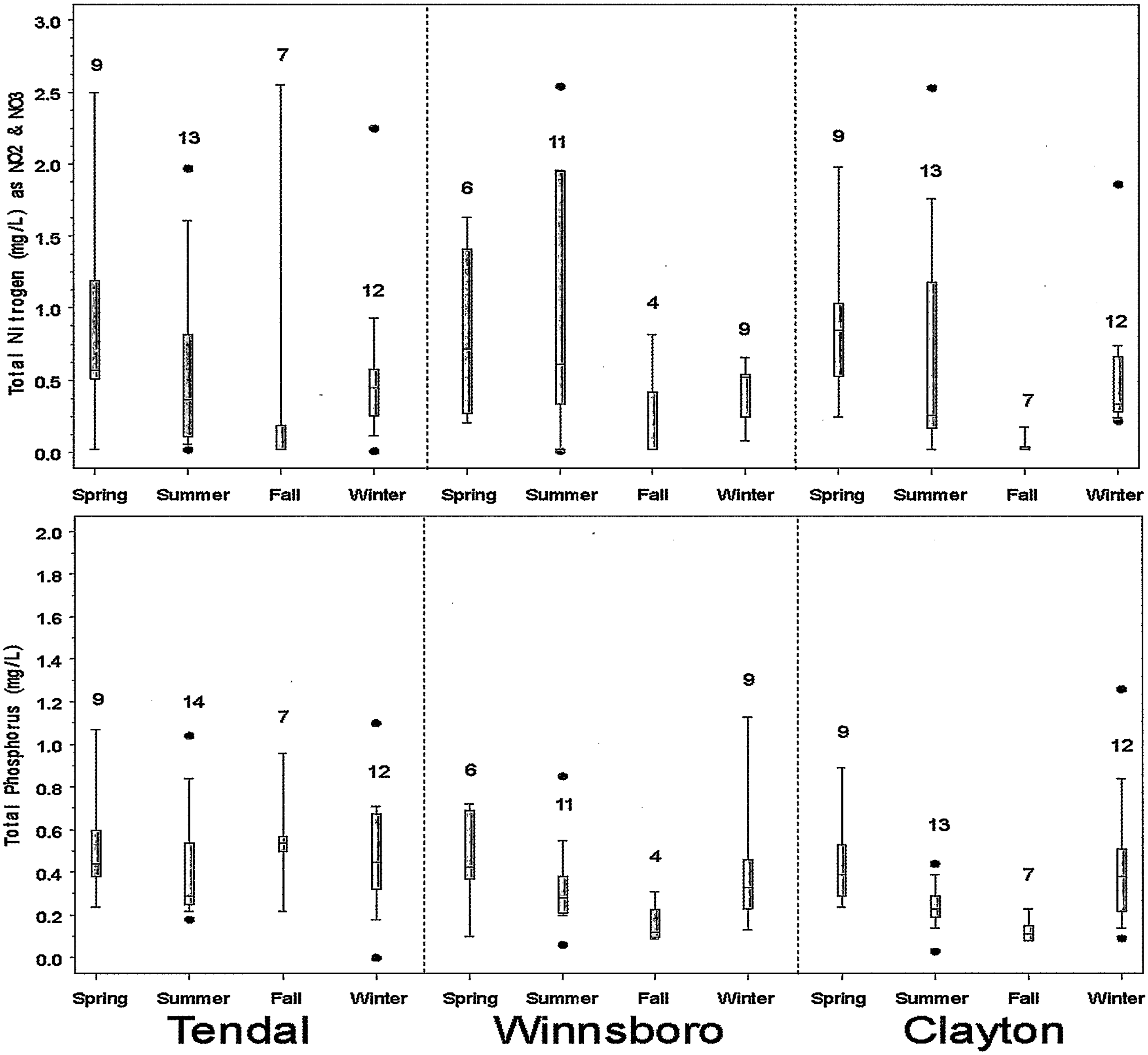


Figure 4.2 Total nitrogen and phosphorus concentrations for three Louisiana state water quality monitoring stations in the Tensas River Basin. Data displayed are from those samples collected 1990 - 1996. The top and bottom edges of the light blue box represent the 25th and 75th percentiles of the distribution of the data (i.e., 50% of the data values fall within this range). The horizontal line drawn within the blue box represents the median value. The vertical lines extend to the 10th and 90th percentile. Any value outside of this range is displayed on the graph as a light blue dot. The number of data points included in the analysis is printed above each box.

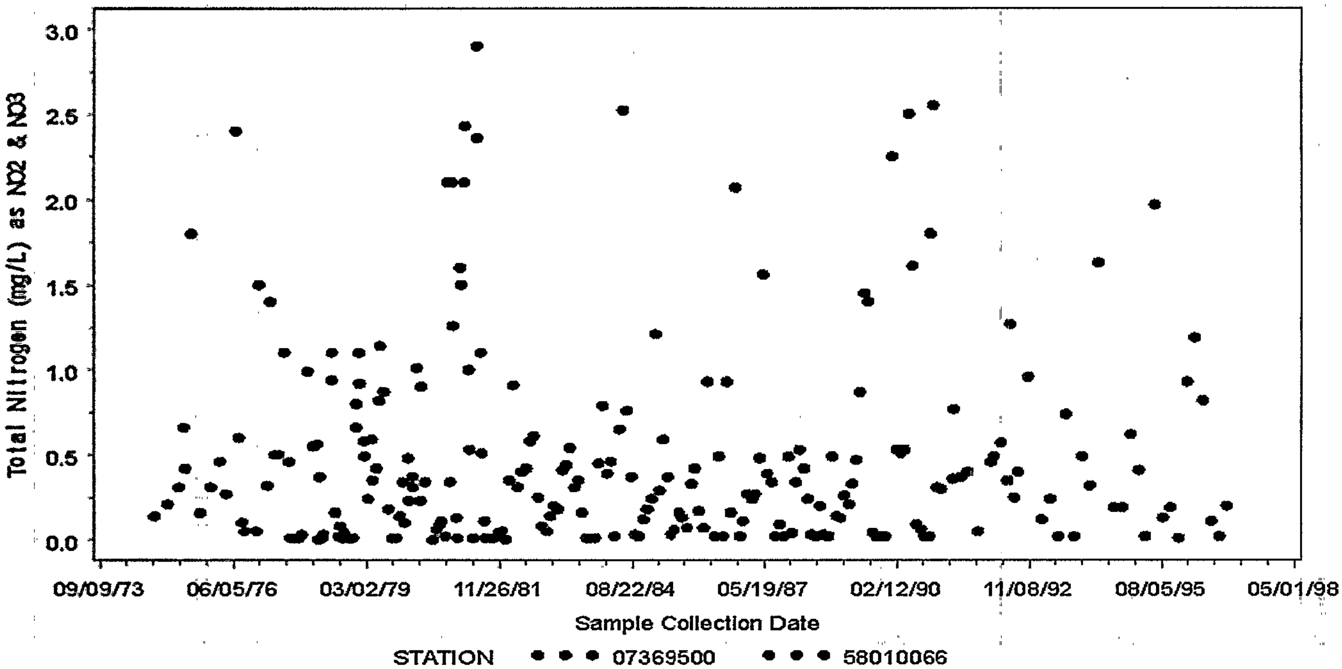


Figure 4.3 Total nitrogen concentrations for two water quality monitoring stations in Tendal, La.

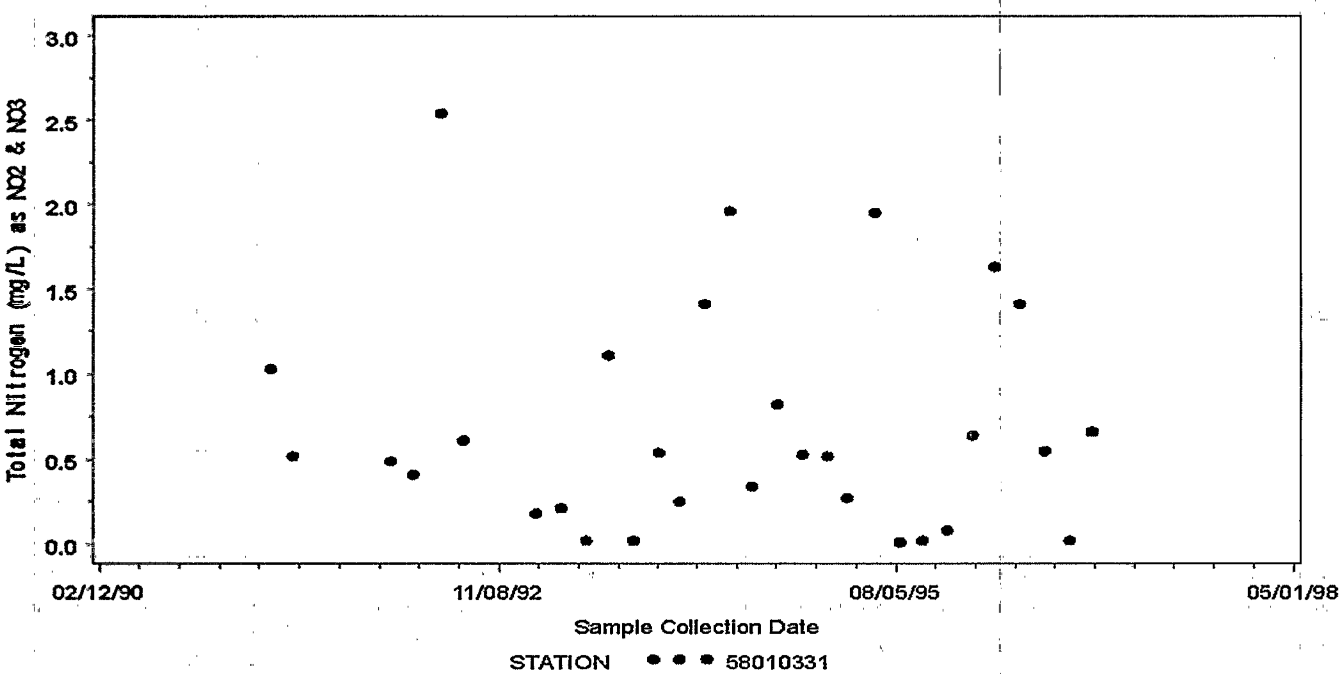


Figure 4.4. Total nitrogen concentrations for Winnsboro, La.

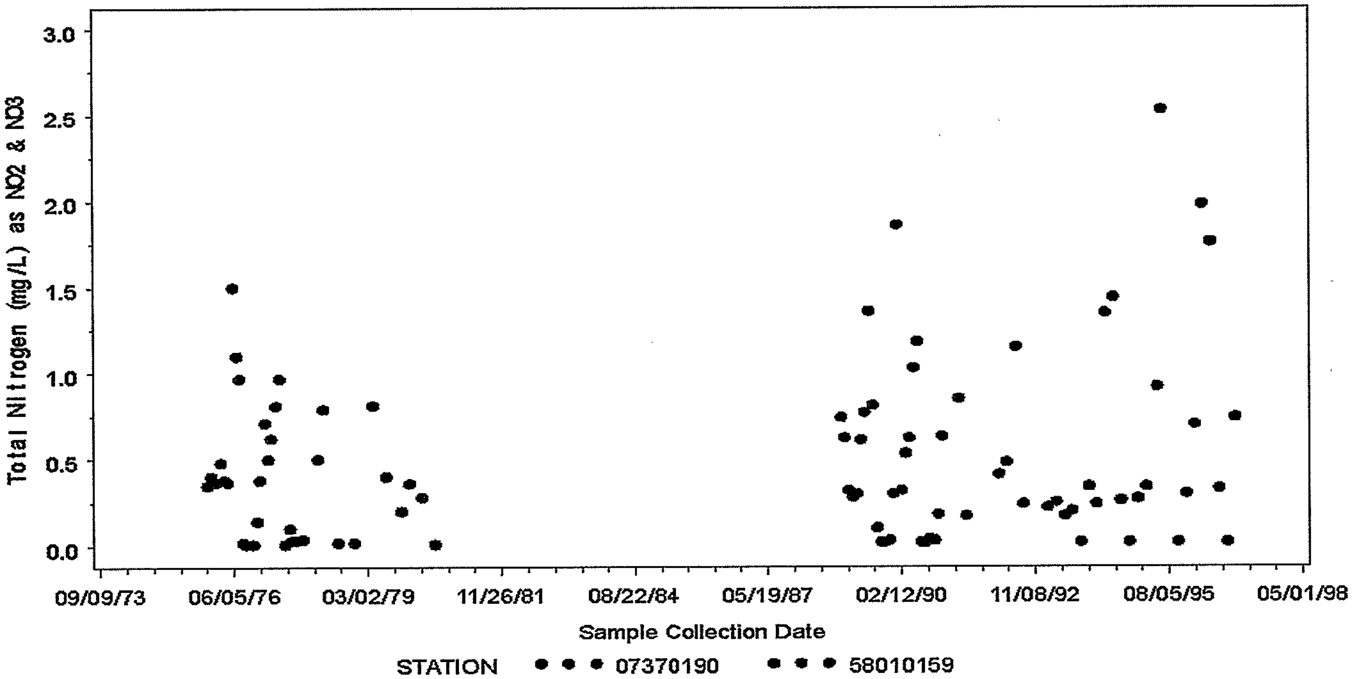


Figure 4.5 Total nitrogen concentrations for two water quality monitoring stations in Clayton, LA

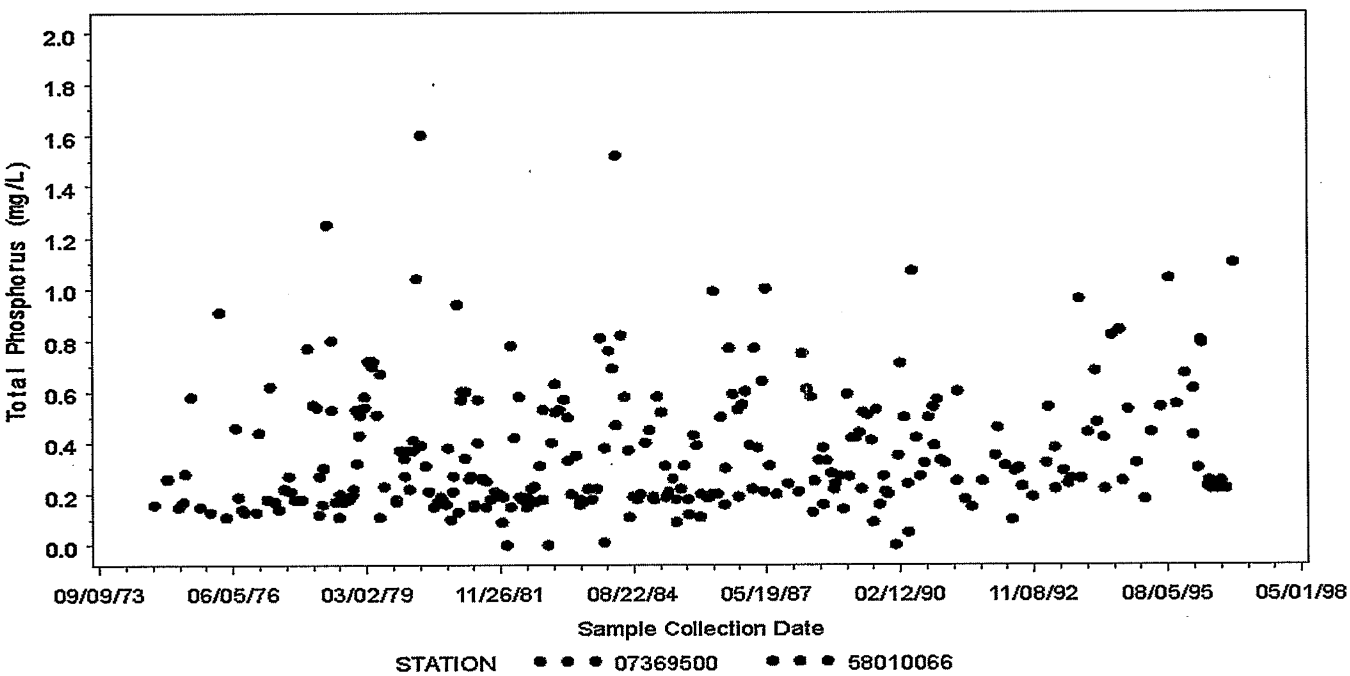


Figure 4.6 Total phosphorus concentrations for two water quality monitoring stations inTendal, LA

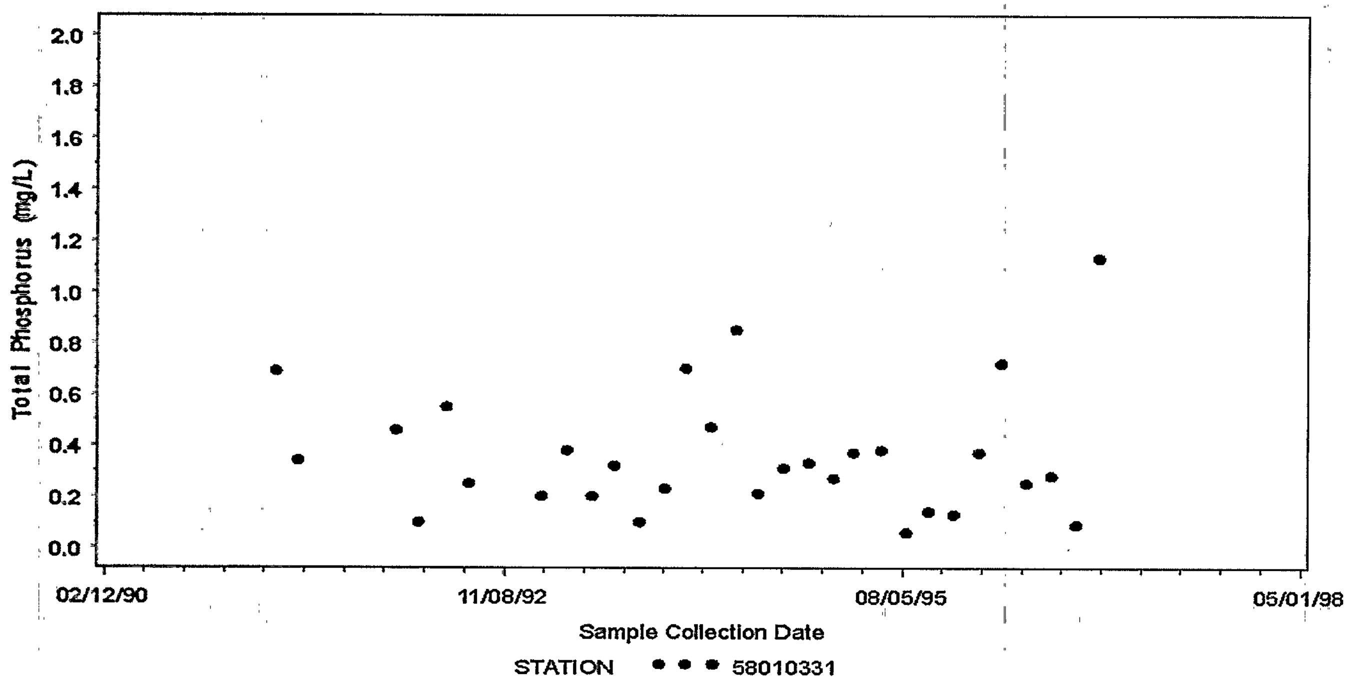


Figure 4.7 Total phosphorus concentrations for Winnsboro, LA

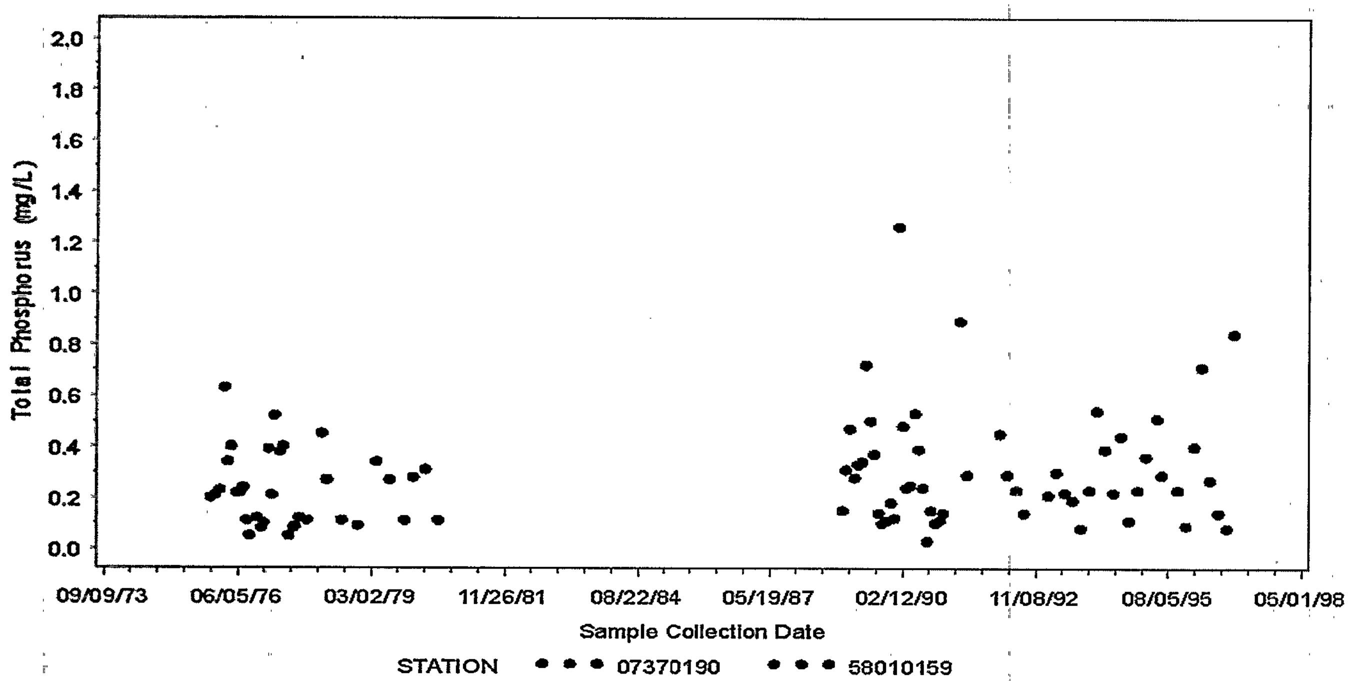


Figure 4.8 Total phosphorus concentrations for two water quality monitoring stations in Clayton, LA

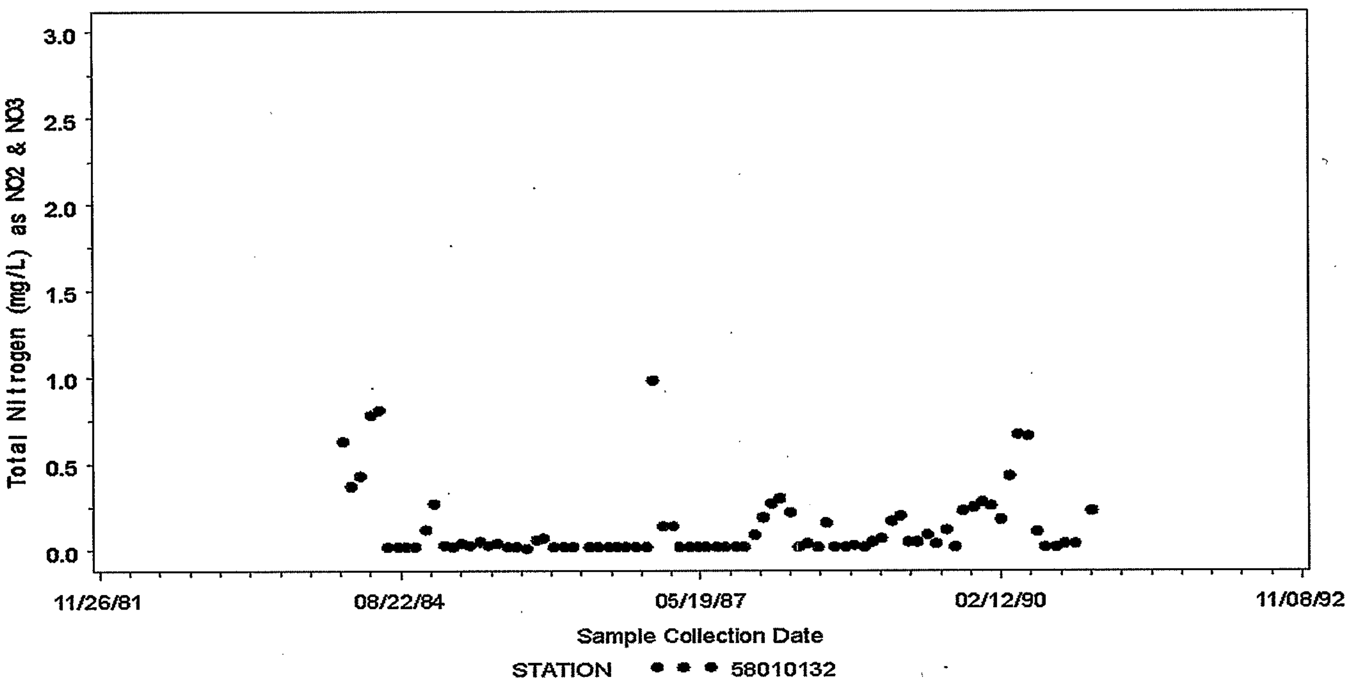


Figure 4.9. Total nitrogen concentrations for Lake Providence at Tensas Bayou

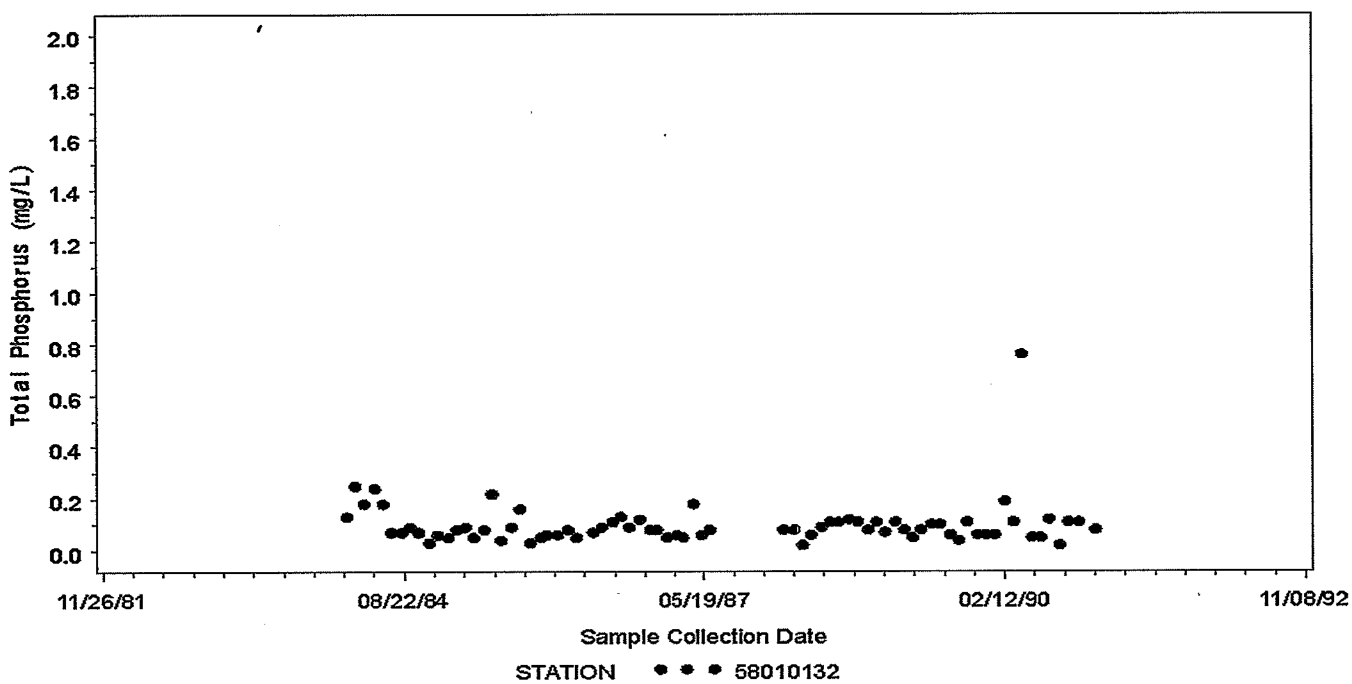


Figure 4.10. Total phosphorus concentrations for Lake Providence at Tensas Bayou

Nitrogen and Phosphorus Export to Streams

Despite the many benefits, there is a potential negative impact of fertilizer application on agricultural fields. The problem was first identified decades ago as part of the study of lake eutrophication. Lake eutrophication is a process by which excess nutrients in lake water make it easier for undesirable plants to thrive, which in turn consume other resources and adversely affect lake water quality for other purposes. The potential effects of the export of nitrogen and phosphorus from farmlands to streams have been intensively studied for several decades. It is now possible to survey the scientific literature to determine how much nitrogen and phosphorus export can be expected for different types of land uses in different areas.

A literature survey of North American nutrient export studies (Young and others, 1996, in the *Journal of Environmental Management*) provided coefficients for estimated export (kg/ha/yr) for nitrogen and phosphorus under different types of land uses. To estimate total nutrient export potential on the Tensas River Basin, the reported median coefficients for comparable agricultural uses were multiplied by the amount of land cover in the agriculture land cover classes. The coefficient-times-land use model was developed in 1980 for the United States Environmental Protection Agency by Rechow and others (US EPA 440/5-80-011, Washington, DC). The coefficients reported for nitrogen varied from 2.6 to 6.2 kg/ha/yr, with a median value of 3.9 kg/ha/yr. The values reported for phosphorus ranged from 0.3 to 1.5 kg/ha/yr, with a median value of 0.7 kg/ha/yr.

The scientific literature provides a simple predictive model based only on nitrogen and phosphorus loadings to streams. Of course, this model does not reflect actual fertilizer application rates which determine local export amounts. However, over an area such as the Tensas River Basin, the models are valuable as a screening tool to rank subwatersheds based on potential impacts, assuming that average fertilizer rates are used throughout the region. In a nutshell, if there are no agricultural lands in a watershed, then fertilizer application is near zero. Such a watershed has less risk of impacts than a watershed for which 30 percent of the area is used for agriculture. One major drawback of this simple model is that it ignores fertilizer applications in urban areas, where areas such as lawns, gardens, and golf courses can receive heavy fertilizer doses several times a year.

When this model was applied to the Tensas River Basin the potential nitrogen loading was 4.96 kg/ha/yr and the potential phosphorus loading was 1.34 kg/ha/yr. These are very high values when compared to values found elsewhere in the U.S. These values were calculated from the agricultural landuse data shown in the landcover data in Chapter 3 (Figure 3.4). These data show 225,708 hectares of land used for intensive agriculture, which does not include grasslands for grazing, orchards, and vegetation in towns. This is 60% of the total land area which is consistent with the human use index shown in Chapter 3 (Figure 3.6). Again, this model only shows the amount of nitrogen and phosphorus that may be available for transport into the water system.

Chapter 5: Comments and Recommendations

There are many fine features which make up the Tensas River Basin. Fertile farmlands, deep forests and abundant wildlife form the basis of the good life provided by the land near the Tensas River. The continued good health of the Tensas River Basin depends on how the land is used. The health of the basin should be of concern to everyone living there because their livelihood depends on what the land can provide. Efforts to practice Best Farming Practices and the steps taken to restore forested wetlands in the Tensas River Basin are a big step in the direction of keeping the Tensas healthy. A healthy Tensas River providing clean water and sound products will also benefit those living down stream and can improve the quality of the Gulf of Mexico.

This chapter draws comments and recommendations from what was learned from the landscape analysis of the Tensas River Basin. Two of the main concerns of land management and environmental monitoring and protection are determining whether environmental features are changing (for better or worse) and determining whether management and protection practices are working effectively. These are complex issues. While the landscape analysis performed in this atlas begins to address these questions, it is only a beginning and is only part of the scientific work needed to answer complex ecological questions.

Comments

The forest loss over the time period studied was remarkable. Forest loss of this magnitude is bound to have an effect on environmental quality. Much of the lost forest was converted to agriculture making human use of the land very high in most of the subwatersheds. High intensity agriculture makes use of fertilizer. The landscape model showing the potential for nutrient (nitrogen and phosphorus) loading is high when compared to other watersheds throughout the United States. Although most of the fertilizer applied is effectively used to grow a good crop, it is virtually unavoidable that some of the fertilizer will run off the land. The fertilizer which does run off can be intercepted by natural vegetation but when this vegetation is gone, excess fertilizer can run directly into the water and be carried down stream.

The land of the Tensas River Basin is flat. Water moves slowly compared to a river located in the mountains. Water flow is driven by events such as rain storms and hurricanes. Water and nutrients can be held in swamp areas only to be flushed out during high precipitation events. The natural vegetation located in the backswamp areas can be as or more important in holding excess nutrients than the vegetation located near the stream.

The landscape analyses demonstrated that since 1972 the forest was lost around the forest edges and generally not separated into small patches. Forest patch size was maintained so that in the event of stress to the forest (fire or flood) the forest and forest wildlife should be able to reestablish itself in a robust manner. Looking at the forest restoration efforts indicated that very wise decisions were made in the locations of forests reestablishment. Areas chosen included riparian areas, backswamp areas and areas which connected forest patches. Hopefully this landscape assessment can verify that the correct decisions were made, reveal how the forest changes will look when the trees have matured, and identify additional areas to restore. It also showed that little or no restoration efforts are underway in the southern part of the watershed. Using Best Farming Practices to reduce fertilizer runoff combined with forest restoration should make a positive impact on the quality of water and the quality of the land.

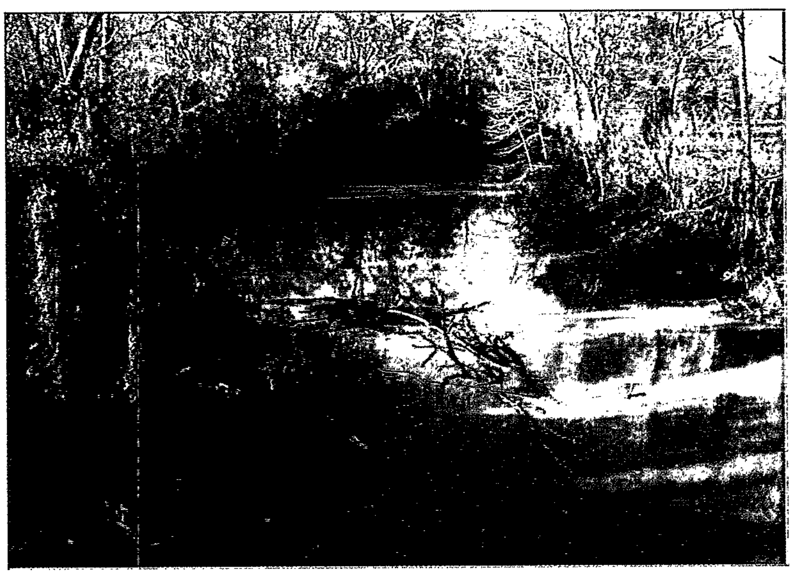


Figure 5.1 *The Tensas River Winter 1997-1998*

Tensas River Basin Landscape Indicator Analysis

Sub-basin	U-Index		Roads Km/Km²	# Roads Crossing Streams	Forest Fragmentation		Forest Change	NDVI Change	Riparian Forest Change	Back-swamp Forest Change	Forest Change with Restoration
	1970	1990			1970	1990					
[illegible]	65.0	[illegible]	0.98	0.28	88.7	84.5	-12.3	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	1.49	[illegible]	[illegible]	[illegible]	1.7	-8.5	1.7	3.7	1.7
3	[illegible]	[illegible]	1.07	[illegible]	[illegible]	[illegible]	-1.4	-8.1	-1.0	-2.5	-1.2
[illegible]	[illegible]	[illegible]	1.03	[illegible]	86.2	76.6	[illegible]	[illegible]	[illegible]	[illegible]	-8.6
5	49.9	66.0	0.80	0.19	93.0	91.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	30.0	38.9	0.42	0.07	95.2	94.9	-8.8	-5.5	-8.8	-3.9	-8.8
7	38.3	39.0	0.87	0.27	87.2	88.1	-1.0	-3.7	7.2	-5.5	6.4
8	48.5	69.6	0.98	0.28	90.3	85.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	69.9	[illegible]	1.06	[illegible]	80.9	75.0	-9.2	-6.9	-8.4	[illegible]	-9.2

Table 5.1 *gives a summary of all the landscape indicators given in this report. The colors along with the values represent the Tensas River Basin's ecological condition. Red for concern, yellow for caution, and green for sound.*

Recommendations

There are many more types of landscape analyses which could be done to provide information to land managers, farmers and environmental quality specialists. The landcover map shown in Chapter 3 (Figure 3.4) could be used to perform much more detailed analysis investigating different types of agricultural use. These data could be analyzed to further identify locations of landuse and landcover in relation to features on the landscape. If wildlife species-specific questions arise, these data can be used to model habitat requirements. For example, if a given species requires a certain size forest patch and has a distance to water requirement, the data can be queried to identify land parcels that meet those requirements.

As discussed in Chapter 3 in the Wetland Restoration section, the data layers included in this data set can be used to help identify sites for potential wetland forest restoration. The data can be queried based on a set of "rules" defined by local land managers, farmers, and environmental quality specialists. For example, one could identify (as we did in Chapter 3) all patches of land within 360 meters of the Tensas River that are currently agriculture but were historically forested, have hydric soils, and have a high potential to flood. Perhaps current agricultural use would be a factor. Maybe it would be more economically feasible to convert land from one type of agricultural use that it would from another (e.g., more economical to convert from soybean than from rice).

Using the forest change data, all of the landscape indicator data and the landuse/landcover data, more analyses could be done on comparing the subwatersheds to each other. Indicators such as U-index, roads crossing streams, forest loss and nutrient loading could be used to rank the subwatersheds. This would be used to target landuse practice changes to areas most in need.

The North American Landscape Characterization image database provides 20 years of change detection data. These data could be classified and used effectively to identify status and trends of landuse elsewhere in the Mississippi River Basin. The NDVI analysis was an informative, cost effective, and quick method for assessing ecological change detection for the Tensas River Basin. This method could also be developed and used to characterize ecological changes for the entire Mississippi River Basin or to target areas that need further analysis using traditional land classification methods.

Water quality continues to be an issue in the Tensas River Basin yet there is very little data available to adequately characterize water quality for the basin. This is particularly true when trying to link water quality with any of the landscape metrics discussed in this report. The water quality data presented in Chapter 4 is easy to use in terms of characterizing individual water quality monitoring stations but difficult to use in terms of characterizing a subbasin or the entire Watershed. The present sampling locations can detect the presence and quantity of nutrients but can't tell you if one subbasin or area is contributing more or less than another. We feel that a well-designed water quality study would add a wealth of information to the data available for the Tensas River Basin. This study should be designed and implemented to characterize each subwatershed along with the entire Tensas River Basin using randomized sampling techniques stratified within the subwatersheds. With this type of information, there are many questions that could be answered such as: do certain types of agriculture affect the Tensas River nutrient loads more that others; does landuse (forest cover or agricultural) in backswamps or riparian areas have an effect on the flow of nutrients; does landuse in the subwatershed have an affect on water quality. With an in-depth water quality study, not only would researchers be able to answer questions such as those posed above but the data would provide a baseline data base of water quality that could be used later to determine whether restoration and protections efforts made today have the desired effect in the future. Without this type of information, it will be difficult to determine how successful these efforts have been.

"A system of conservation based solely on economic self-interest is hopelessly lopsided. It tends to ignore, and thus eventually to eliminate, many elements in the land community that lack commercial value, but that are (as far as we know) essential to its healthy functioning."

- Aldo Leopold (father, farmer, and ecologist)

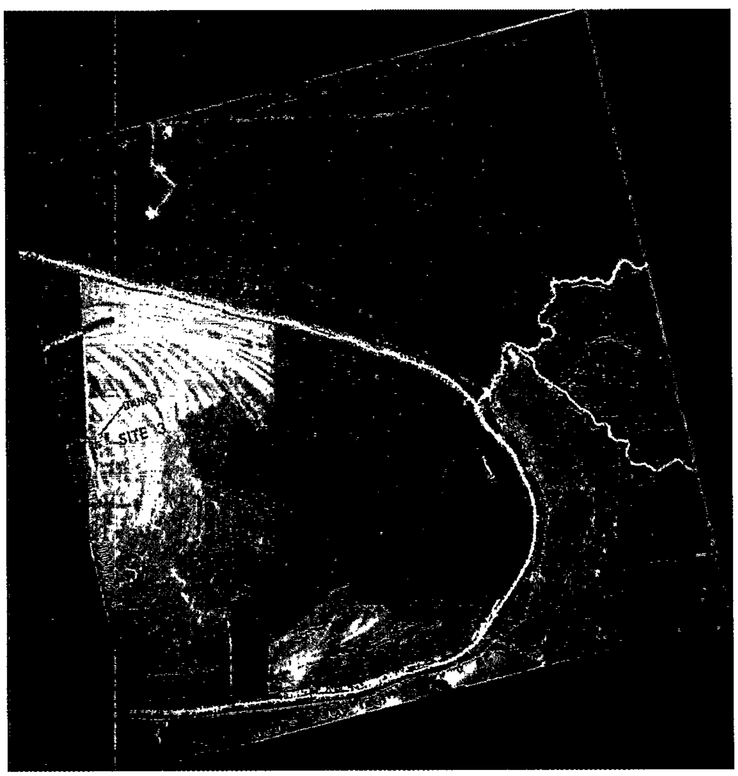


Figure 5.2 *Airphoto of the Tensas River near Westwood, LA*

Appendix: Additional Information About the Tensas River Basin

Tensas River Basin - Forest Change Analysis for the 1970 Classification
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

3 types found.
1043984 pixels (non-missing).
2256364 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
2	679228	0.65061
1	350828	0.33605
3	13928	0.01334

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
2	1393704	0.939641
1	742606	0.886800
3	34785	0.591778

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
2	1066	621658	779	637.174	0.9982
1	3248	152609	2159	108.014	0.9897
3	878	2969	673	15.863	0.9219
Overall values, not area-weighted:	5192	621658		201.076	0.9943

T3L TCL701.wpd - 078Leb98

LEGEND
1: Forest; 2: Human Use; 3: Water

Tensas River Basin - Forest Change Analysis 1970 Class Subwatershed 2
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

3 types found.
15569 pixels (non-missing).
13339 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
2	13267	0.85214
1	712	0.04573
3	1590	0.10213

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
2	26724	0.952253
1	1973	0.439432
3	3413	0.846469

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
2	24	13159	15	552.792	0.9978
1	93	101	67	7.656	0.8666
3	8	1564	3	198.750	0.9975
Overall values, not area-weighted:	125	13159		124.552	0.9918

T3L TCL702.wpd - 078Leb98

LEGEND
1: Forest; 2: Human Use; 3: Water

Tensas River Basin - Forest Change Analysis 1970 Class Subwatershed 3
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer
3 types found.
126078 pixels (non-missing).
115728 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
2	120252	0.95379
1	5403	0.04285
3	423	0.00336

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
2	242246	0.969626
1	14325	0.484328
3	1169	0.426005

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
2	37	120166	31	3250.054	0.9997
1	746	864	597	7.243	0.8286
3	78	155	67	5.423	0.7754
Overall values, not area-weighted:	861	120166		146.432	0.9916

T3L TCL703.wpd - 078Leb98

LEGEND
1: Forest; 2: Human Use; 3: Water

Tensas River Basin - Forest Change Analysis 1970 Class Subwatershed 4
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

3 types found.
256891 pixels (non-missing).
235912 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
2	193968	0.75506
1	61666	0.24005
3	1257	0.00489

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
2	395488	0.954090
1	131605	0.862444
3	3259	0.505370

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
2	191	190513	142	1015.539	0.9987
1	788	36436	529	78.256	0.9854
3	165	297	137	7.618	0.8282
Overall values, not area-weighted:	1144	190513		224.555	0.9947

T3L TCL704.wpd - 078Leb98

LEGEND
1: Forest; 2: Human Use; 3: Water

Tensas River Basin - Forest Change Analysis 1970 Class Subwatershed 5
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

3 types found.
171594 pixels (non-missing).
409844 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
1	84382	0.49175
2	85707	0.49948
3	1505	0.00877

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
1	173218	0.930307
2	174895	0.932977
3	3482	0.430213

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
1	449	49643	279	187.933	0.9940
2	226	39931	168	379.235	0.9968
3	235	95	155	6.404	0.8246
Overall values, not area-weighted:	910	49643		188.565	0.9939

T3L TCL705.wpd - 078Leb98

LEGEND
1: Forest; 2: Human Use; 3: Water

Tensas River Basin - Forest Change Analysis 1970 Class Subwatershed 6
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

3 types found.
30910 pixels (non-missing).
35042 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
1	21398	0.69227
2	9300	0.30087
3	212	0.00686

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
1	42860	0.952077
2	19261	0.910025
3	509	0.235756

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
1	132	19442	107	162.106	0.9920
2	68	6530	59	136.765	0.9909
3	99	30	93	2.141	0.3679
Overall values, not area-weighted:	299	19442		103.378	0.9874

T3L TCL706.wpd - 078Leb98

LEGEND
1: Forest; 2: Human Use; 3: Water

Tensas River Basin - Forest Analysis 1970 Class Subwatershed 7
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

3 types found.
20411 pixels (non-missing).
30425 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
3	246	0.01205
1	12354	0.60526
2	7811	0.38269

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
3	720	0.298611
1	26329	0.872498
2	16763	0.799081

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
3	75	38	67	3.280	0.5650
1	124	11878	100	99.629	0.9870
2	84	7163	63	92.988	0.9853
Overall values, not area-weighted:	283	11878		72.124	0.9812

T3L TCL707.wpd - 078Leb98

LEGEND
1: Forest; 2: Human Use; 3: Water

Tensas River Basin - Forest Change Analysis 1970 Class Subwatershed 8
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

3 types found.
221441 pixels (non-missing).
224103 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
1	108326	0.48919
3	5713	0.02580
2	107402	0.48501

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
1	226751	0.903630
3	13033	0.692550
2	224181	0.905822

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
1	974	53393	754	111.218	0.9892
3	322	2952	260	17.742	0.9249
2	559	98811	462	192.132	0.9935
Overall values, not area-weighted:	1855	98811		119.375	0.9896

T3L TCL708.wpd - 078Leb98

LEGEND
1: Forest; 2: Human Use; 3: Water

Tensas River Basin - Forest Change Analysis 1970 Class Subwatershed 9
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

3 types found.
200615 pixels (non-missing).
505923 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
2	140272	0.69921
1	57279	0.28552
3	3064	0.01527

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
2	290790	0.914664
1	125715	0.809879
3	8241	0.475549

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
2	286	113329	199	490.462	0.9979
1	919	8394	600	62.328	0.9825
3	157	643	111	19.516	0.9445
Overall values, not area-weighted:	1362	113329		147.294	0.9927

T3L TCL709.wpd - 078Leb98

LEGEND
1: Forest; 2: Human Use; 3: Water

Tensas River Basin - Forest Change Analysis for the 1990 Classification
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer		
3 types found.		
1043948 pixels (non-missing).		
2256400 pixels coded as missing.		
Data Code	Pixel Count	Pixel Percent
2	806490	0.77254
1	224465	0.21502
3	12993	0.01245

Number of edges and percent of same-type edges		
Data code	Number edges	Same-type percentage
2	1643483	0.954937
1	484982	0.845994
3	31735	0.621932

Patch Statistics					
Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
2	753	750008	561	1071.036	0.9989
1	3488	105548	2364	64.353	0.9825
3	691	3036	465	18.803	0.9423
Overall values, not area-weighted:	4932	750008		211.668	0.9947

T3L TCL901.wpd - 078Leb98

LEGEND
1: Forest; 2: Human Use; 3: Water

Tensas River Basin - Forest Change Analysis 1990 Class Subwatershed 2
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

3 types found.
15558 pixels (non-missing).
13350 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
2	12809	0.82331
1	1056	0.06788
3	1693	0.10882

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
2	25848	0.953536
1	2728	0.538123
3	3521	0.867367

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
2	26	12695	18	492.654	0.9977
1	75	242	48	14.080	0.9375
3	5	1582	3	338.600	0.9965
Overall values, not area-weighted:	106	12695		146.774	0.9935

T3L TCL902.wpd - 078Leb98

LEGEND
1: Forest; 2: Human Use; 3: Water

Tensas River Basin - Forest Change Analysis 1990 Class Subwatershed 3
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer
3 types found.
126080 pixels (non-missing).
115726 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
2	121907	0.96690
1	3872	0.03071
3	301	0.00239

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
2	244617	0.976800
1	10325	0.483196
3	929	0.290635

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
2	83	121748	76	1468.759	0.9992
1	496	368	388	7.806	0.8355
3	82	34	68	3.671	0.6379
Overall values, not area-weighted:	661	121748		190.741	0.9933

T3L TCL903.wpd - 078Leb98

LEGEND
1: Forest; 2: Human Use; 3: Water

Tensas River Basin - Forest Change Analysis 1990 Class Subwatershed 4
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

3 types found.
256905 pixels (non-missing).
235898 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
2	225015	0.87587
1	31199	0.12144
3	691	0.00269

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
2	456804	0.963801
1	69663	0.766648
3	2009	0.367845

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
2	123	220608	91	1829.390	0.9994
1	793	11614	507	39.343	0.9715
3	110	51	71	6.282	0.8336
Overall values, not area-weighted:	1026	220608		250.395	0.9955

T3L TCL904.wpd - 078Leb98

LEGEND
1: Forest; 2: Human Use; 3: Water

Tensas River Basin - Forest Change Analysis 1990 Class Subwatershed 5
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer
3 types found.
171571 pixels (non-missing).
409867 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
2	113185	0.65970
1	57244	0.33365
3	1142	0.00666

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
2	228851	0.958877
1	117397	0.918022
3	2657	0.458412

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
2	125	109734	97	905.480	0.9987
1	535	24872	367	106.998	0.9889
3	162	153	116	7.049	0.8196
Overall values, not area-weighted:	822	109734		208.724	0.9943

T3L TCL905wpd - 078Leb98

LEGEND
1: Forest; 2: Human Use; 3: Water

Tensas River Basin - Forest Change Analysis 1990 Class Subwatershed 6
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

3 types found.
30923 pixels (non-missing).
35029 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
2	12025	0.38887
1	18864	0.61003
3	34	0.00110

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
2	24805	0.925257
1	37566	0.949742
3	107	0.271028

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
2	48	8770	34	250.521	0.9959
1	138	13133	107	136.696	0.9907
3	9	13	7	3.778	0.7353
Overall values, not area-weighted:	195	13133		158.579	0.9925

T3L TCL906.wpd - 078Leb98

LEGEND
1: Forest; 2: Human Use; 3: Water

Tensas River Basin - Forest Change Analysis 1990 Class Subwatershed 7
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer
3 types found.
20413 pixels (non-missing).
30423 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
1	12266	0.60089
2	7962	0.39005
3	185	0.00906

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
1	25914	0.881223
2	17072	0.816483
3	495	0.298990

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
1	175	11186	144	70.091	0.9825
2	72	6181	52	110.583	0.9882
3	50	37	39	3.700	0.7081
Overall values, not area-weighted:	297	11186		68.731	0.9822

T3L TCL907.wpd - 078Leb98

LEGEND
1: Forest; 2: Human Use; 3: Water

Tensas River Basin - Forest Change Analysis 1990 Class Subwatershed 8
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

3 types found.
221446 pixels (non-missing).
224098 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
1	61431	0.27741
2	154211	0.69638
3	5804	0.02621

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
1	131713	0.853325
2	316410	0.941313
3	12986	0.742030

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
1	1123	28713	874	54.703	0.9774
2	368	145233	309	419.052	0.9969
3	268	3014	219	21.657	0.9388
Overall values, not area-weighted:	1759	145233		125.893	0.9900

T3L TCL908.wpd - 078Leb98

LEGEND
1: Forest; 2: Human Use; 3: Water

Tensas River Basin - Forest Change Analysis 1990 Class Subwatershed 9
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer
3 types found.
200602 pixels (non-missing).
505936 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
2	158225	0.78875
1	39231	0.19557
3	3146	0.01568

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
2	325007	0.933106
1	88907	0.750256
3	8482	0.475949

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
2	245	130614	179	645.816	0.9981
1	1047	6618	705	37.470	0.9699
3	193	1065	115	16.301	0.9406
Overall values, not area-weighted:	1485	130614		135.086	0.9917

T3L TCL909.wpd - 078Leb98

LEGEND
1: Forest; 2: Human Use; 3: Water

Tensas River Basin - Riparian Analysis 120 meter Buffer
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

5 types found.
691533 pixels (non-missing).
2608815 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
5	406345	0.58760
2	112527	0.16272
1	147034	0.21262
4	13105	0.01895
9	12522	0.01811

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
5	819978	0.922619
2	246478	0.800923
1	312040	0.852474
4	39447	0.266433
9	30836	0.610455

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
5	1752	216825	1203	231.932	0.9954
2	3758	21183	3002	29.943	0.9595
1	2673	74997	1930	55.007	0.9789
4	4459	196	3868	2.939	0.5519
9	808	2998	624	15.498	0.9206
Overall values, not area-weighted:	13450	216825		51.415	0.9763

T2L120.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Riparian Analysis Zone 2 120 meter Buffer
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

5 types found.
6071 pixels (non-missing).
22837 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
5	4117	0.67814
2	65	0.01071
1	138	0.02273
4	171	0.02817
9	1580	0.26025

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
5	7312	0.920268
2	197	0.192893
1	382	0.306283
4	431	0.361949
9	3351	0.862728

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
5	59	3508	35	69.780	0.9840
2	31	7	26	2.097	0.4769
1	44	29	39	3.136	0.6014
4	43	31	35	3.977	0.6374
9	3	1574	1	526.667	0.9994
Overall values, not area-weighted:	180	3508		33.728	0.9641

T2L120z2.wpd - 078Leb98

LEGEND

1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Riparian Analysis Zone 3 120 meter Buffer
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

5 types found.
67779 pixels (non-missing).
174027 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
5	63736	0.94035
2	1675	0.02471
1	1282	0.01891
4	992	0.01464
9	94	0.00139

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
5	124010	0.958269
2	4978	0.281237
1	3352	0.465394
4	2991	0.265129
9	223	0.358744

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
5	131	44560	92	486.534	0.9977
2	557	77	494	3.007	0.5648
1	198	229	152	6.475	0.7956
4	356	195	322	2.787	0.5161
9	25	27	19	3.760	0.6702
Overall values, not area-weighted:	1267	44560		53.496	0.9757

T2L120z3.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Riparian Analysis Zone 4 120 meter Buffer
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer
5 types found.
178889 pixels (non-missing).
313914 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
2	30382	0.16984
5	123765	0.69185
4	2677	0.01496
1	21443	0.11987
9	622	0.00348

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
2	66396	0.811871
5	247653	0.941265
4	8046	0.237882
1	46917	0.781593
9	1703	0.369348

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
2	931	18102	757	32.634	0.9609
5	310	102728	210	399.242	0.9972
4	979	38	831	2.734	0.5159
1	568	11243	389	37.752	0.9686
9	127	113	104	4.898	0.7379
Overall values, not area-weighted:	2915	102728		61.368	0.9795

T2L120z4.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Riparian Analysis Zone 5 120 meter Buffer
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

5 types found.
56051 pixels (non-missing).
525387 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
2	10188	0.18176
5	18202	0.32474
1	25536	0.45559
4	1072	0.01913
9	1053	0.01879

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
2	20235	0.831085
5	33670	0.885061
1	49159	0.919038
4	2833	0.289799
9	2362	0.455546

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
2	294	1722	202	34.653	0.9664
5	247	2394	132	73.692	0.9886
1	251	12462	150	101.737	0.9898
4	365	73	320	2.937	0.5075
9	174	95	126	6.052	0.7854
Overall values, not area-weighted:					
	1331	12462		42.112	0.9721

T2L120z5.wpd - 078Leb98

LEGEND

1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Riparian Analysis Zone 6 120 meter Buffer
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer
5 types found.
30904 pixels (non-missing).
35048 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
2	3294	0.10659
5	8736	0.28268
1	18088	0.58530
9	208	0.00673
4	578	0.01870

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
2	7270	0.794360
5	18187	0.909441
1	36335	0.941764
9	510	0.233333
4	1680	0.252976

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
2	134	2233	113	24.582	0.9502
5	38	6204	30	229.895	0.9958
1	148	12910	124	122.216	0.9896
9	99	30	93	2.101	0.3462
4	220	54	201	2.627	0.5000
Overall values, not area-weighted:	639	12910		48.363	0.9736

T2L120z6.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Riparian Analysis Zone 7 120 meter Buffer
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

5 types found.
4164 pixels (non-missing).
46672 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
1	832	0.19981
5	2232	0.53602
9	88	0.02113
2	356	0.08549
4	656	0.15754

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
1	1589	0.643172
5	4113	0.743010
9	232	0.206897
2	858	0.403263
4	1505	0.390033

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
1	89	220	65	9.348	0.8798
5	80	1527	55	27.900	0.9601
9	40	10	35	2.200	0.3864
2	88	60	78	4.045	0.6826
4	144	59	115	4.556	0.7332
Overall values, not area-weighted:	441	1527		9.442	0.8725

T2L120z7.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Riparian Analysis Zone 8 120 meter Buffer
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

5 types found.
199037 pixels (non-missing).
246507 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
1	55256	0.27762
2	50401	0.25322
5	84262	0.42335
4	3229	0.01622
9	5889	0.02959

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
1	117407	0.870348
2	109954	0.827846
5	175871	0.891574
4	10432	0.200920
9	13355	0.704231

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
1	809	27137	650	68.302	0.9805
2	1260	20356	1080	40.001	0.9687
5	602	63889	475	139.970	0.9916
4	1382	51	1251	2.336	0.4230
9	338	2956	281	17.423	0.9221
Overall values, not area-weighted:	4391	63889		45.328	0.9714

T2L120z8.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Riparian Analysis Zone 9 120 meter Buffer
LANDSTAT: Landscape Statistics Program, v. 7-94

<u>Results of Pixel Analyzer</u>

5 types found.
148346 pixels (non-missing).
558192 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
5	99881	0.67330
2	16982	0.11448
4	4564	0.03077
1	24001	0.16179
9	2918	0.01967

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
5	205285	0.899340
2	39785	0.670806
4	13792	0.264139
1	53387	0.752861
9	7863	0.467125

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
5	565	54525	384	176.781	0.9942
2	1152	2744	896	14.741	0.9195
4	1574	109	1366	2.900	0.5537
1	936	6286	687	25.642	0.9560
9	209	729	152	13.962	0.9147
Overall values, not area-weighted:	4436	54525		33.441	0.9643

T2L120z9.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Reach and Major Tributaries
Riparian Analysis 360 Meter Buffer
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

5 types found.
76659 pixels (non-missing).
1720848 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
5	39356	0.51339
1	20793	0.27124
9	4527	0.05905
2	8883	0.11588
4	3100	0.04044

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
5	78676	0.841362
1	44387	0.757406
9	12243	0.470228
2	19844	0.657327
4	9503	0.260549

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
5	367	5116	239	107.237	0.9911
1	647	4686	475	32.138	0.9621
9	307	1343	238	14.746	0.9123
2	665	763	505	13.358	0.9097
4	990	131	836	3.131	0.5842
Overall values, not area-weighted:	2976	5116		25.759	0.9527

TBLM360j2.wpd - 078Leb98

LEGEND: 1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Backswamp Analysis
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

5 types found.
125436 pixels (non-missing).
3162902 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
5	52834	0.42120
2	22824	0.18196
4	4506	0.03592
1	35286	0.28131
9	9986	0.07961

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
5	77195	0.860405
2	33574	0.760410
4	9158	0.304761
1	50619	0.801754
9	19588	0.740147

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
5	5688	2281	4370	9.289	0.8549
2	3569	1944	2930	6.395	0.7833
4	1951	178	1760	2.310	0.4257
1	4574	2681	3524	7.714	0.8255
9	732	2656	560	13.642	0.9116
Overall values, not area-weighted:	16514	2681		7.596	0.8227

T2LXxffl1.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Backswamp Analysis Zone 2
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

5 types found.
2616 pixels (non-missing).
26094 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
5	950	0.36315
2	26	0.00994
4	124	0.04740
1	115	0.04396
9	1401	0.53555

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
5	1197	0.729323
2	37	0.027027
4	264	0.291667
1	214	0.392523
9	2696	0.918769

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
5	184	133	145	5.163	0.7305
2	23	2	23	1.130	0.0000
4	51	20	47	2.431	0.4113
1	33	26	27	3.485	0.6696
9	12	1371	9	116.750	0.9893
Overall values, not area-weighted:	303	1371		8.634	0.8440

T2LXxffl2.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Backswamp Analysis Zone 3
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

5 types found.
7005 pixels (non-missing).
233235 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
5	5480	0.78230
1	522	0.07452
2	478	0.06824
9	225	0.03212
4	300	0.04283

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
5	7390	0.905683
1	1020	0.503922
2	1030	0.416505
9	503	0.493042
4	667	0.560720

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
5	685	1296	531	8.000	0.8279
1	104	91	83	5.019	0.7414
2	122	43	100	3.918	0.7176
9	29	100	20	7.759	0.8756
4	60	189	54	5.000	0.7700
Overall values, not area-weighted:					
	1000	1296		7.005	0.8130

T2LXxfll3.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Backswamp Analysis Zone 4
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer
5 types found.
33623 pixels (non-missing).
452883 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
5	19018	0.56562
2	6909	0.20548
4	879	0.02614
1	6551	0.19484
9	266	0.00791

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
5	26988	0.913739
2	10140	0.781262
4	1868	0.328694
1	10236	0.777354
9	479	0.455115

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
5	1558	2279	1104	12.207	0.8935
2	911	1173	703	7.584	0.8136
4	320	46	271	2.747	0.5290
1	652	333	469	10.048	0.8773
9	84	35	69	3.167	0.6165
Overall values, not area-weighted:	3525	2279		9.538	0.8622

T2LXxfll4.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Backswamp Analysis Zone 5
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer
5 types found.
23173 pixels (non-missing).
540827 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
5	6798	0.29336
2	3704	0.15984
1	11259	0.48587
4	551	0.02378
9	861	0.03716

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
5	9827	0.905973
2	4550	0.827692
1	15566	0.926057
4	997	0.368104
9	1349	0.607858

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
5	694	2010	526	9.795	0.8601
2	633	300	506	5.852	0.7643
1	1119	2688	874	10.062	0.8595
4	201	24	168	2.741	0.4791
9	159	89	120	5.415	0.7573
Overall values, not area-weighted:	2806	2688		8.258	0.8316

T2LXxfll5.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Backswamp Analysis Zone 6
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer
5 types found.
2259 pixels (non-missing).
62721 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
5	214	0.09473
4	71	0.03143
1	1717	0.76007
9	97	0.04294
2	160	0.07083

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
5	162	0.746914
4	79	0.265823
1	1758	0.883959
9	127	0.299213
2	220	0.572727

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
5	65	19	54	3.292	0.5140
4	49	6	48	1.449	0.0845
1	330	139	258	5.203	0.7490
9	59	11	56	1.644	0.2474
2	43	22	34	3.721	0.6875
Overall values, not area-weighted:	546	136		4.137	0.6799

T2LXxffll6.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Backswamp Analysis Zone 7
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

5 types found.
3266 pixels (non-missing).
43902 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
5	646	0.19780
4	188	0.05756
1	1992	0.60992
2	367	0.11237
9	73	0.02235

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
5	781	0.706786
4	278	0.370504
1	2378	0.890664
2	520	0.650000
9	146	0.534247

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
5	130	44	95	4.969	0.7152
4	72	23	63	2.611	0.4734
1	265	498	204	7.517	0.8183
2	81	76	66	4.531	0.6948
9	12	23	8	6.083	0.7534
Overall values, not area-weighted:	560	498		5.832	0.7627

T2LXxffll7.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Backswamp Analysis Zone 8
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

5 types found.
20543 pixels (non-missing).
421657 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
2	4544	0.22119
1	5872	0.28584
5	4679	0.22777
4	760	0.03700
9	4688	0.22820

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
2	6077	0.726181
1	8188	0.693942
5	6824	0.709115
4	1620	0.211728
9	9057	0.814066

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
2	988	938	861	4.599	0.6912
1	1135	860	904	5.174	0.7301
5	848	305	728	5.518	0.7459
4	397	22	377	1.914	0.2421
9	281	2551	236	16.683	0.9185
Overall values, not area-weighted:	3649	2551		5.630	0.7500

T2LXx fll8.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Backswamp Analysis Zone 9
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

5 types found.
32976 pixels (non-missing).
670510 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
2	6840	0.20742
1	7172	0.21749
5	14994	0.45469
9	2217	0.06723
4	1753	0.05316

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
2	11575	0.748855
1	11057	0.700009
5	23820	0.809908
9	4481	0.561928
4	3726	0.273484

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
2	844	1944	711	8.104	0.8266
1	1146	435	907	6.258	0.7896
5	1608	1974	1272	9.325	0.8533
9	227	464	156	9.767	0.8836
4	775	40	691	2.262	0.4278
Overall values, not area-weighted:	4600	1974		7.169	0.8133

T2LXxfll9.wpd - 078Leb98

LEGEND

1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Forest Change Analysis
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer
5 types found.
1043907 pixels (non-missing).
2256441 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
5	660978	0.63318
2	147836	0.14162
4	19409	0.01859
1	202203	0.19370
9	13481	0.01291

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
5	1362552	0.931209
2	330052	0.789288
4	60144	0.272363
1	435798	0.852767
9	33600	0.595476

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
5	1387	595999	1086	476.552	0.9975
2	5047	21183	4064	29.292	0.9582
4	6209	196	5326	3.126	0.5763
1	3220	99871	2324	62.796	0.9819
9	943	3006	731	14.296	0.9140
Overall values, not area-weighted:	16806	595999		62.115	0.9800

T2LFor.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Forest Change Analysis Zone 2
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer
5 types found.
15559 pixels (non-missing).
13349 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
5	12776	0.82113
4	473	0.03040
2	209	0.01343
1	503	0.03233
9	1598	0.10271

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
5	25877	0.941415
4	1397	0.342162
2	683	0.218155
1	1397	0.437366
9	3413	0.850864

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
5	36	12554	21	354.889	0.9970
4	102	56	80	4.637	0.7230
2	81	14	64	2.580	0.5742
1	71	88	54	7.085	0.8410
9	9	1574	5	177.556	0.9956
Overall values, not area-weighted:	299	12554		52.037	0.9778

T2LForZ2.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Forest Change Analysis Zone 3
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

5 types found.
126076 pixels (non-missing).
115730 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
5	118966	0.94361
2	3140	0.02491
1	2210	0.01753
4	1419	0.01126
9	341	0.00270

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
5	240508	0.962758
2	9303	0.321187
1	5979	0.465295
4	4581	0.220912
9	936	0.444444

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
5	99	118759	89	1201.677	0.9990
2	896	199	783	3.504	0.6325
1	317	229	253	6.972	0.8154
4	584	195	537	2.430	0.4355
9	50	121	40	6.820	0.8358
Overall values, not area-weighted:	1946	118759		64.787	0.9799

T2LForZ3.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Forest Change Analysis Zone 4
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

5 types found.
256864 pixels (non-missing).
235939 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
5	190676	0.74232
2	34739	0.13524
1	26983	0.10505
4	3765	0.01466
9	701	0.00273

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
5	390435	0.946759
2	77568	0.786497
1	60100	0.776123
4	11769	0.242671
9	1943	0.387545

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
5	216	187267	163	882.759	0.9986
2	1204	18102	986	28.853	0.9553
1	645	11243	440	41.834	0.9719
4	1292	38	1080	2.914	0.5461
9	139	113	117	5.043	0.7432
Overall values, not area-weighted:					
	3496	187267		73.474	0.9826

T2LForZ4.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Forest Change Analysis Zone 5
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

5 types found.
171505 pixels (non-missing).
409933 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
2	30141	0.17574
5	83380	0.48617
1	54148	0.31572
4	2487	0.01450
9	1349	0.00787

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
2	64889	0.850545
5	170793	0.928662
1	111406	0.920202
4	7090	0.301410
9	3076	0.443108

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
2	576	8090	431	52.328	0.9756
5	165	38714	124	505.333	0.9977
1	350	16950	227	154.709	0.9928
4	756	180	644	3.290	0.5746
9	221	120	156	6.104	0.8013
Overall values, not area-weighted:	2068	38714		82.933	0.9846

T2LForZ5.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Wetland Restoration Analysis Zone 6
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

5 types found.
30904 pixels (non-missing).
35048 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
2	3294	0.10659
5	8736	0.28268
1	18088	0.58530
9	208	0.00673
4	578	0.01870

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
2	7270	0.794360
5	18187	0.909441
1	36335	0.941764
9	510	0.233333
4	1680	0.252976

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
2	134	2233	113	24.582	0.9502
5	38	6204	30	229.895	0.9958
1	148	12910	124	122.216	0.9896
9	99	30	93	2.101	0.3462
4	220	54	201	2.627	0.5000
Overall values, not area-weighted:	639	12910		48.363	0.9736

T2LForZ6.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Wetland Restoration Analysis Zone 7
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

5 types found.
20405 pixels (non-missing).
30431 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
1	10572	0.51811
5	6337	0.31056
9	234	0.01147
2	1731	0.08483
4	1531	0.07503

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
1	22433	0.881246
5	13925	0.756266
9	693	0.285714
2	4528	0.523410
4	4457	0.329370

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
1	138	9851	110	76.609	0.9834
5	90	3781	60	70.411	0.9858
9	77	33	66	3.039	0.5812
2	205	631	182	8.444	0.8458
4	345	70	278	4.438	0.7054
Overall values, not area-weighted:	855	9851		23.865	0.9470

T2LForZ7.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Forest Change Analysis Zone 8
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

5 types found.
221426 pixels (non-missing).
224118 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
1	56488	0.25511
2	51239	0.23140
5	103493	0.46739
4	4261	0.01924
9	5945	0.02685

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
1	120778	0.860927
2	112422	0.819075
5	216924	0.898218
4	13786	0.222690
9	13549	0.698280

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
1	898	27145	706	62.904	0.9794
2	1400	20356	1198	36.599	0.9659
5	546	88833	451	189.548	0.9936
4	1634	101	1469	2.608	0.4799
9	355	2965	298	16.746	0.9196
Overall values, not area-weighted:	4833	88833		45.815	0.9717

T2LForZ8.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Forest Change Analysis Zone 9
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

5 types found.
200588 pixels (non-missing).
505950 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
5	134423	0.67014
2	24496	0.12212
4	6039	0.03011
1	32586	0.16245
9	3044	0.01518

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
5	280756	0.900811
2	57829	0.683602
4	18850	0.265517
1	73665	0.756302
9	8265	0.462795

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
5	413	106774	312	325.479	0.9964
2	1415	3731	1110	17.312	0.9315
4	1964	109	1679	3.075	0.5753
1	993	6286	715	32.816	0.9672
9	228	729	168	13.351	0.9067
Overall values, not area-weighted:	5013	106774		40.014	0.9697

T2LForZ9.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Wetland Restoration Analysis
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

5 types found.
1043906 pixels (non-missing).
2256442 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
5	652100	0.62467
2	146646	0.14048
4	30335	0.02906
1	201389	0.19292
9	13436	0.01287

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
5	1344920	0.930219
2	327272	0.789948
4	83052	0.446022
1	433866	0.853519
9	33469	0.596343

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
5	1420	587999	1108	459.225	0.9974
2	5034	21183	4058	29.131	0.9577
4	6100	1574	5227	4.973	0.7337
1	3207	99710	2320	62.797	0.9818
9	932	3006	722	14.416	0.9146
Overall values, not area-weighted:	16693	587999		62.536	0.9801

T2LWrpFLwpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Wetland Restoration Analysis Zone 2
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

5 types found.
15559 pixels (non-missing).
13349 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
5	12776	0.82113
4	473	0.03040
2	209	0.01343
1	503	0.03233
9	1598	0.10271

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
5	25877	0.941415
4	1397	0.342162
2	683	0.218155
1	1397	0.437366
9	3413	0.850864

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
5	36	12554	21	354.889	0.9970
4	102	56	80	4.637	0.7230
2	81	14	64	2.580	0.5742
1	71	88	54	7.085	0.8410
9	9	1574	5	177.556	0.9956
Overall values, not area-weighted:	299	12554		52.037	0.9778

T2LWz2.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Wetland Restoration Analysis Zone 3
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

5 types found.
126076 pixels (non-missing).
115730 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
5	118781	0.94214
2	3140	0.02491
1	2210	0.01753
4	1604	0.01272
9	341	0.00270

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
5	240195	0.962235
2	9303	0.321187
1	5979	0.465295
4	5008	0.264577
9	936	0.444444

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
5	99	118574	89	1199.808	0.9990
2	896	199	783	3.504	0.6325
1	317	229	253	6.972	0.8154
4	588	195	537	2.728	0.5006
9	50	121	40	6.820	0.8358
Overall values, not area-weighted:					
	1950	118574		64.654	0.9799

T2LWz3.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Wetland Restoration Analysis Zone 4
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

5 types found.
256865 pixels (non-missing).
235938 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
5	184146	0.71690
2	33844	0.13176
1	26341	0.10255
4	11848	0.04613
9	686	0.00267

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
5	377554	0.944336
2	75536	0.787929
1	58623	0.777971
4	28668	0.629168
9	1901	0.391899

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
5	242	180859	181	760.934	0.9984
2	1188	17264	976	28.488	0.9543
1	641	11112	435	41.094	0.9715
4	1227	1502	1015	9.656	0.8634
9	130	113	108	5.277	0.7522
Overall values, not area-weighted:	3428	180859		74.931	0.9830

T2LWz4.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Wetland Restoration Analysis Zone 5
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

5 types found.
171511 pixels (non-missing).
409927 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
2	30119	0.17561
5	82039	0.47833
1	54134	0.31563
4	3869	0.02256
9	1350	0.00787

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
2	64831	0.851013
5	168118	0.927456
1	111379	0.920227
4	9945	0.481750
9	3079	0.442676

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
2	568	8090	424	53.026	0.9759
5	171	34533	128	479.760	0.9976
1	349	16937	226	155.112	0.9929
4	751	1587	643	5.152	0.7268
9	222	120	157	6.081	0.8007
Overall values, not area-weighted:	2061	34533		83.217	0.9846

T2LWz5.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Wetland Restoration Analysis Zone 6
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer
5 types found.
30904 pixels (non-missing).
35048 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
2	3294	0.10659
5	8736	0.28268
1	18088	0.58530
9	208	0.00673
4	578	0.01870

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
2	7270	0.794360
5	18187	0.909441
1	36335	0.941764
9	510	0.233333
4	1680	0.252976

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
2	134	2233	113	24.582	0.9502
5	38	6204	30	229.895	0.9958
1	148	12910	124	122.216	0.9896
9	99	30	93	2.101	0.3462
4	220	54	201	2.627	0.5000
Overall values, not area-weighted:	639	12910		48.363	0.9736

T2LWz6.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Wetland Restoration Analysis Zone 7
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

5 types found.
20405 pixels (non-missing).
30431 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
1	10416	0.51046
5	5570	0.27297
9	207	0.01014
2	1448	0.07096
4	2764	0.13546

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
1	22018	0.888364
5	12252	0.745674
9	618	0.266990
2	3833	0.504305
4	7007	0.549451

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
1	120	9786	100	86.800	0.9847
5	91	3780	58	61.209	0.9847
9	74	33	65	2.797	0.5314
2	210	620	188	6.895	0.8004
4	307	1315	251	9.003	0.8538
Overall values, not area-weighted:					
	802	9786		25.443	0.9493

T2LWz7.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Wetland Restoration Analysis Zone 8
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer
5 types found.
221426 pixels (non-missing).
224118 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
1	56488	0.25511
2	51239	0.23140
5	103493	0.46739
4	4261	0.01924
9	5945	0.02685

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
1	120778	0.860927
2	112422	0.819075
5	216924	0.898218
4	13786	0.222690
9	13549	0.698280

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
1	898	27145	706	62.904	0.9794
2	1400	20356	1198	36.599	0.9659
5	546	88833	451	189.548	0.9936
4	1634	101	1469	2.608	0.4799
9	355	2965	298	16.746	0.9196
Overall values, not area-weighted:	4833	88833		45.815	0.9717

T2LWz8.wpd - 078Leb98

LEGEND
1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Tensas River Basin - Wetland Restoration Analysis Zone 9
LANDSTAT: Landscape Statistics Program, v. 7-94

Results of Pixel Analyzer

5 types found.
200588 pixels (non-missing).
505950 pixels coded as missing.

Data Code	Pixel Count	Pixel Percent
5	134408	0.67007
2	24496	0.12212
4	6054	0.03018
1	32586	0.16245
9	3044	0.01518

Number of edges and percent of same-type edges

Data code	Number edges	Same-type percentage
5	280727	0.900793
2	57829	0.683602
4	18883	0.266483
1	73665	0.756302
9	8265	0.462795

Patch Statistics

Data code	Number patches	Largest patch	N patches <5 cells	Avg patch size	Proportion 5
5	415	106754	314	323.875	0.9964
2	1415	3731	1110	17.312	0.9315
4	1962	109	1676	3.086	0.5771
1	993	6286	715	32.816	0.9672
9	228	729	168	13.351	0.9067
Overall values, not area-weighted:	5013	106754		40.014	0.9697

T2LWz9.wpd - 078Leb98

LEGEND

1: Forest; 2: Forest Loss; 4: Forest Gain; 5: Human Use; 9: Water

Summary Statistics for water quality parameters from three water quality monitoring stations in the Tensas River Basin.

Station	Season	Parameter	N	Mean	Standard Deviation	Maximum	Median	Minimum
Clayton	Fall	Nitrogen	7	0.05	0.059	0.18	0.02	0.02
Clayton	Fall	Phosphorus	7	0.12	0.053	0.23	0.11	0.08
Clayton	Spring	Nitrogen	9	0.89	0.523	1.98	0.85	0.25
Clayton	Spring	Phosphorus	9	0.46	0.225	0.89	0.39	0.24
Clayton	Summer	Nitrogen	13	0.73	0.802	2.53	0.26	0.02
Clayton	Summer	Phosphorus	13	0.24	0.106	0.44	0.23	0.03
Clayton	Winter	Nitrogen	12	0.53	0.456	1.86	0.34	0.22
Clayton	Winter	Phosphorus	12	0.44	0.331	1.26	0.38	0.09
Tendal	Fall	Nitrogen	7	0.43	0.938	2.55	0.02	0.02
Tendal	Fall	Phosphorus	7	0.55	0.216	0.96	0.54	0.22
Tendal	Spring	Nitrogen	9	0.88	0.775	2.50	0.57	0.02
Tendal	Spring	Phosphorus	9	0.53	0.261	1.07	0.44	0.24
Tendal	Summer	Nitrogen	14	0.98	1.547	5.90	0.38	0.02
Tendal	Summer	Phosphorus	14	0.43	0.276	1.04	0.29	0.18
Tendal	Winter	Nitrogen	12	0.56	0.586	2.25	0.45	0.01
Tendal	Winter	Phosphorus	12	0.49	0.290	1.10	0.45	0.00
Winnsboro	Fall	Nitrogen	4	0.22	0.400	0.82	0.02	0.02
Winnsboro	Fall	Phosphorus	4	0.16	0.102	0.31	0.12	0.09
Winnsboro	Spring	Nitrogen	6	0.83	0.615	1.63	0.72	0.21
Winnsboro	Spring	Phosphorus	6	0.45	0.230	0.72	0.42	0.10
Winnsboro	Summer	Nitrogen	11	1.00	0.857	2.54	0.61	0.01
Winnsboro	Summer	Phosphorus	11	0.33	0.210	0.85	0.28	0.06
Winnsboro	Winter	Nitrogen	9	0.43	0.209	0.66	0.52	0.08
Winnsboro	Winter	Phosphorus	9	0.42	0.313	1.13	0.33	0.13

Results of Wilcoxon Rank Sum Test for Determining differences between water quality monitoring stations

Compare Station to Station		Parameter	Season	Significantly Different
Tendal	Clayton	Total Nitrogen	All Combined	No
Tendal	Clayton	Total Phosphorus	All Combined	Yes
Tendal	Winnsboro	Total Nitrogen	All Combined	No
Tendal	Winnsboro	Total Phosphorus	All Combined	Yes
Clayton	Winnsboro	Total Nitrogen	All Combined	No
Clayton	Winnsboro	Total Phosphorus	All Combined	No
Clayton	Winnsboro	Total Nitrogen	Spring	No
Clayton	Winnsboro	Total Nitrogen	Summer	No
Clayton	Winnsboro	Total Nitrogen	Fall	No
Clayton	Winnsboro	Total Nitrogen	Winter	No
Tendal	Clayton	Total Nitrogen	Spring	No
Tendal	Clayton	Total Nitrogen	Summer	No
Tendal	Clayton	Total Nitrogen	Fall	No
Tendal	Clayton	Total Nitrogen	Winter	No
Tendal	Winnsboro	Total Nitrogen	Spring	No
Tendal	Winnsboro	Total Nitrogen	Summer	No
Tendal	Winnsboro	Total Nitrogen	Fall	No
Tendal	Winnsboro	Total Nitrogen	Winter	No
Clayton	Winnsboro	Total Phosphorus	Spring	No
Clayton	Winnsboro	Total Phosphorus	Summer	No
Clayton	Winnsboro	Total Phosphorus	Fall	No
Clayton	Winnsboro	Total Phosphorus	Winter	No
Tendal	Clayton	Total Phosphorus	Spring	No
Tendal	Clayton	Total Phosphorus	Summer	Yes
Tendal	Clayton	Total Phosphorus	Fall	Yes
Tendal	Clayton	Total Phosphorus	Winter	No
Tendal	Winnsboro	Total Phosphorus	Spring	No
Tendal	Winnsboro	Total Phosphorus	Summer	No
Tendal	Winnsboro	Total Phosphorus	Fall	Yes

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Jones, K.B., K.H. Riitters, J.D. Wickham, R.D Tankersley, Jr., R.V. O'Neill, D.J. Chaloud, E.R. Smith, and A.C. Neale, 1997. An Ecological Assessment of the United States Mid-Atlantic Region: A Landscape Atlas U.S. EPA/ ORD, EPA/600/R-97/130

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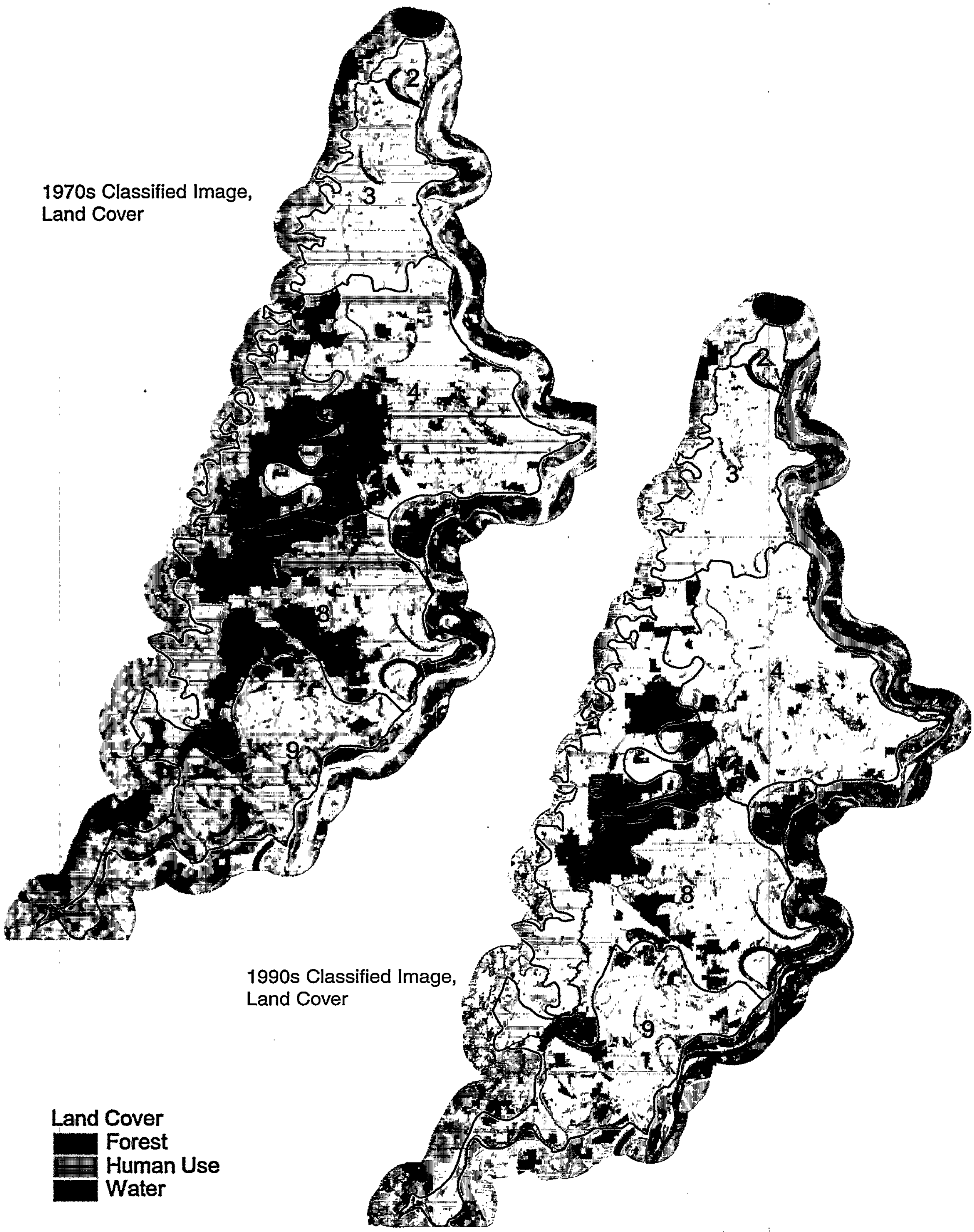
Notice

The purpose of this atlas is to show examples of how the principles of landscape ecology can be applied in a watershed-scale ecological assessment. The examples do not constitute a definitive assessment of ecological conditions in the Tensas River Basin. The EPA, through its Office of Research and Development (ORD), partially funded the research described here under U.S. EPA contract #68-C5-0065 to Lockheed/Martin Corporation. It has been peer reviewed by the EPA and approval for publication. Mentions of trade names does not constitute endorsement or recommendation for use.


1970s Classified Image,
Land Cover
2
3
4
8
9
1990s Classified Image,
Land Cover
2
3
4
8
9
Land Cover
Forest
Human Use
Water