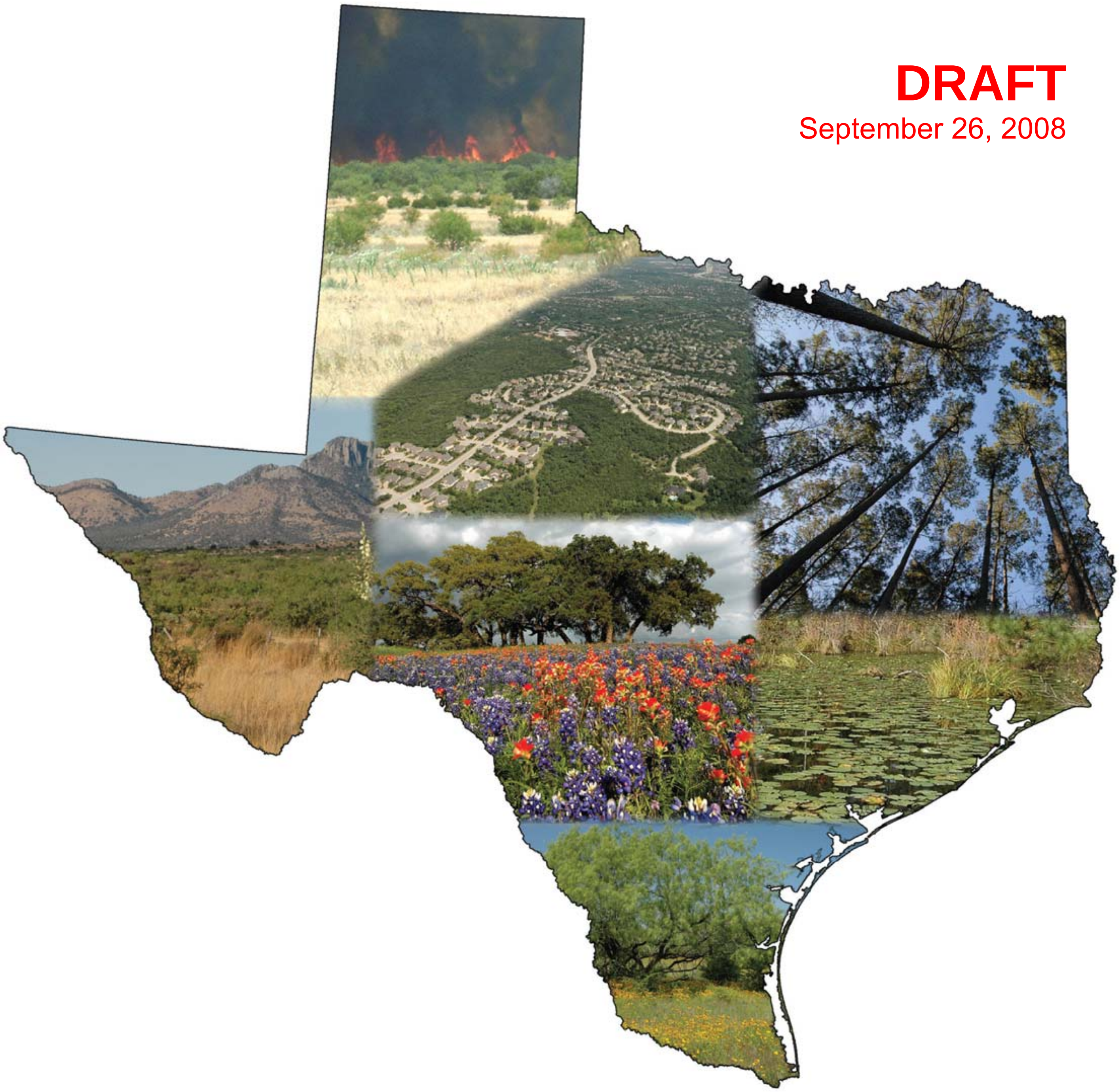
Texas Statewide Assessment of Forest Resources

A comprehensive analysis of forest-related
conditions, trends, threats, and opportunities



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FOREST SERVICE
The Texas A&M University System

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A comprehensive analysis of forest-related conditions, trends, threats, and opportunities

September 2008

Produced by

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Abbreviations Used:

AMO	Atlantic Multi-Decadal Oscillation
BMPs	Best Management Practices
CARS	Community Accomplishment Reporting System
CCX	Chicago Climate Exchange
EPA	Environmental Protection Agency
ETJ	Extraterritorial Jurisdiction
FEI	Fire Effects Index
FIA	Forest Inventory and Analysis
GIS	Geographic Information Systems
HUC	Hydrologic Unit Code
LOC	Level of Concern
MRLC	Multi-resolution Lands Characteristics Consortium
NASF	National Association of State Foresters
NED	National Elevation Dataset
NHD	National Hydrography Dataset
NHP	Natural Heritage Program
NIDRM	National Insect and Disease Risk Map
NLCD	National Land Cover Database
NRCS	Natural Resource Conservation Service
NWI	National Wetlands Inventory
PAD	Protected Areas Database
PDO	Pacific Decadal Oscillation
REIT	Real Estate Investment Trust
S&PF	State & Private Forestry
SAP	Spatial Analysis Project
SFLA	Southern Forest Land Assessment
SGSF	Southern Group of State Foresters
SPB	southern pine beetle
SSURGO	Soil Survey Geographic Dataset
STATSGO	State Geographic Dataset
SWRA	Southern Wildfire Risk Assessment
TFS	Texas Forest Service
TIMO	Timberland Investment Management Organization
UFS	Urban Forest Sustainability
U.S.	United States
USDA	United States Department of Agriculture
USFS	United States Forest Service
WFSI	Wildland Fire Susceptibility Index

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EXECUTIVE SUMMARY

Texas is a big and diverse state with areas similar to Georgia to the east and Arizona to the west. It is second only to Alaska in area and California in population. This size and diversity bring many challenges in managing the forest and tree resources of the state. Many of the issues and challenges, and thus opportunities, result from these characteristics. The rapidly-increasing population is placing an unprecedented demand on Texas forests, whether for wood and paper products, wildlife habitat, clean water, or 10-acre ranchettes. As urban sprawl expands into the forest and other rural areas, less area becomes available for providing the traditional benefits of these lands. These challenges are not unique to Texas. In fact, the changes that create these challenges are occurring in every state in the nation.

Significant threats to forests, such as insects and diseases, catastrophic fire, and loss of critical forested landscapes to development, coupled with pressure placed on local economies by the increasingly global nature of the forest products industry, point to the need for more progressive strategies for conserving the forest resource. To have a meaningful beneficial impact on the forest and tree resources, state forestry agencies must change the way they deliver their programs. With the tightening of federal funds, Congress is demanding additional accountability on how federal funds are spent and wants assurance that the funds are actually resulting in positive benefits on the ground. In response to these increasing demands, the USDA Forest Service is in the process of transforming how they and the states deliver the federally-funded State and Private Forestry (S&PF) programs.

In 2008, the USDA Forest Service implemented a "Redesigned" State and Private Forestry Program (S&PF Redesign). It was conceived in response to the combined impacts of increasing pressure on the nation's forests and decreasing S&PF resources and funds. Under S&PF Redesign, each state is required to analyze its forest conditions and trends and delineate priority rural and urban forest landscapes. From this state assessment, a statewide forest resource strategy, or response plan, will be developed that will be the basis for formulating competitive proposals for S&PF funds.

Redesign focuses on three national themes: conserve working forests, protect forests, and enhance benefits from trees and forests. At a minimum, statewide assessments of forest resources should:

- Describe forest conditions on all ownerships in the state
- Identify forest-related benefits and services
- Identify threats to the forest resources
- Highlight issues and trends of concern as well as opportunities for action
- Delineate high priority forest landscapes to be addressed
- Be geospatially based and make use of the best existing data

The Texas Statewide Assessment of Forest Resources was developed around the issues facing the state's forest and tree resources rather than being based on the forest resources themselves. With input from interested stakeholders from across the state representing the diverse interests of the forest resource, Texas Forest Service program leaders identified six primary issues for the rural and urban forests of the state:

(1) Population Growth and Urbanization
(2) Central Texas Woodlands Conservation
(3) Sustainability of Forest Resources in East Texas
(4) Water Quality and Quantity
(5) Wildfire and Public Safety
(6) Urban Forest Sustainability

For each issue, a geospatial analysis was conducted to delineate areas across the Texas landscape where future efforts might best be focused. These areas of priority were determined using weighted overlay analysis. This involved identifying thematic layers of spatial data that could inform the issue, weighting them according to their relative importance, and then combining them into one priority output layer on a map that provides a visual indication of where these priority areas occur. Thematic layers from the Southern Forest Land Assessment (SFLA) provided the necessary data for the overlay analyses. Additional layers were developed for the urban forest sustainability analysis.

The following paragraphs summarize each of the six issues.

Issue 1: **Population Growth and Urbanization**
Texas communities are growing at an alarming rate. Community leaders need proactive management tools and technical support systems to help prepare for the effects of "high-velocity" growth on forest resources before it happens—not after. Geospatial analysis revealed areas of high priority in East Texas, the Hill Country of Central Texas, and around the Metroplex in North-Central Texas.

Issue 2: **Central Texas Woodlands Conservation**
The woodlands of Central and West Texas are valuable resources for shade, recreation, wildlife, environmental, and watershed protection. Yet, these resources are coming under increasing pressure from an exploding population, land fragmentation, wildfires, invasive plants, oak wilt, and other pests. Cooperation and partnerships to protect and conserve these critical resources are essential if the high quality of life residents have come to expect in these regions of the state is to continue. Geospatial analysis identified areas of high priority as the Hill Country of Central Texas and the Cross Timbers area west of Fort Worth.

Issue 3: **Sustainability of Forest Resources in East Texas**
For more than a century, the forests of East Texas have provided a number of economic and societal advantages such as manufacturing, employment, recreation, and environmental protection. Today, pressure on this resource has never been greater. East Texas is experiencing unprecedented change in the management and use of the Pineywoods. Population growth, ownership changes and parcelization, residential development, and non-consumptive demands will impact the forested landscape for decades to come. Although much of East Texas appeared as high priority in the geospatial analysis, the highest priority was assigned to two areas—one in Southeast Texas and one in Northeast Texas.

Issue 4: **Water Quality and Quantity**
In Texas, most freshwater resources originate in the eastern portion of the state, making forestland a critical factor in meeting the state's water needs since they provide the cleanest water of any land use. In the rest of the state, where water supplies are limited, controlling non-native and invasive vegetation may produce higher water yields. With Texans already placing high demands on water resources, and the state's population exploding, it is imperative to continue to focus on this critical issue to ensure the quality of life that Texans expect. Two areas were shown through geospatial analysis to be of high priority for focusing future efforts concerning water quality and quantity—East Texas and the Balcones Escarpment region of Central Texas.

Issue 5: **Wildfire and Public Safety**
Since it's inception in 1915, Texas Forest Service has been tasked with the responsibility of wildfire suppression, defending both the property and lives of Texas citizens. This is a growing issue for Texas. Since 1996, the state has seen significant fire seasons in 8 of the past 12 years. Once primarily a rural issue, wildfires are now clearly a statewide threat. In recent years, wildfires have threatened and, in some cases, burned through small towns and large cities alike, destroying hundreds of homes. Three primary factors are combining to create these intense fire seasons—population growth, changing land use, and increasing drought frequency.

Issue 6: **Urban Forest Sustainability**
With the addition of 6.5 million residents since 1990, rapid urbanization is creating intense pressure on the sustainability of the trees and forests in Texas communities. Trees provide economic, health, and environmental benefits that are important to the quality of life in Texas communities. It is critical to plant, care for, and conserve the trees in the communities where Texans live, work, and play. An overall urban priority analysis showed that 34 percent of the urban landscapes across the state is considered either very high or high priority for focusing future program efforts.

Combined Rural and Urban Priority
A requirement for the development of a statewide assessment of forest resources for S&PF Redesign is that it include the entire state—public and private, rural and urban. The Southern Forest Land Assessment (SFLA) did not include urban areas since it was focused on identifying important rural lands across the landscape. To cover the entire state in one analysis, the model for the SFLA was run with several updated thematic layers and then was combined with the overall urban analysis output to produce one layer for the state covering both rural and urban landscapes. Areas of high priority were revealed to be East Texas, the Hill Country of Central Texas, the area around the Metroplex of North-Central Texas, and the Valley in South Texas. When analyzed by ecoregion, the Pineywoods of East Texas received the highest priority.

CONDITIONS AND TRENDS

National and Regional Overview of State Assessments

The purpose of the new approach to State and Private Forestry (S&PF) is to shape and influence use of forest land to optimize benefits from trees and forests for both current and future generations.

The USDA Forest Service (USFS) worked closely with the National Association of State Foresters (NASF) to:

- Examine current conditions and trends affecting forest lands
- Review existing S&PF programs to determine how best to address threats to forests
- Develop a strategy for delivering a relevant and meaningful set of S&PF programs and opportunities

The new Redesign approach focuses on three consensus-based S&PF National Themes:

- Conserve working forest landscapes
- Protect forests from harm
- Enhance public benefits from trees and forests

National and state resource assessments are used to develop competitive proposals for S&PF funds. To receive federal funding under the S&PF Redesign Program, projects must follow the annual national direction developed by the USFS and directly address one or more of the three National Themes.

In order to ensure that S&PF resources are being focused on high priority areas with the greatest opportunity to achieve meaningful outcomes, each state, territory, and island works collaboratively with the USFS and other key partners to develop a comprehensive statewide assessment of forest resources. This assessment provides a comprehensive analysis of the forest-related conditions, trends, threats, and opportunities in each state.

Comprehensive statewide assessment of forest resources provide a valuable and unique opportunity to highlight the full scale of work needed to address priorities in the forests of each state and potentially across multiple states. Statewide forest resource strategies will be developed on the basis of the state assessments by identifying landscapes and projects where an investment of federal competitive grant funding, called an annual report on use of funds, could most effectively accomplish goals or leverage desired action.

At a minimum, statewide assessments of forest resources:

- Describe forest conditions on all ownerships in the state
- Identify forest-related benefits and services
- Identify threats to the forest resources
- Highlight issues and trends of concern as well as opportunities for action

- Delineate high priority forest landscapes to be addressed
- Are geospatially based and make use of the best existing data

Three components are required in the assessment and planning process:

- *Statewide Assessment of Forest Resources*—provides an analysis of forest conditions and trends in the state and delineates priority rural and urban forest landscape areas and is the focus of this document.
- *Statewide Forest Resource Strategy*—provides long-term strategies for investing state, federal, and other resources to manage priority landscapes identified in the assessment, identifying where federal investment can most effectively stimulate or leverage desired action and engage multiple partners.
- *Annual Report on Use of Funds*—describes how S&PF funds were used to address the assessment and strategy, including the leveraging of funding and resources through partnerships, for any given fiscal year.

The Southern Group of State Foresters (SGSF) and USFS Southern Region represent 13 southern states and Puerto Rico. More than 5 million private owners control 89 percent of forests in this area. While each state ultimately decides how to approach its own state assessment, members of SGSF elected to collectively create a template, or sample state assessment, to be used (if desired) by all southern states.

The SGSF and USFS Southern Region have identified the following common set of regional priority issues or opportunities that southern states may want to consider collectively while guiding their own assessment process:

- Significant forest ecosystems and landscapes
- Urbanization, fragmentation, and loss of forestland
- Fire
- Forest health
- Water quality protection and watershed management
- Wildlife habitat and species conservation
- Forest resource market opportunities

Led by Carl Garrison, state forester of Virginia and 2008 treasurer of the SGSF executive team, an SGSF State Assessment Committee was formed and met in Texas on March 3 – 4 and again on May 14 – 15, 2008. State Assessment Committee members represent SGSF states and are familiar with all of the concerns and opportunities common to the South. Committee members also included chairs of the SGSF committees.

Texas was identified as the pilot state by the SGSF executive team and produced this assessment document and a companion methodology document. The Texas Statewide Assessment of Forest Resources is issue-driven, based on state and stakeholder input, and meets requirements as specified in the national guidance for state assessments.

Southern Wildfire Risk Assessment

Goals and Objectives

The purpose of the Southern Wildfire Risk Assessment (SWRA) is to quantify and document the wildfire problem in the South. The SWRA is a scientifically-robust assessment that provides results that are repeatable, consistent, and comparable among states. It provides baseline information that will allow southern fire managers to implement proactive fire management planning.

The objectives are to provide information necessary to support the following key priorities:

- Identify those areas that are currently most prone to wildfire
- Identify areas that may require additional tactical planning, specifically related to mitigation projects and community wildfire protection planning
- Provide information necessary to support resource and budget and funding requests in response to the wildfire risk
- Allow agencies to work together to define priorities and improve emergency response, particularly across jurisdictions
- Increase communication with local residents and the public to address community priorities and needs
- Plan and prioritize hazardous fuel treatment programs
- Establish a data repository and a series of software tools to support continued analysis and monitoring of wildfire risk across the South

The results of the SWRA will allow the southern states to identify areas of wildfire risk in a relative manner from low to high, for each community, county, congressional district, fire response zone, state, or region. This will allow fire managers to prioritize and focus resources and funding efforts in those areas that need it most.

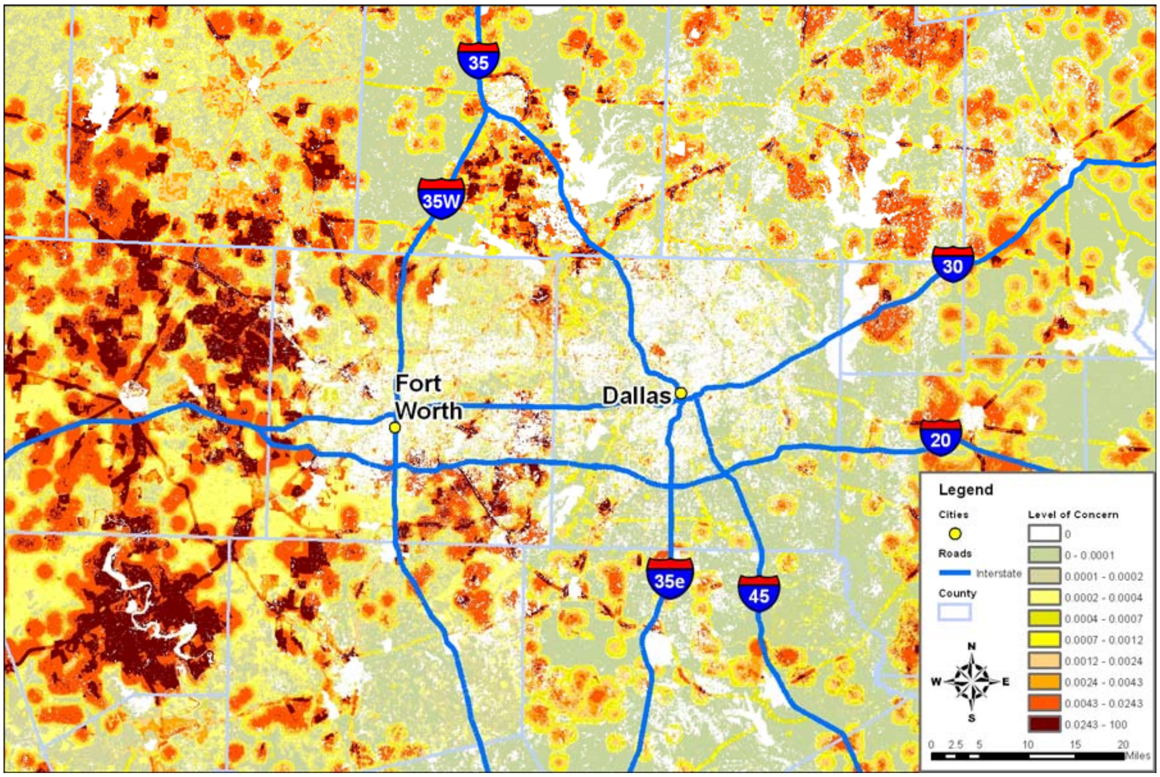
Use of SWRA in Texas Statewide Assessment of Forest Resources

The SWRA's Level of Concern (LOC) Index was used to assess the impact of wildland fire in Texas. The LOC Index, explained in more detail in the next section, includes both the threat posed by wildland fire and the values at risk from wildland fire in its formula. The result is a spatial representation of wildfire risk. Risk is defined in the SWRA as the probability of suffering loss from a wildfire. The higher the LOC Index, the higher is the probability of suffering loss. Based on the results of the SWRA, areas with higher LOC indices can be used in the state assessment to help identify priority areas for planning and implementing mitigation measures.

Level of Concern (LOC) Index

The LOC index represents the overall wildfire risk. It combines the probability of an acre burning with the expected effects if a fire occurs. This reflects the possibility of suffering loss. The LOC output values are assigned to nine categories ranging from low concern to high concern. The actual LOC value is a number between 0 and 100. It is calculated by multiplying the Wildland Fire Susceptibility Index (WFSI) by the Fire Effects Index (FEI). The WFSI represents the fire component of the equation, and is an estimate of the probability of an acre burning. The FEI accounts for the effects of a fire when it occurs, and is a relative measure of the values at risk to a fire. Both the WFSI and FEI are intermediate outputs of the SWRA.

Figure 1
Example Level of Concern Index Output Data



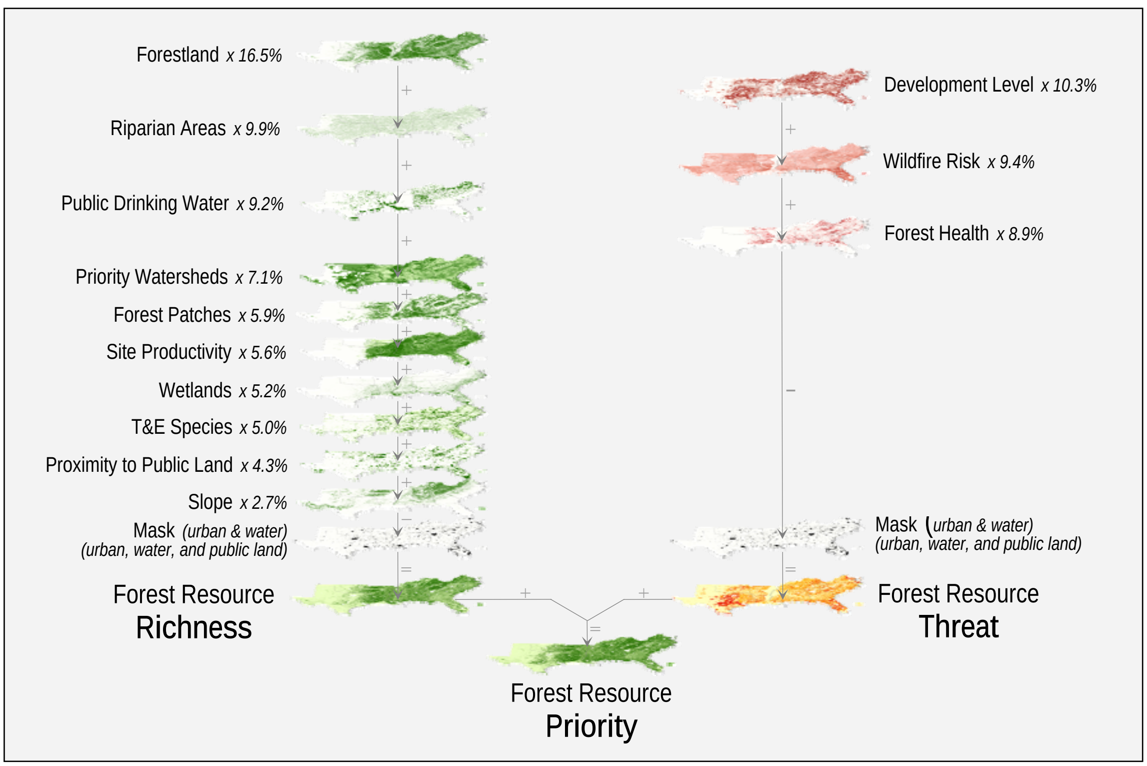
Southern Forest Land Assessment

The Southern Forest Land Assessment (SFLA) is a cooperative project of the Southern Group of State Foresters to identify important lands across the southern landscape where future efforts in rural forestry assistance should be focused. The project serves as the assessment component of the Forest Stewardship Program's Spatial Analysis Project (SAP). All 50 states and territories have either completed or are in the process of completing the SAP assessment. The South is the only region that conducted the analysis at the regional scale. There are three primary reasons the SGSF partnered in this effort: (1) to pool resources and take advantage of an economy of scale, (2) to standardize data and analyses, and (3) to complement the Southern Wildfire Risk Assessment.

Methods

Weighted overlay spatial analysis of some or all of 13 input data layers was used to produce three primary output layers, or themes (Figure 2). Ten of the layers were used to represent Forest Resource Richness and three of the layers were used to represent Forest Resource Threat. The main output layer—Forest Resource Priority—was produced from a weighted overlay analysis of all thirteen layers. Two sets of output layers were produced—one that included public land and one that did not. For all analyses, open water and urban areas were masked. Twelve of the input layers were standard core layers used nationwide in the SAP. The South included the additional Site Productivity layer to represent commercial forestry potential.

Figure 2
Schematic Diagram of Input Layers Used in Weighted Overlay Analysis for the Southern Forest Land Assessment



Each input layer was assigned a weight according to the perceived relative importance of the layer to the overall model output. Weights were assigned by ecoregion as defined by National Land Cover Database (NLCD) 2001 Mapping Zones. Each SGSF Management Chief *et al.* assigned weights to each layer for each ecoregion that occurred within his or her state. Weights for ecoregions were determined as a weighted mean where each state's contribution to the mean was proportional to the area that the particular ecoregion occupies within that state.

When weights were averaged across all ecoregions, Forestland was deemed most important at 16.5 percent contribution to the Forest Resource Priority output layer. Forestland was followed in weight by Development Level at 10.3 percent, Riparian Areas at 9.9 percent, Wildfire Risk at 9.4 percent, Public Drinking Water at 9.2 percent, and Forest Health at 8.9 percent. The importance of the remaining layers ranged from 7.1 percent for Priority Watersheds down to 2.7 percent for Slope. After Forestland, threats to forests and water issues were considered most important in setting priority for future landowner assistance efforts.

The weighted overlay analyses resulted in output layers where each 30- by 30-meter pixel exhibited a value between 0 and 100 percent of the potential maximum. To simplify presentation of these output layers and to conform to the SAP, the data were classified into three levels of importance, or priority—high, medium, and low. The Natural Breaks Method of classification was used on the regional data as a whole. Natural Breaks is a classification algorithm that allows the data to determine where best the place break points between adjacent classes. It minimizes variation within each class while maximizing variation among classes.

Results

The Forest Resource Priority output layer that includes public land is shown in Figure 3. The high class was assigned to pixels that had values of greater than 39.5 percent of the maximum possible. Pixels with values between 18.9 and 39.5 percent were classed as medium. All others were considered low priority. High priority areas, or areas considered important in terms of the input layers and weights used in the analysis, are found in areas where forestland exists. Several regions across the South exhibit concentrations of high priority areas: (1) the Appalachians, (2) a region that includes eastern Texas, northwestern Louisiana, and southwestern Arkansas, (3) the Ouachita and Ozark Mountains in Arkansas, and (4) the coastal region from Mississippi through the panhandle of Florida, and through Georgia and the Carolinas.

Forestland influenced the model significantly. For instance, 54.9 percent of forestland is considered high priority and 0.1 percent is considered low priority (Table 1). In contrast, 78.2 percent of non-forestland is considered low priority while only 0.8 percent is high. Most of the low priority land occurs in western Texas and Oklahoma where forestland is not as prevalent as it is to the east.

Figure 3
Forest Resource Priority for the Southern Forest Land Assessment

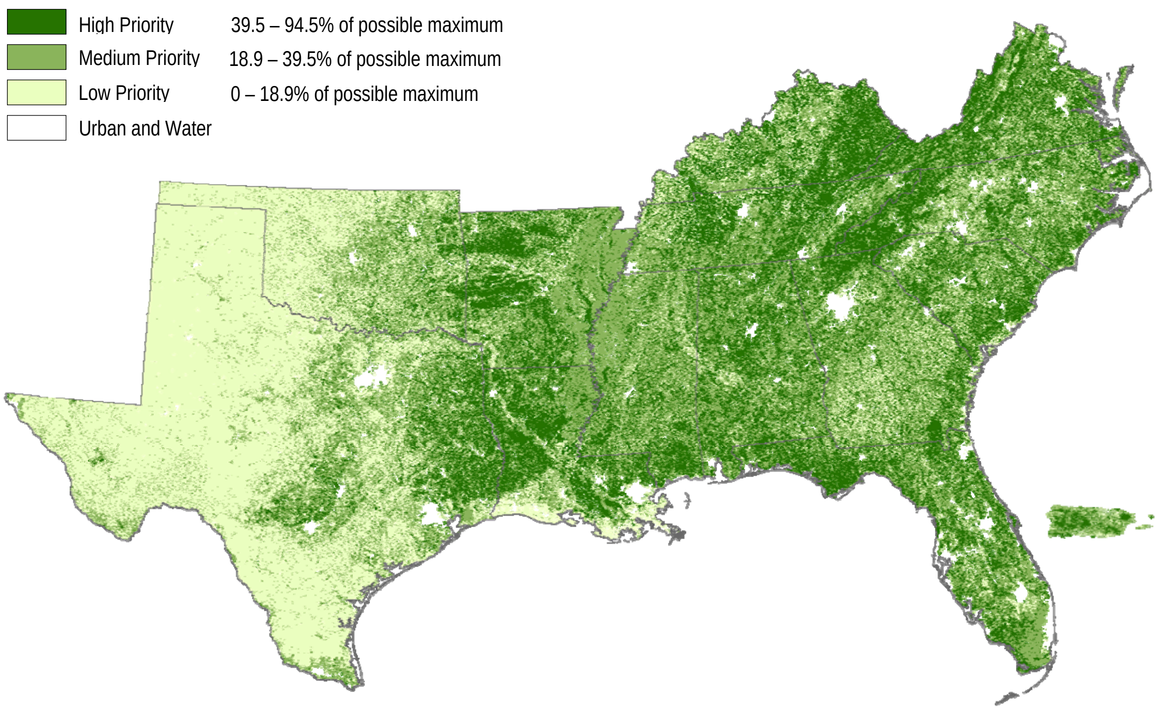


Table 1
Acres in Each Priority Class for the Southern Forest Land Assessment

Forest Resource Priority	13 Southern States (and Puerto Rico) Excluding Urban and Water					
	Forest		Non-Forest		Total	
	Acres	Percent of Total Forest	Acres	Percent of Total Non-Forest	Acres	Percent of Total
High	155,567,904	69.5%	4,117,573	1.4%	159,685,477	31.0%
Medium	68,341,243	30.5%	110,526,080	38.1%	178,867,323	34.8%
Low	85,037	0.0%	175,725,335	60.5%	175,810,373	34.2%
Total	223,994,185		290,368,988		514,363,173	

Application of the SFLA

Foremost, the SFLA can be used to identity areas across the southern landscape where future efforts in rural forestry assistance should be focused. This will be especially important as state forestry agency resources—funding, manpower, and time—become more limiting. This will likely occur as state and federal budgets shrink. Tracking accomplishments in relation to the priority areas will also allow for more accountability. In theory, agencies should be accomplishing more in areas that are considered high priority. Similarly, past accomplishments can be evaluated in relation to where the various priority areas occur.

A next step in the SFLA will be to summarize the data by some larger geographic extent, such as watersheds, counties, or agency administrative boundaries. This will identify landscape areas of high priority, not just 30- by 30-meter areas of priority.

The SFLA produced a model that will allow each state to rerun the analysis. This might occur as newer, more up-to-date data become available, or if a state wants to apply differing layer value schemes and weighting schemes to the model, or if a state wants to add additional layers of local importance.

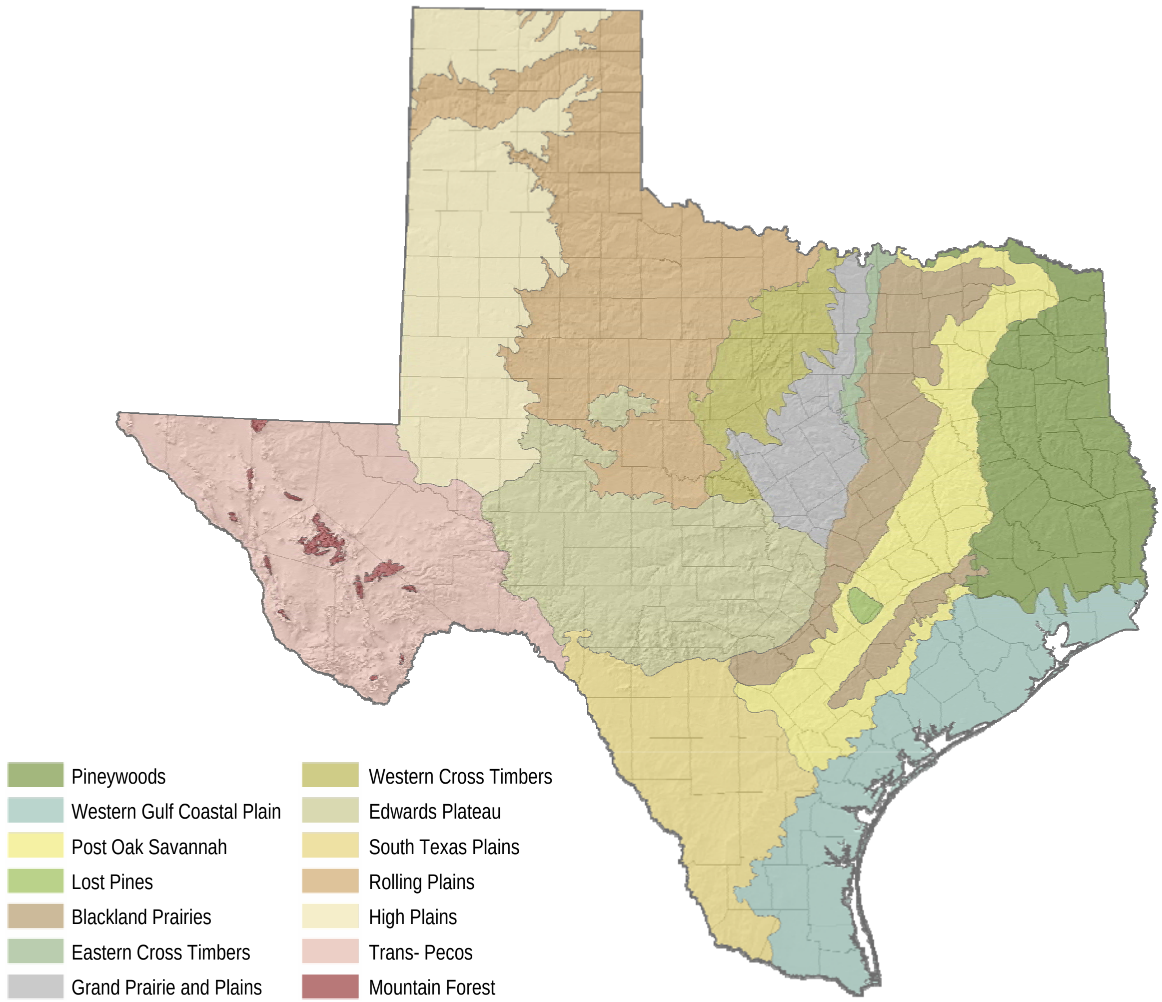
Also, the analysis can be conducted at various scales. This includes analyses at the regional scale, which was done in the SFLA, at the state scale, at the intra-state regional scale, and even at the county scale. For instance, a forester may only be interested in the counties for which he or she is responsible. The forester can compare where the high, medium, and low areas occur in the counties of interest from the regional analysis, the state analysis, and the county or multi-county analysis.

In the end, the SFLA will help to focus cooperative forestry program efforts and be more accountable for where and how resources are spent.

Texas Ecoregions

Texas is a vast and diverse state with areas that are similar to both Georgia to the east and Arizona to the west. There are nine primary ecoregions as defined by Level III Ecoregions of the Environmental Protection Agency (EPA) (Figure 4).

Figure 4
Texas Ecoregions as Defined by a Slight Modification of EPA's Level III Ecoregions to Emphasize Forested Areas †



† This map is a version of the EPA's Level III Ecoregions modified to emphasize forested regions that are not delineated by Level III Ecoregions. The Crosstimbers and Prairies ecoregion has been subdivided to include several, but not all, of EPA's Level IV ecoregions. Also, the Lost Pines and Mountain Forest regions have been added. Two Level III ecoregions were combined to form the Rolling Plains. Most of the descriptions of the various ecoregions were taken from the *Plant Guidance by Ecoregions* web pages maintained by the Texas Parks and Wildlife Department. Also, some of the Level III names were changed to more closely agree with common terminology used in Texas.

Pineywoods

The Pineywoods of East Texas is the western extension of the Southern Pine Region. It ranges from gently rolling hills to flatwoods and receives between 35 and 55 inches of rain each year. About half of the region is forested and is where most commercial forestry operations occur in the state. These rich timberlands contain not only southern pine—loblolly (Figure 5), shortleaf, and longleaf—but a diverse mixture of upland and bottomland hardwoods common to the rest of the South.

Figure 5
Loblolly Pine Stands in the Pineywoods Support Wood Product Industries, Wildlife, Recreation, Watersheds, and Other Desirable Resources

Western Gulf Coastal Plain

The Western Gulf Coastal Plain (also called Gulf Coast Prairies and Marshes) is a narrow band about 60 miles wide along the coast of Texas. It is a nearly level, slowly-drained plain dissected by streams and rivers that flow into highly productive estuaries and marshes. The region receives between 20 and 50 inches of annual rainfall.

Post Oak Savannah

Immediately west of the Pineywoods is the Post Oak Savannah that emerges almost imperceptibly with subtle changes in soil and vegetation. This gently rolling to hilly land receives annual rainfall of 35 to 45 inches. The Post Oak Savannah is punctuated by scattered oaks—mainly post oak (Figure 6). Elm, sugarberry, eastern redcedar, and persimmon are also widespread. This scattering of trees among the grassland gives the landscape a very park-like appearance and was especially attractive to early settlers. Today the region is mostly improved pasture with vast acreages seeded to Bahiagrass and bermudagrass.

Figure 6
The Post Oak Savannah is Characterized by Woodlands of Post Oak, Elm, and Other Hardwoods, Interspersed with Farms and Pastures

Lost Pines

The Lost Pines is actually a part of the Post Oak Savannah but is similar to the Pineywoods in that it is the westernmost extension of the native range of loblolly pine, the most important commercial pine species in the South. The distinctive sandy soils of the Lost Pines harbor one of the last refuges for the endangered Houston toad.

Blackland Prairies

The fertile, dark clay soils of the Blackland Prairies are some of the richest soils in the world. These gently rolling to nearly level grasslands are just west of and, in some cases, surrounded by the Post Oak Savannah. Pecan, cedar elm, various oaks, and hackberry dot the landscape with mesquite invading in much of the area. Today less than half of the original area remains in true prairie condition as much of it is plowed for crops. Annual rainfall is between 30 and 40 inches.

The Cross Timbers and Prairies

This region includes Grand Prairie and the Lampasas Cut Plains with the Cross Timbers to the east and to the west. It is characterized by alternating bands of woodlands scattered throughout a mostly prairie region. Annual rainfall ranges between 25 inches in the west to 35 inches in the east. Texas mulberry, American elm, and Osage-orange are more common here than they are to the east. In the west, blackjack oak and live oak become more important, largely replacing post oak, a species more common to the east.

Edwards Plateau

Nearly 24 million acres dominated by Ashe juniper, live oak, and mesquite comprise the beautifully-rugged, semi-arid region of the Edwards Plateau in Central Texas. The region overlays the immense Edwards Aquifer, which feeds many clear streams. Annual rainfall ranges from a meager 15 inches in the west to more than 33 inches in the east. The moist river corridors are lined with baldcypress, pecan, hackberry, and sycamore. The region is also host to spectacular wildflower displays featuring bluebonnets, Indian paintbrush, and Gaillardia (Figure 7).

Figure 7
Live Oaks and Wildflowers Abound in the Edwards Plateau Ecoregion of Central Texas

South Texas Plains

East of the Rio Grande River and south of the Balcones Escarpment lies a relatively unpopulated region known as the South Texas Plains (or South Texas Brush Country). This warm region that receives annual rainfall between 16 and 30 inches is a land of recurring drought, a factor that distinctly marks the landscape. The region owes its diversity to converging elements of the Chihuahuan Desert to the west, the Tamaulipan thornscrub and subtropical woodlands along the Rio Grande, and the coastal grasslands to the east. The region is cut by arroyos and streams and is blanketed with low-growing, mostly thorny vegetation. Where conditions allow, a dense understory of small trees and shrubs develops, hence, the name “brush country.”

Rolling Plains

The Rolling Plains is the southern extent of the great continental prairie ecosystem—the Great Plains. This region is east of the Caprock Escarpment and receives 22 to 33 inches of rainfall each year. It is gently rolling grasslands that originally included midgrass to tallgrass communities, but overgrazing has allowed mesquite, shinnery oak, and other species to invade the native prairie. Trees, such as cottonwood, are common along the waterways. The gently rolling hills and broad flats of the Rolling Plains harbor the headwaters of several Texas rivers, including the Canadian, the Colorado, the Concho, and the Red rivers.

High Plains

Like the Rolling Plains, the High Plains region is at the southern end of the Great Plains. This ecoregion is a relatively high and level plateau separated from the Rolling Plains to the east by the Caprock Escarpment. The winters here are the coldest in Texas and annual rainfall averages 12 to 21 inches. The High Plains has been described as a sea of waving grasslands and is composed of shortgrass prairie vegetation. Mesquite and yucca have invaded some of the areas that were once free of trees and brush, and sand sage and shinnery oak have spread across most of the sandy lands. The once luxuriant growth of willows and cottonwoods along the Red and Canadian rivers has now been largely replaced by two introduced species, Russian olive and tamarisk, or salt cedar. Today, most of the High Plains is irrigated by the vast Ogallala Aquifer. The region's other name, "Llano Estacado," or "Staked Plains," refers to the stakes that Spanish explorers drove into the ground to help guide them across this featureless region.

Trans Pecos and Mountain Forest

Perhaps the most spectacular ecoregion in Texas is the Trans-Pecos, offering both breathtaking landscapes and incredible biodiversity. West of the Pecos River, this region contains impressive desert grassland, desert scrub, salt basins, and rugged plateaus to wooded mountain slopes. Parts of the region are the hottest and driest of the state, with some areas receiving less than 8 inches of annual rainfall. Since precipitation increases with elevation, more of the moisture-loving plant communities are found in the mountains. Creosote-tarbush desert-scrub grasslands are the dominant features, but forests of pinyon pine, ponderosa pine, and oak intersperse these areas at the higher elevations (Figure 8).

Figure 8
The Davis Mountains, Trans Pecos Ecoregion, Support Forests of Western Juniper, Pinyon Pine, and Ponderosa Pine

Status of the Forest Resource

Texas Forest Service, in cooperation with the Southern Research Station of the USDA Forest Service, conducts a forest inventory to measure the status of all the forest resources in the state. The Forest Inventory and Analysis (FIA) program is the vehicle that determines extent, growth, composition, and mortality of forests, as well as land use changes and potential for wildfire in the state. The inventory consists of a series of permanent survey plots established in a grid pattern across the state that is remeasured every five years in the eastern 43 counties of the state and every 10 years in the central and western 211 counties. Inventory of the Central and West Texas plots began in 2004. The first measurement of all Central and West Texas plots will be completed in 2013.

East Texas

An inventory of all plots in the 43-county region of East Texas (3,800 plots) was completed in June 2003. Since then, 20 percent of the plots have been remeasured annually, with each year's newly-measured data incorporated into the inventory figures. The most recent inventory figures are for 2007.

Forest Area

The 43 counties of East Texas contain 22.4 million acres consisting of 12.1 million acres of forest and 9.4 million acres of non-forest land. Most forest is classified as timberland[†] (11.9 million acres), while a small portion is classified as productive reserved[†] (122,300 acres) or woodland[†] (39,000 acres). The net overall timberland acreage for all East Texas counties in 2007 was the highest ever recorded, showing an increase of 53,300 acres from the 2003 inventory (Table 2).

Table 2
Timberland Area by Survey Unit in East Texas, 1975 to 2007

Forest Survey Unit	Survey Year				
	1975	1986	1992	2003	2007
	Thousand acres				
Northeast Texas	4,856	4,906	5,070	5,341	5,260
Southeast Texas	6,806	6,665	6,703	6,544	6,678
Total	11,662	11,571	11,774	11,885	11,938

Southeast Texas has the most timberland (6.7 million acres) showing an increase of 142,400 acres over that reported in the 2003 inventory. Northeast Texas reported decreased timberland acreage at 5.3 million acres in 2007, 81,500 acres less than what was reported in the 2003 inventory. This slight decrease in timberland acreage in Northeast Texas occurred despite efforts to encourage conversion of openland to pine plantation through a tax incentive enacted in 1997 that allowed landowners to convert agricultural land to pine plantation and retain the lower agricultural property tax valuation.

[†] Timberland is defined as forestland that can produce at least 20ft3/ac/yr while woodland is forestland that produces less than 20ft3/ac/yr. Productive reserved forest is land that has been withdrawn from timber production by law (e.g. Wilderness).

Forest Ownership

Most timberland (8.2 million acres) in East Texas is in family forest ownership (non-industrial private forestland), making up 69 percent of the total. Forest industry (now mainly large timberland investors) follows with 2.7 million acres (23%), then national forests and other public timberlands, with 654,900 acres (5%) and 317,000 acres (3%), respectively.

Distribution of timberland ownership is different in Northeast Texas than Southeast Texas. Family forest ownership is greater in Northeast Texas at 4.4 million acres, while this region shows the least amount of forest industry land at 628,500 acres. Overall public ownership is also smaller in this region with 94,400 acres of National Forest and 179,100 acres of other public land.

Forest industry, now largely timberland investors, owns a much larger proportion of timberland (2.1 million acres) in Southeast Texas. The proportion of family forest land is smaller in Southeast Texas (3.9 million acres), but is still the largest ownership group at 58 percent of the region. Most of the states' national forests occur in Southeast Texas, with 560,600 acres. The region also contains 137,900 acres of other public timberland. The effect of the recent sales of large timber industry lands, culminating in the sale of Temple-Inland properties in late 2007, was not captured in the most recent inventory, but will be accounted for in the remeasurement of inventory plots after their sale.

Forest Type

The predominant forest-type group in East Texas is loblolly-shortleaf pine (Figure 9), with 4.9 million acres (41% of all timberland). Next in order are oak-hickory, 2.9 million acres (24%); bottomland hardwoods, 2.0 million acres (16%); oak-pine, 1.5 million acres (13%); and longleaf-slash forest-type groups, 0.2 million acres (2%).

Figure 9
Commercial Plantations of Loblolly Pine Have Long Dominated the Landscape in East Texas

Sixty-eight percent of the loblolly-shortleaf pine forest-type (3.3 million acres) is located in Southeast Texas. This is a slight increase of 21,600 acres in this region from the 2003 inventory. The majority of the oak-hickory forest-type (1.8 million acres) is located in Northeast Texas, which constitutes 62 percent of all oak-hickory forest-type in East Texas. The oak-hickory forest-type showed a decrease of 168,400 acres in Northeast Texas from the 2003 inventory.

Central and West Texas

An inventory began in January 2004 in the 211 counties not included in the East Texas inventory. There are 25,000 plot locations throughout Central and West Texas with 10 percent being measured annually since 2004. Measurements collected on these plots are identical to those on East Texas plots, with additional measurements taken to account for wildfire fuel and wildlife habitat. This expanded survey will increase knowledge of statewide issues, such as fire fuel loading, tree regeneration rates, invasive species encroachment, and overall forest health. The inventory of the West Texas plots is on a 10-year cycle with the first cycle to be completed in 2013.

Forest Area

Based on the FIA data collected thus far, the 211 counties of West and Central Texas contain 149.5 million acres of which 59.3 million (40%) are estimated to meet the current national definition of forest land (5 percent crown cover or 40 seedlings per acre)[†]. Of this acreage, only 3.2 million acres are considered productive timberland (forestland that grows at least 20 cubic feet per acre per year). The remaining 56.1 million acres are considered "unproductive" woodlands.

Forest Ownership and Type

Private entities including individuals, partnerships, or corporations own 55.9 million acres (94%) while the remainder is owned by state and local government (2.6 million) and the federal government (801,800 acres). Mesquite woodlands (Figure 10) make up the largest percentage of forestland with an estimated coverage of 20.4 million acres (34%), followed closely by 12.6 million acres (21%) of oak/hickory forests, and 9.3 million acres (16%) of juniper woodlands. More than two thirds of the forestland is less than 60 years old.

As more data are collected, the analysis will yield more detailed, accurate, and precise details on the forests and woodlands of Central and West Texas. Readers are cautioned that these data so far represent only 30 percent of the FIA plots. In addition, the USFS is likely to change the definition of forestland to 10 percent crown cover, causing a decrease in forestland acreage. This Central and West Texas data, combined with data from East Texas, will provide an unprecedented understanding of the vast forest resources of the state.

[†] When the national definition of forestland changes to 10 percent crown cover from the current 5 percent crown cover, forestland acreage will be closer to 46 million.

Figure 10
Mesquite Woodlands Make Up the Largest Percentage of Forestland Outside of East Texas

Population and Demographics

Texas Is a Big State

Texas is the largest state in the lower 48 and contains the combined area of 17 states at 170 million acres or 261,797 square miles (268,581 square miles if water bodies are included). To put it another way, Texas is as large as all of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, Pennsylvania, Ohio, and North Carolina combined. It is the second most populous state and has three of the ten largest cities in the nation. In addition, Texas has 25 metropolitan areas as defined by the U.S. Census Bureau (at least one urbanized area of 50,000 or more inhabitants), the most in the nation. In 2007, Texas grew by more than 440,000 residents and held four of the ten fastest growing metropolitan areas in the nation. Evidence of the urban nature of Texas is the fact that there are an estimated 2.98 million rural residents and 20.93 million (85.6%) urban residents.

The population of Texas was estimated by the U.S. Census to be 23.9 million in 2007, an increase of almost 13 percent over the 20.9 million in 2000. The state's population is younger with 27.6 percent under 18 years old (compared to 24.6 % in the U.S.) and 9.9 percent over 65 (12.4% U.S.). Texas is 48.3 percent white (66.4 % U.S.), 35.7 percent Hispanic (14.8 % U.S.) and 11.9 percent black (12.8% U.S.). The Texas population became less than 50 percent Anglo in 2004. It has 13.9 percent foreign born residents (11.1% U.S.) and 31.2 percent speak a language other than English at home (17.9% U.S.).

Future Texas State Demographics

Projections from the Texas State Data Center and Office of the State Demographer indicate that the past pattern of rapid growth will likely continue in Texas. Texas is projected to grow by some 71.5 percent for the 40-year period from 2000 to 2040, adding at least 14.9 million people to the State's population. In comparison, there are currently only four states that have a population over 13 million. Such an increase would be like moving each person from Illinois (the 5th most populous state) to Texas.

Texas will also become increasingly diverse with Anglos—already less than half of the population—accounting for no more than one-third of the total population by 2040. Hispanics, who made up 10.8 percent of the population in 1970, will be the majority by 2035.

Metropolitan Population Change

Under the most likely population growth scenarios from the State Demographer, metropolitan areas in Texas will grow dramatically. Dallas-Fort Worth-Arlington, with a population of roughly 5.2 million in 2000, is expected to increase to more than 15.3 million by 2040. The equivalent values for Houston-Sugarland-Baytown are 4.7 million in 2000 and between 8.4 million and nearly 11.1 million by 2040. For San Antonio, with a population of 1.7 million in 2000, projections are for between 2.5 and 2.7 million; for Austin-Round Rock with a 2000 population of more than 1.2 million, 2.7 million to 3.5 million; for El Paso with a population of nearly 680,000 in 2000, between 900,000 and 1.2 million; and for McAllen-Edinburg-Mission with a population of more than 569,000 in 2000, between 1.4 million and 1.6 million in 2040.

Regional Population Change:
The State Demographer also indicates that several regions will grow dramatically. The North-Central Texas area is projected to increase by 5.0 to 10.3 million from 2000 to 2040. The Houston-Galveston area will increase between 3.7 and 6.4 million by 2040. The Capital Area will increase between 1.5 and 2.3 million by 2040. The Lower Rio Grande increase will be between 1.2 and 1.3 million by 2040. The Alamo Area will increase between 826,000 and 1.1 million by 2040. By 2040, the Lower Rio Grande region will have more than 2.1 million people, the Rio Grande 1.2 million, and East Texas will have more than 1.0 million residents.

Population and Land Use Changes
Texas boasts 25 metropolitan areas and 43 micropolitan areas (at least one urban cluster of at least 10,000 but less than 50,000 population). The population in these urban areas equals nearly one in four residents of the 13-state USFS Southern Region. In addition, the Texas population growth rate is more than two times the national average. Of the 50 states, Texas ranks first in area converted to development each year. A USDA NRCS study determined that between 1992 and 1997 in Texas, 893,500 acres of open space were converted to development at an annual rate of 178,700 acres per year. Urban land in Texas now makes up almost ten million acres.

As communities sprawl outward, this growth results in a permanent removal of natural forest cover for new residential, commercial, industrial, and government developments (Figure 11). Additionally, while large acreages of forestland are converted to development, redevelopment is also destroying large numbers of valuable landscape trees within already developed communities. Forests and trees affected by urbanization are the most critically impacted of all forest resources. Texas has no statewide land conservation initiative, state land use planning, nor county zoning authority, and with the projected surge in population growth (23.9 million in 2007 to 51.7 million in 2040), it is likely that the high rate of open space converted to development will continue well into the future. Of all the southern states, the effect of urbanization and associated development is greatest on critical open space and forestlands in Texas.

Forest resources in and around urban areas are the highest value and most critically affected forest resources in the U.S. The Southern Region, and Texas especially, have the most forest resources affected due to rapid population growth and associated development. Since 1990, Texas has added nearly 7 million people. To understand the scale of this growth, consider that this 7-million increase in population is greater than the population of 40 of the 50 states. This rapid growth rate and associated conversion of critical forest land to development have created issues that can be addressed, in part, through forestry efforts.

Figure 11
Forest and Agricultural Lands in Many Regions of Texas Are Being Lost to Urban Expansion, Such as this Housing Development Near Austin

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http://www.ers.usda.gov/Data/Population/PopList.asp?ST=TX&LongName=Texas
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Climate Change and Weather Patterns

Climate Change

There is growing concern that climate change will adversely affect people and the ecosystems on which they depend (The National Academies 2008). Much of the scientific community believes this change is caused by man through the burning of fossil fuels and tropical deforestation, both of which result in release of CO_2, the primary greenhouse gas of concern. If the increasing concentration of CO_2 is a major cause of change in climate, then opportunities exist for the forestry community to help mitigate the impact by promoting carbon sequestration and carbon storage by trees and forests as well as use of woody biomass for energy.

Forests provide numerous ecosystem services that benefit society. As an integral part of the global carbon cycle, forests help maintain the balance of CO_2 in the atmosphere. Trees convert CO_2 from the atmosphere into organic carbon compounds through photosynthesis. Though CO_2 is also released from trees through cellular respiration and from decomposition, healthy, growing forests usually have net gains in carbon and act as carbon sinks.

The capacity of trees to store carbon differs by tree species, tree age, geographic location, and management intensity. The annual increase in stored carbon in a well-stocked forest of common commercial tree species in the U.S. varies from 2.5 to 12.5 or more metric tons of CO_2 per hectare per year (equivalent to about 1 to 5 or more short tons of CO_2 per acre per year). Since carbon storage in trees is proportional to tree biomass weight, traditional silvicultural practices that increase volume for wood products are suitable for increasing the amount of carbon stored in wood. As such, managed stands will store carbon at a faster rate than slower-growing natural stands of the same species (Birdsey 1992). When trees reach maturity and volume growth slows or stops, additional carbon sequestration no longer occurs.

Climate change has the potential to change the distribution and composition of forests. Though effects of climate change on forest resources are not entirely clear, limited research and modeling of potential effects have been conducted in the South, and offer insights on how certain aspects of tree growth and forest health may be affected.

Besides carbon sequestration and storage, opportunities also exist in reducing net CO_2 release through increased utilization of traditionally unused biomass from forests and forestry operations. Using this biomass to produce energy can displace the use of fossil fuel. Since biomass in forests is renewable and relatively rapidly grown and fossils fuels are nonrenewable, there is no net increase in CO_2 emissions from burning forest biomass for energy. Any CO_2 emissions would just return to the atmosphere what was removed just years earlier.

Increasing carbon sequestration and carbon storage and utilizing forest biomass for energy production also provides opportunities for landowners to increase their income from the forest. This ultimately helps in the effort to keep forests in forests.

Climate change could impact forests and other ecosystems through changes in rainfall, both in amount and distribution, and storm frequency and intensity. These changes in climate could also affect the occurrence and severity of wildland fire.

Cyclical Weather Patterns

Oceanic conditions in both the Atlantic and Pacific Oceans seem to influence long-term drought conditions within the U.S. Scientists monitoring both oceans have been able to match the changing phases of multi-decadal oscillations within each ocean to the presence or absence of drought. The oscillations are called multi-decadal because they can last as long as 30 years.

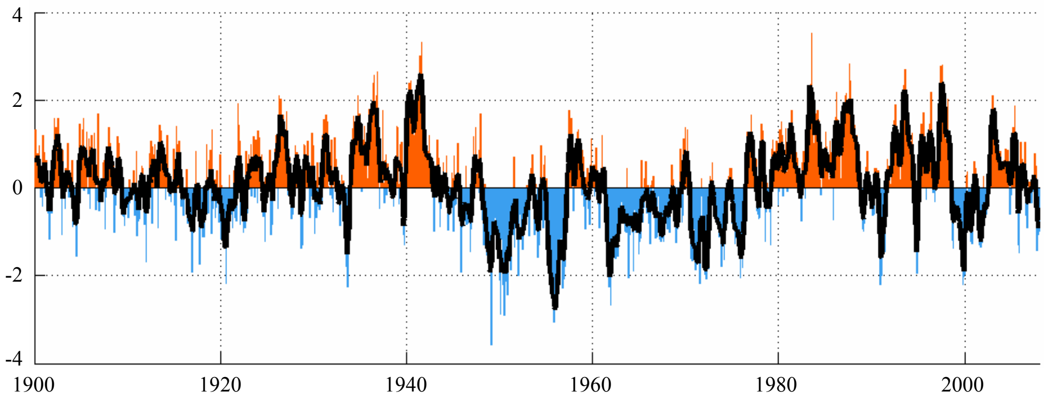
In the Pacific, this event is called the Pacific Decadal Oscillation (PDO). In the Atlantic, it is called the Atlantic Multi-Decadal Oscillation (AMO).

Scientists have made the following observations in regard to the Pacific Decadal Oscillation:

> *The cooler and drier conditions in Southern California over the last few years appear to be a direct result of the long-term ocean pattern known as the Pacific Decadal Oscillation (PDO). The study, by Steve LaDochy, associate professor of geography at California State University-Los Angeles; Bill Patzert, research oceanographer at NASA's Jet Propulsion Laboratory in Pasadena, Calif.; and others, suggests Pacific oceanic and atmospheric measurements can be used to forecast seasonal West Coast temperatures and precipitation up to a year in advance. The PDO shifted to its current negative or cool phase this decade, leading to wetter conditions in the Pacific Northwest, and drier than normal conditions in Central and Southern California. The huge West Coast fires over the past few years have been greatly exacerbated by PDO- induced drought, Patzert added. These shifts in the PDO are long-term tendencies, which actually have a bigger economic impact than El Niño, said Patzert. People talk about floods from El Niño, but what really has a harsh and costly impact is a five-year drought.*

Figure 12 shows the changing phases of the PDO for the last century, with red representing the positive or warm phase and blue the cool or negative phase (Joint Institute for the Study of the Atmosphere and Ocean: http://www.jisao.washington.edu/pdo/).

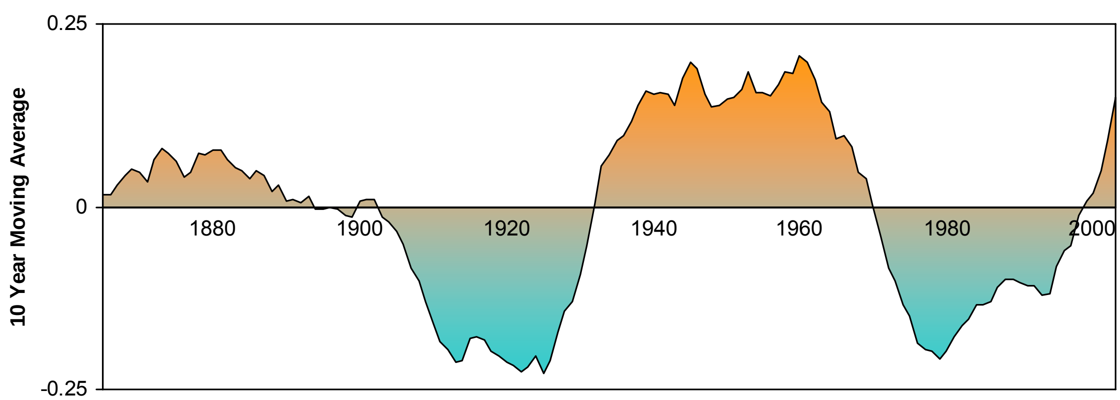
Figure 12
Monthly Values or the PDO Index, 1900–January 2008



The following is a summary of observations on the Atlantic Multi-Decadal Oscillation:

> *Several authors have reported on the climatic relationships between the wildland fire problem and climatic trends (e.g., Westerling et al. 2003). The relationship between sea surface temperatures and the atmosphere has been shown in these studies to be critical to influencing precipitation patterns and thus drought in the United States. One sea surface measurement that is correlated with drought is the Atlantic Multi-decadal Oscillation (Brown et al. 2004). The AMO shows a very persistent multi-decadal pattern. The AMO illustrates longer duration of wet periods and dry periods over time. The AMO is a good indicator of long term drought trends. It takes a long time (measured in decades) to shift from a wetting to drying period and back again. The United States is currently in the early stages of what appears to be a long term dry period (Figure 13).*

Figure 13
Atlantic Mean Oscillation (Departure) as an Indicator of Drought Trend



Since 1996, Texas has experienced extended dry periods with severe fire seasons in 1996, 1998, 1999, 2000, 2005, 2006, and so far 2008 as well. It appears from the PDO and AMO charts above that Texas experiences a long-term drought cycle when the PDO is in the cool (or negative phase) and the AMO is in the warm (or positive phase). This was the case during the droughts of the 1950s and 1960s. If history can be used as an indicator of what to expect in the future, and the PDO and AMO are in fact indicators of prolonged drought periods within the state, the current weather pattern could likely last another 15 to 20 years. Several more dry years over this time span would have significant impacts on wildfire occurrence, water resources, land use, tree health, and ultimately the citizens of Texas. These weather related effects should be considered in any strategic or tactical response plans.

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REVIEW OF STATE WILDLIFE ACTION PLAN AND OTHER NATURAL RESOURCE PLANS

National guidance on state assessments and the 2008 Farm Bill require that state assessments and resource strategy plans pertaining to forestry assess commonalities between a statewide assessment of forest resources and a state wildlife action plan within a state. The Texas Comprehensive Wildlife Conservation Strategy, or wildlife action plan, was produced by Texas Parks & Wildlife Department (TPWD). It was created as a complete wildlife management guide for Texas. The wildlife action plan replaced several other plans previously published in order to align with required directive elements set forth by the U.S. Fish & Wildlife Service.

Although the wildlife action plan was the most inclusive document reviewed, Texas Forest Service also reviewed plans from other agencies and organizations with natural resource responsibilities. These agencies were selected based upon similar interests when managing natural resources, similar organizational structure, and having published resource management plans.

In cases where Texas Forest Service has existing partnerships with other agencies, commonalities were found between Texas Forest Service management plan issues and other agency management plans. Water quality, supply, and use of water were a common issue among many of the agencies. Some organizations mention land management, but forestry and management of forested land are not commonly mentioned. When forestry is mentioned, it is often as a secondary issue instead of a primary management objective. Agencies that did focus on timber product usage and direct forest land management, mentioned in their text conservation of resources, methods for efficient production, and cost-effective use of available resources. Other agencies did not view forests for product use, but rather as potential areas for loss of habitat and further fragmentation created by increased population growth and urban development.

To address land or resource conservation and management, many state agencies provide conservation and education programs to raise citizen awareness. Private landowners, who own 97 percent of land in Texas, manage their own land. Therefore, the state establishes education programs to provide support and partnership to achieve desired land stewardship and conservation goals.

Below is a listing of agencies and documents reviewed.

Agency Documents Reviewed

Agency/Organization	Document Title (date)
Alabama-Coushatta Tribe of Texas	Website--Forestry
Bureau of Land Management	*no documents found*
Environmental Protection Agency	Strategic Plan (2006-2011)
Governor's Task Force on Conservation	Taking Care of Texas-Report (2000)
National Forests & Grasslands in Texas	Revised Land and Resource Management Plan (1996)
National Park Service	Historic Preservation Planning Program (2001)

National Resource Conservation Service	*no documents found*
Railroad Commission of Texas	Notice to Oil and Gas Well Operators (2008)
Railroad Commission of Texas	Strategic Plan (2007-2011)
Southern Forest Resource Assessment	Summary (2002)
Texas AgriLife Extension Service	TAMU AgriLife Strategic Plan (2007-2012)
Texas Commission on Environmental Quality	State Implementation Plan Concerning Regional Haze (2007)
Texas General Land Office	Strategic Plan (2007-2011)
Texas Land Trust Council	Land Trust Standards and Practices (2004)
Texas Parks & Wildlife Department	Energy Conservation Plan (2005)
Texas Parks & Wildlife Department	Land and Water Resources Conservation and Recreation Plan (2005)
Texas Parks & Wildlife Department	Texas Comprehensive Wildlife Conservation Strategy (2005-2010)
Texas Parks & Wildlife Department	Texas Wetlands Conservation Plan (1997)
Texas Parks & Wildlife Department	Texas Wildlife Action Plan (1997, 2002, 2005)
Texas Parks & Wildlife Department	The Texas Shrimp Fishery Executive Summary (2002)
Texas Water Development Board	State Water Plan-Vol. 1 (2007)
Texas Water Development Board	State Water Plan-Vol. 2 (2007)
U.S. Army Corps of Engineers	Environmental Stewardship Operations & Maintenance Guidance and Procedures (1996)

STAKEHOLDER ISSUES

Issue 1: **Population Growth and Urbanization**
Texas communities are growing at an alarming rate. Community leaders need proactive management tools and technical support systems to help prepare for the effects of "high-velocity" growth on forest resources before it happens—not after.

Issue 2: **Central Texas Woodlands Conservation**
The woodlands of Central and West Texas are valuable resources for shade, recreation, wildlife, environmental, and watershed protection. Yet, these resources are coming under increasing pressure from an exploding population, land fragmentation, wildfires, invasive plants, oak wilt, and other pests. Cooperation and partnerships to protect and conserve these critical resources are essential if the high quality of life residents have come to expect in these regions of the state is to continue.

Issue 3: **Sustainability of Forest Resources in East Texas**
For more than a century, the forests of East Texas have provided a number of economic and societal advantages such as manufacturing, employment, recreation, and environmental protection. Today, pressure on this resource has never been greater. East Texas is experiencing unprecedented change in the management and use of the Pineywoods. Population growth, ownership changes and parcelization, residential development, and non-consumptive demands will impact the forested landscape for decades to come.

Issue 4: **Water Quality and Quantity**
In Texas, most freshwater resources originate in the eastern portion of the state, making forestland a critical factor in meeting our water needs since they provide the cleanest water of any land use. In the rest of the state, where water supplies are limited, controlling non-native and invasive vegetation may produce higher water yields. With Texans already placing high demands on water resources, and the state's population exploding, it is imperative to continue to focus on this critical issue to ensure the quality of life that we Texans expect.

Issue 5: **Wildfire and Public Safety**
Since its inception in 1915, Texas Forest Service has been tasked with the responsibility of wildfire suppression, defending both the property and lives of Texas citizens. This is a growing issue for Texas. Since 1996, the state has seen significant fire seasons in 8 of the past 12 years. Once primarily a rural concern, wildfires are now clearly a statewide threat. In recent years, wildfires have threatened and, in some cases, burned through small towns and large cities alike, destroying hundreds of homes. Three primary factors are combining to create these intense fire seasons—population growth, changing land use, and increasing drought frequency.

Issue 6: **Urban Forest Sustainability**
With the addition of nearly 7 million residents since 1990, rapid urbanization is creating intense pressure on the sustainability of the trees and forests in Texas communities. Trees provide economic, health, and environmental benefits that are important to the quality of life in Texas communities. It is critical to plant, care for, and conserve the trees in communities where Texans live, work, and play.

Overview of Spatial Analysis

For each stakeholder issue, a separate geospatial analysis was conducted to identify areas across the landscape that are important for focusing Cooperative Forestry efforts. Geospatial analysis, or simply spatial analysis, is a way of making sense of how various types of information (e.g. natural resource, environmental, or cultural) are related geographically and expresses this visually as a map.

Spatial analysis involves geospatial layers, or themes. A layer is a thematic set of spatial data representing one type of information, such as land use, cover type, roads, census tracts, or streams. When only two or three layers are overlaid and are made somewhat transparent, the apparent relationship between the two layers can be easily seen and understood. However, as more layers are added, comprehension becomes more difficult, if not impossible. Spatial analysis allows us to simplify and quantify these relationships.

Spatial analysis can be performed in many ways. In producing the priority maps for this state assessment, weighted overlay analysis was used. This technique involves assigning a weight to each of several geospatial layers, overlaying them, and summing the weighted values of coincident pixels for all the layers. A pixel is a square unit that represents a specific spot on the ground and is the smallest unit of resolution of geographic area used in the analysis. For the Texas assessment, all analyses were done at the 30- by 30-meter pixel size (0.22 acres).

A guiding principle used for all analyses was to take advantage of input data layers that already exist. More specifically, there was a desire to use layers from the SFLA, which also contains the primary composite output index layer of the SWRA, Level of Concern. Each of the eight recommended GIS layers, or themes, specified in the Redesign Guidelines for State Assessments is covered by one or more of the layers used in the SFLA, with the exception of the Green Infrastructure theme. This theme is included to address an urban analysis since the SFLA and the associated Forest Stewardship Program's Spatial Analysis Project were designed for rural forestry. To represent Green Infrastructure, two layers from the 2001 National Land Cover Database—Tree Canopy and Imperviousness—were included in the urban analysis.

For each issue, the layers to be included and the weights assigned to each layer were determined by Texas Forest Service program leaders. Weights were assigned such that they summed to 100 percent. Thus, an individual weight for a particular layer is the percent contribution of that layer to the overall model output.

The weighted values for coincident pixels of the inclusive input layers were then summed resulting in values ranging from 0 to 100 percent of the maximum possible. To simplify results, the composite output index layer was classified into five classes using the Natural Breaks method. This method uses the data to determine where breaks between classes should occur by minimizing variation within classes while maximizing variation among classes. On the maps produced, the classes are referred to as Very Low, Low, Medium, High, and Very High. In addition, the range of pixel values that occur within each class are given. These values range from 0 to 100 percent of maximum possible.

Maps are identified by a number and letter. Map identifiers ending with "a" are for maps showing results at the pixel level. Identifiers ending in "b" are for summarization maps where the mean of pixels within a county, in the case of the rural analyses, and U.S. Census Places, in the case of the urban analyses, are shown. The map ending in "c" is a summarization by watershed.

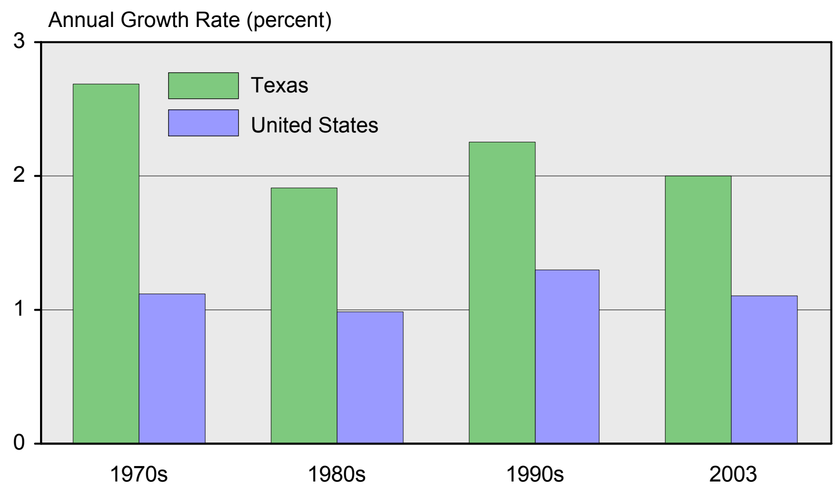
Issue 1
Population Growth and Urbanization

Issue Description

Texas is experiencing "high-velocity" change through population growth and urbanization in its communities. With a seeming abundance of natural resources, an incredible amount of open land, and a convenient geographic location within the U.S., Texas has become an extremely attractive destination—not only for millions of Americans, but for those from international destinations as well.

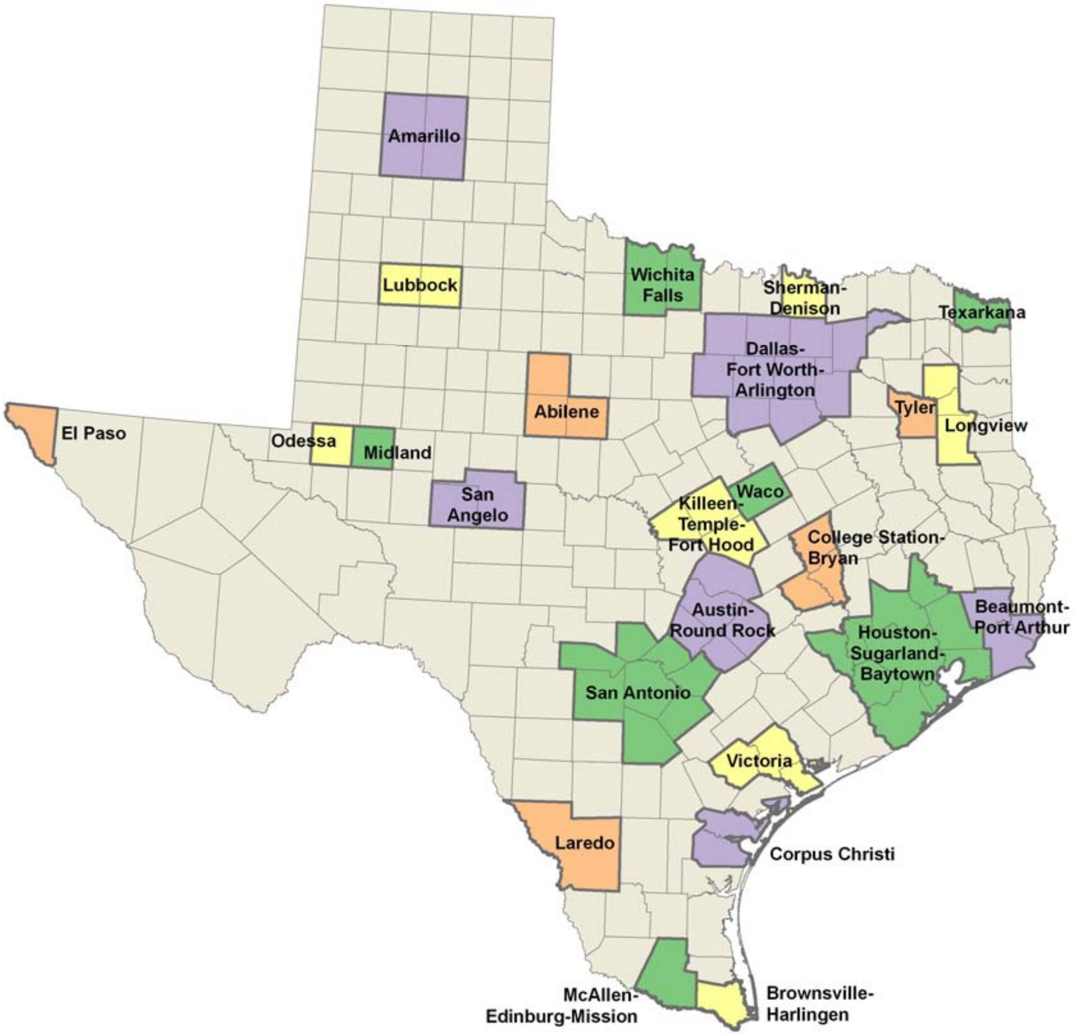
As a result of a thriving economy, relatively low cost of living, and a mild climate, the population of Texas has grown at an explosive pace. To better understand just how quickly Texas has grown, consider the 10-year period from 1990 to 2000 (Figure 14). During this decade, the Texas population grew by 3.9 million people, surpassing New York as the nation's second most populated state (Gilmer, 2005). The Texas State Demographer expects that by 2040, the population is likely to increase by as much as 72 percent, or 15 million people. All will be relying on Texas for land, water, and other natural resources to sustain and enhance their quality of life.

Figure 14
Population Growth for Texas and the United States, 1970s – 2003



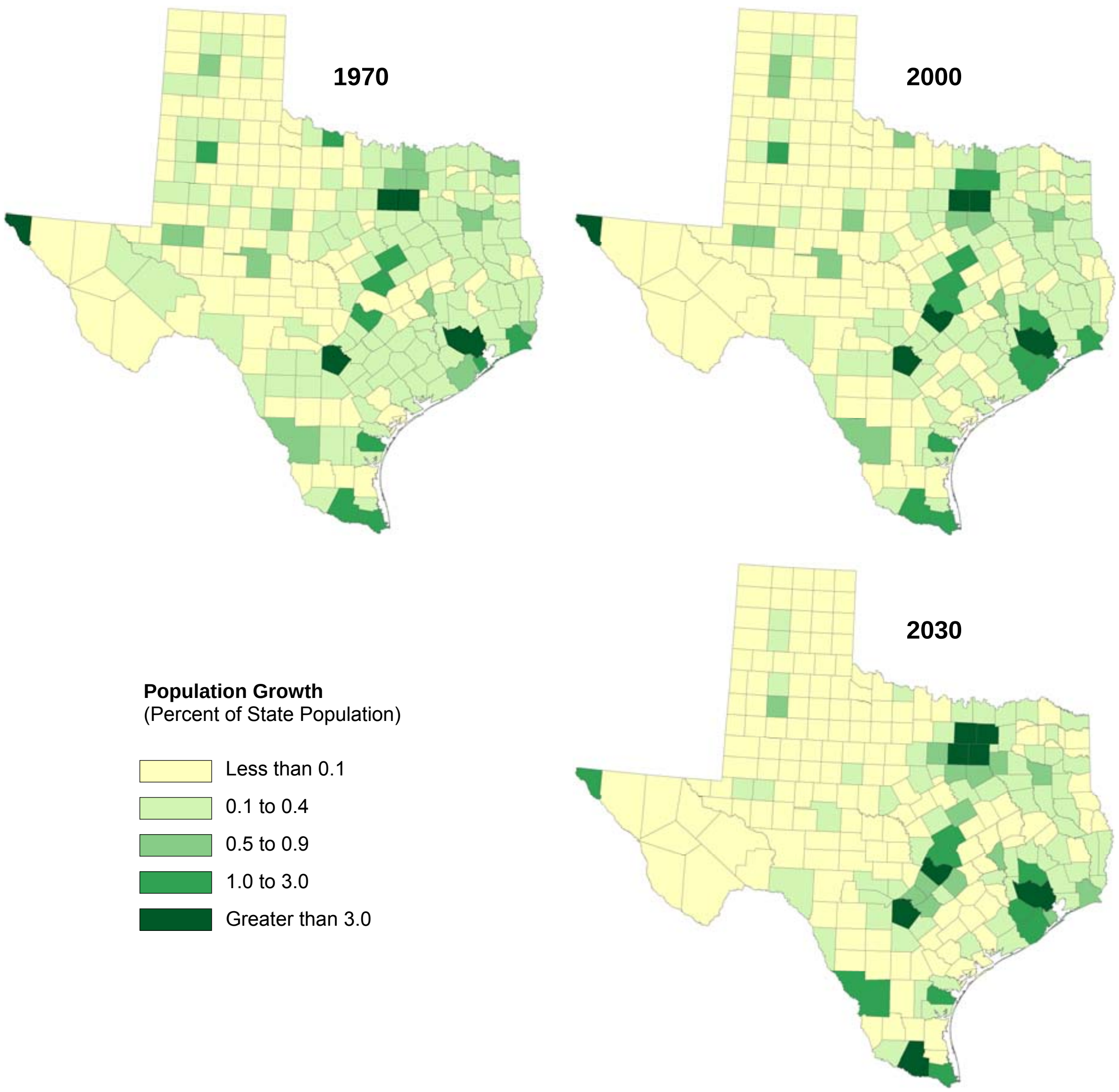
According to the Texas State Demographer, the state's established metropolitan areas (Figures 15 & 16) will likely absorb the vast majority of the predicted population surge. Such population increases will force further expansion of metropolitan regions to engulf smaller and previously more rural neighboring communities. As a result of the pressures associated with rapid urbanization and population growth, these small communities will undergo a high-velocity change and will emerge into a new and different place. These emerging communities will face new challenges. They will have to make key decisions on how to embrace and effectively manage the fast track of development—and all of the high-velocity changes that will precede the transformation.

Figure 15
Metropolitan Statistical Areas
Source*: Texas State Data Center and Office of the State Department*



For example, after becoming home to Dell Computer Corporation, the once sleepy town of Round Rock experienced rapid economic and population growth. The expansion resulted in its fusion with the greater Austin metropolitan area. Current estimates from the State Demographer show that by 2040, the Austin-Round Rock area is expected to gain between 1.5 and 2.3 million new residents—surpassing San Antonio as the third largest metropolitan area in the nation.

Figure 16
Population Growth in Texas Counties, 1970 – 2030
Source*: Texas State Data Center and Office of the State Department*



To gain an even deeper perspective of the growth in this region of Texas, consider a recent report from a May 2008 forum of national city-planning experts in Washington D.C. entitled *America 2050* (http://www.america2050.org/). This forum projected that by 2050, the area between Houston, San Antonio, and Dallas-Fort Worth (which is commonly known as the "golden triangle") will fuse to become a single "mega-region" containing 70 percent of the state's population. The new population would total 24.5 million of the state's projected 35 million residents. Indeed, despite its cowboy lore of wide open spaces, Texas is, and will continue to be, very much an urban state.

Increases in population create the need to expand housing and supporting infrastructure. For example, sewer, water, transportation, and power, along with the businesses and facilities needed to support this infrastructure, would need to be enhanced. A significant need associated with continued urban growth is the search for undeveloped land on which to support the escalating population. For example, in 2006 alone, more than 260,000 building permits were issued in Texas (U.S. Bureau of Census and Real Estate Center at Texas A&M University).

Opportunities currently exist for Texas Forest Service to focus state and federal monies and initiatives on the issues, challenges, and opportunities in urban forests. The agency can optimize public benefit by integrating comprehensive management plans from a multitude of public and private resources and partners. These partnerships will play an important role in the future resource planning at state, regional, and local levels.

Partnerships among state forestry, wildlife, and soil and water conservation agencies will utilize the expertise from existing management plans and leverage services provided by existing technical assistance programs and personnel. Benefits derived will include greater economic vitality, higher levels of public safety, conservation education, increase in environmental justice and outreach, reduced health risks, increased opportunities for outdoor recreation, increased local and citizen stewardship of forest resources, and an overall improved quality of life for tens of millions of Texas residents, now and in the future.

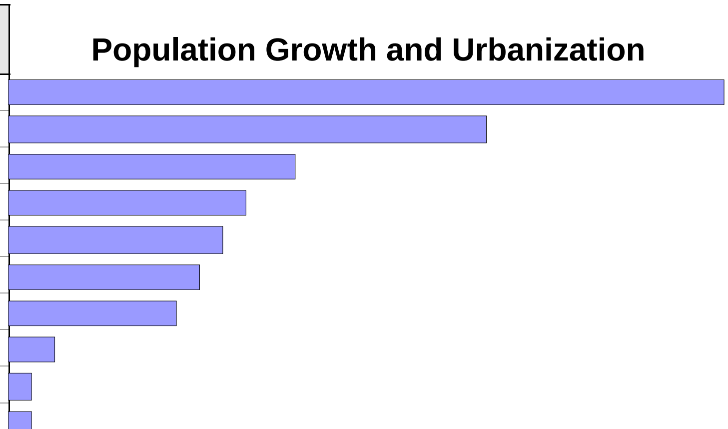
Spatial Analysis

To better understand the relative importance placed on various natural resource issues within Texas, Texas Forest Service used a unique Spatial Analysis process during the planning stage of the Texas Statewide Assessment of Forest Resources. The rank-and-weight system assessed resource layers that were considered most critical to an analysis of issues related to population growth and urbanization (Table 3). Development Level was deemed the most important layer in assessing population growth and urbanization, its potential impact on public and private forestland, and related natural resources in Texas.

Table 3

Layers and Layer Weights Used in Overlay Analysis for Population Growth and Urbanization Issue

Layer Rank	Layer Name	Layer Weight
1	Development Level	30
2	Wildfire Risk	20
3	Forestland	12
4	Forest Health	10
5	Forest Patches	9
6	Public Drinking Water	8
7	Riparian Areas	7
8	Priority Watersheds	2
9	T&E Species	1
10	Protected Areas	1
	TOTAL	100



Results

By combining the information from these weighted resource layers through overly analysis, a data-defined regional "road map" was created. Results of this analysis are shown in Map 1-a. Red denotes higher priority and green denotes lower priority. Higher priority areas identify where the effects of population growth and urbanization are likely to have significant impact on areas of important forestlands and related natural resource areas by the year 2030.

Table 4 summarizes the area within each of the five priority classes by forest versus non-forest land. Very high priority areas make up 9.9 million acres, or 5.5 percent of the total area. Forestland comprises 82.3 percent of these very high priority acres.

Table 4
Area Within Each Priority Class by Forest and Non-Forest for the Population Growth and Urbanization Issue

Priority	Forest	Non-Forest	*TOTAL*
	- - - - - - - - - - - - - - - acres	- - - - - - - - - - - - - - - -	
Very High	7,325,703	1,571,820	8,897,523
High	7,010,014	10,794,566	17,804,579
Medium	7,167,598	17,818,725	24,986,323
Low	3,400,213	34,008,774	37,408,987
Very Low	0	73,940,196	73,940,196
TOTAL	24,903,527	138,134,081	163,037,608

Map 1-b shows results when the data are summarized by county. This can help resource managers to plan and prioritize the implementation of regional conservation programs and personnel.

Conclusion

Through this spatial assessment, stakeholder surveys, and collaborative efforts of public and private partnerships, Texas Forest Service has a unique opportunity to provide technical support and resources that will help the rapidly growing Texas communities to better manage their forestlands and natural resources for the benefit of current and future generations.

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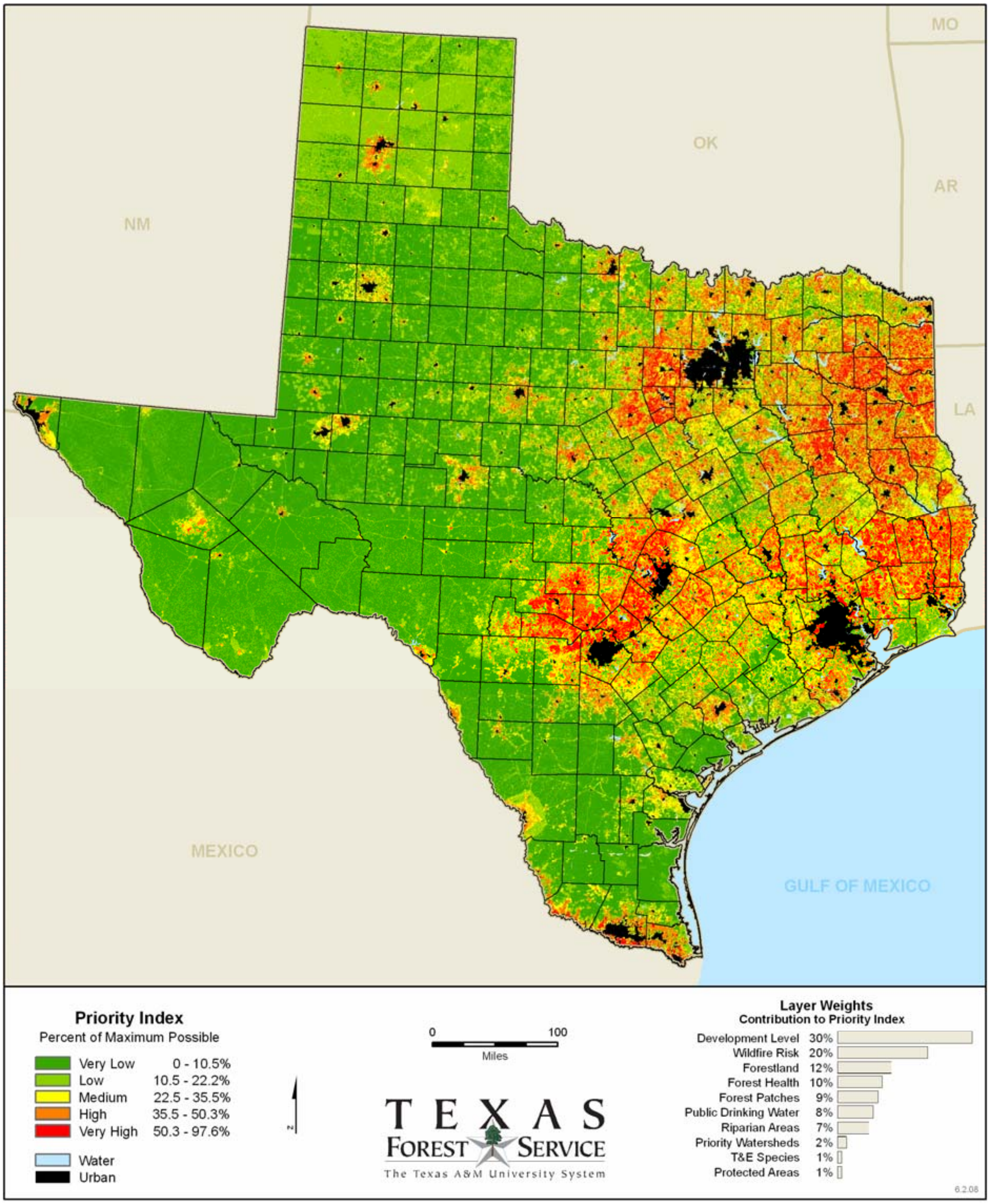
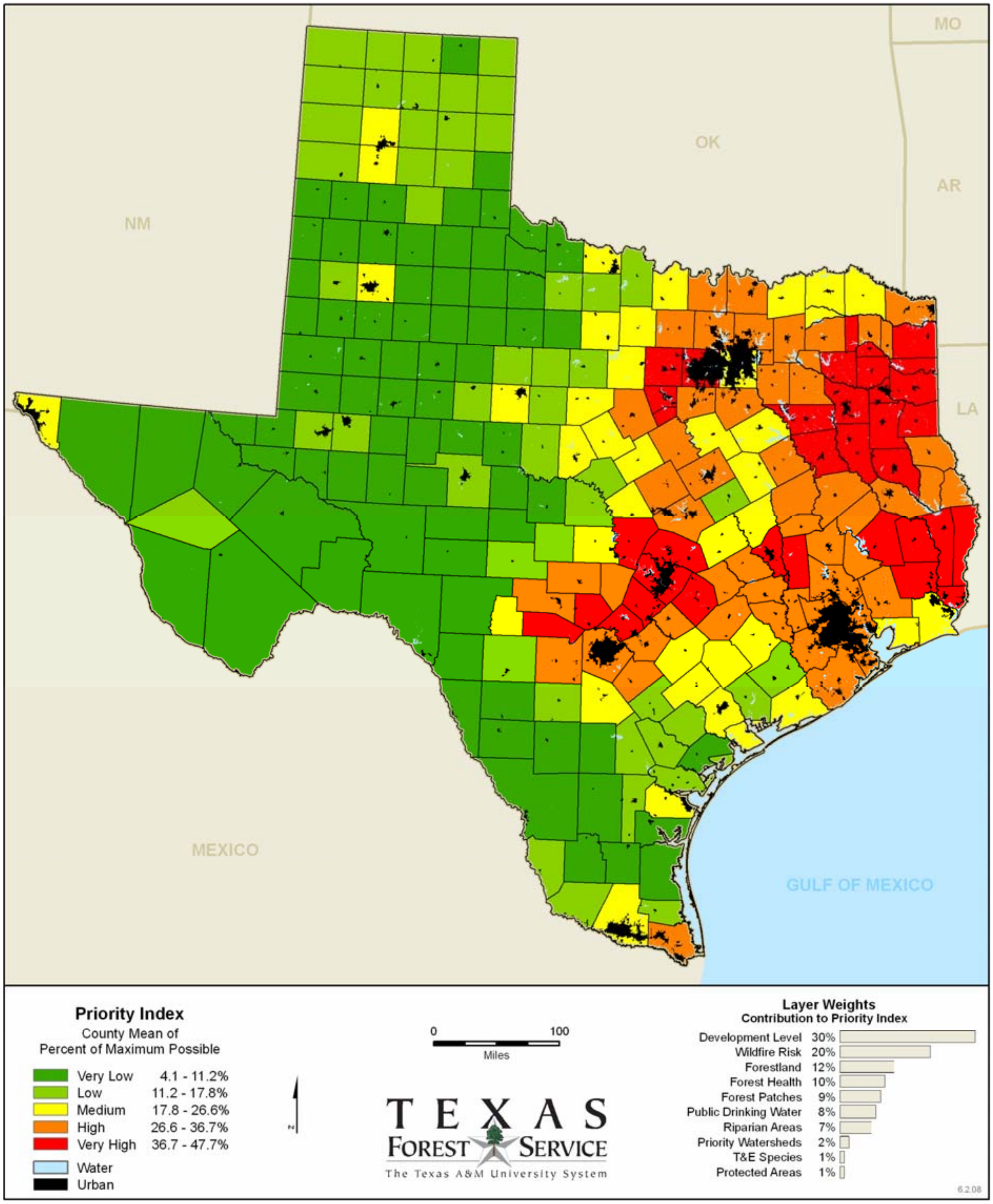
Map 1-a

Population Growth and Urbanization



Map 1-b
Population Growth and Urbanization



Issue 2
Central Texas Woodlands Conservation

Issue Description

Rural Central Texas, a region characterized by non-commercial hardwood forests, private livestock ranches and residential properties, is faced with unprecedented challenges. These include a rapidly-increasing population, water shortages, and forest threats from development, fragmentation, wildfire, oak wilt, and invasive plants. To sustain and protect its valuable woodlands, this region is in urgent need of a well-integrated conservation initiative that incorporates components of stewardship, oak wilt management, watershed protection and restoration, invasive plant management, and wildfire prevention, among other forestry programs.

The portion of the state commonly referred to as Central Texas includes some 90 counties, covering approximately 125,000 square miles, and represents 40 percent of the land area of the state. As described in this document, Central Texas includes the following ecoregions: Eastern and Western Cross Timbers, Grand Prairie and Plains, Blackland Prairies, Edwards Plateau, and Post Oak Savannah.

The hardwood forests found in Central Texas differ from the traditional pine and hardwood timberlands that dominate East Texas. The forest woodlands in this western fringe are prized by many for their beauty, shade, erosion control, wildlife, recreation, real estate value, and watershed protection, rather than for manufactured forest products. Central Texas, in particular, has experienced explosive population growth in recent years as well as major forest health issues. The latter include a severe outbreak of oak wilt, unprecedented wildfires, an influx of non-native invasive plants, and critical watershed protection and ecosystem restoration issues.

For the first 70 years of its existence, Texas Forest Service limited its forestry and woodlands protection programs to the 12 million acres of commercial forests in 43 counties of East Texas (with the exception of urban foresters stationed in Dallas/Fort Worth and San Antonio). In 1988, with the initiation of the Texas Cooperative Oak Wilt Suppression Project, services offered by Texas Forest Service were expanded to counties in Central Texas to address a severe problem of oak wilt, a vascular disease that was killing thousands of valuable live oaks and red oaks (Figure 17) (see www.texasoakwilt.org). These same foresters have expanded their services in recent years and are currently also involved with forest stewardship and other forestry programs.

Figure 17
Oak Wilt Has Killed Thousands of Live Oaks and Red Oaks in Rural and Urban Areas of Central Texas

Eventually, Texas Forest Service fire protection and prevention programs were expanded to Central and West Texas. In addition, the agency expanded its urban forestry program to include urban foresters in Abilene, Austin, Corpus Christi, El Paso, Weslaco, and San Antonio. More recently, in 2004, the Forest Inventory and Analysis (FIA) program for the first time began establishing permanent plots to measure the extent and diversity of woodland resources in Central and West Texas. In 2005, Texas Forest Service initiated a program to detect invasive, non-native plants in various regions of the state. With funding from the USFS, Forest Health Protection, and in partnership with the Lady Bird Johnson Wildflower Center and the Houston Advanced Research Center, Citizen Scientists are being trained to report new invasive plant sightings throughout the state. This cooperative effort is documenting for the first time the extent and severity of exotic plant invasions in different ecoregions of Texas (see www.texasinvasives.org).

Central Texas is home to a majority of the 24 million residents of Texas (www.texasalmanac.com). In recent years, many residents have chosen to leave suburban areas to purchase and enjoy rural life on sub-divided "ranchettes" in a region once dominated by large ranches Today's landowners in Central Texas are faced with a changing and more fragmented landscape, an increasing human population, and special protection needs from wildfire, oak wilt, invasive plants, forest fragmentation, and water shortages. Forest resource information from Central Texas has long been lacking. However, preliminary FIA results estimate the region contains millions of acres of non-commercial forest land.

Current Texas Forest Service programs have addressed oak wilt, forest stewardship, forest inventory and wildfire prevention, but these programs have operated more or less independently and have not been targeted for this new generation of landowners. Development and delivery of an integrated conservation initiative, to address the challenges facing this region of the state is urgently needed. Because Texas Forest Service has a limited staff in Central Texas, such an initiative must necessarily rely on partnerships and cooperation among diverse stakeholders to be successful.

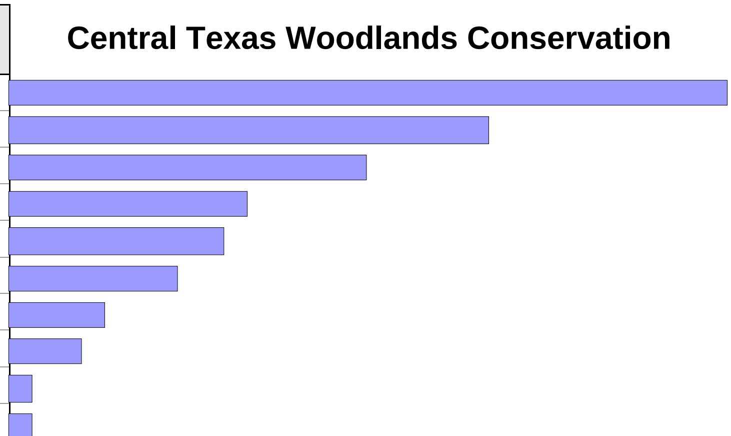
Spatial Analysis

Technology is now available to integrate available computer-based forest, water resource maps, forest health and wildfire occurrence maps as well as urban change maps for this region. Such information will be the basis for developing a GIS-based assessment map to identify priority landscapes on which to focus project efforts. An assessment map for Central Texas Woodlands Conservation is based primarily on six layers (Table 5): Forestland (30%); Development Level (20%), Wildfire Risk (15%), Forest Health (10%), Riparian Areas (9%), and Forest Patches (7%). Other layers (Slope, T&E Species, Wetlands, and Protected Areas) contribute the remaining 9 percent of layer weight.

Table 5

Layers and Layer Weights used in Overlay Analysis for Central Texas Woodlands Conservation Issue

Layer Rank	Layer Name	Layer Weight
1	Forestland	30
2	Development Level	20
3	Wildfire Risk	15
4	Forest Health	10
5	Riparian Areas	9
6	Forest Patches	7
7	Slope	4
8	T&E Species	3
9	Wetlands	1
10	Protected Areas	1
	TOTAL	100



Results

Results from this overlay analysis are shown in Maps 2-a and 2-b. Map 2-a shows results on a 30-meter pixel basis and Map 2-b shows results when pixel data are summarized by county. Very high priority lands include 3.2 million acres, or 7.2 percent of the total (Table 6). Of these high priority acres, almost all are forestland (>99.9%).

Table 6
Area within Each Priority Class by Forest and Non-Forest for the Central Texas Woodlands Conservation Issue

Priority	Forest	Non-Forest	*TOTAL*
	- - - - - - - -	acres - - - - - - - -	
Very High	3,186,534	1,446	3,187,981
High	4,028,343	609,857	4,638,200
Medium	1,613,417	6,196,575	7,809,992
Low	0	12,971,177	12,971,177
Very Low	0	15,967,806	15,967,806
TOTAL	8,828,295	35,746,862	44,575,157

Woodlands conservation in Central Texas would contribute to and support the Texas Wildlife Plan, as described by the Texas Parks and Wildlife Department (http://www.tpwd.state.tx.us/publications/pwdpubs/pwd_pl_w7000_1187a/). By protecting and enhancing Central Texas woodlands and water resources, as well as habitat for endangered and threatened species, conservation efforts would directly supplement the Land and Water Resources Conservation and Recreation Plan, a major component of the Texas Wildlife Plan. Though almost all the woodlands in Central Texas is privately owned, coordinated conservation efforts would encompass all ownerships, including state- and federally-owned properties.

Conclusion

An integrated approach to woodland protection and management, public education, and technical assistance to the new generation of landowners would directly address all three of the National Redesign themes of 1) conserving working forest landscapes, 2) protecting forests from harm, and 3) enhancing public benefits from trees and shrubs.

References

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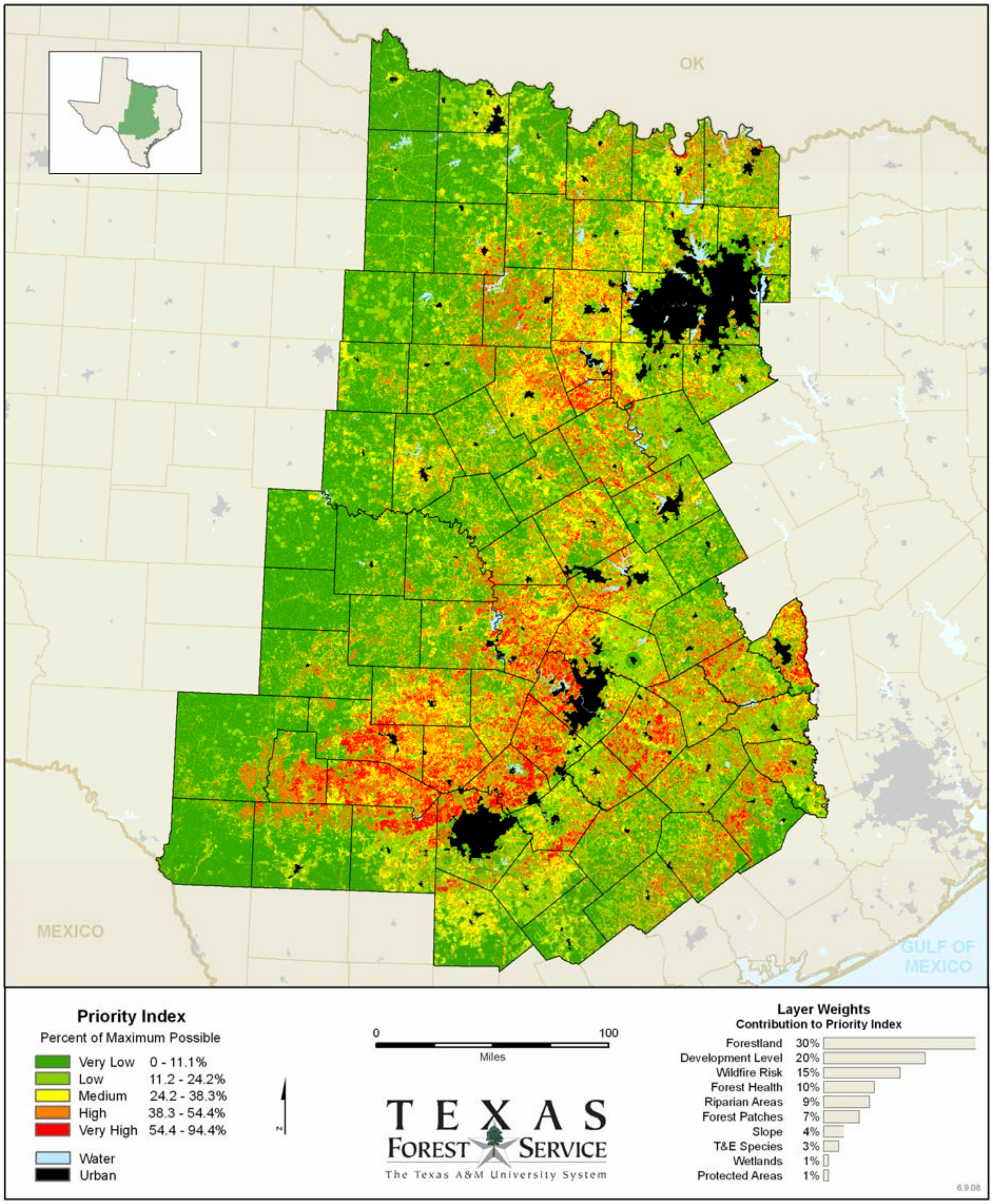
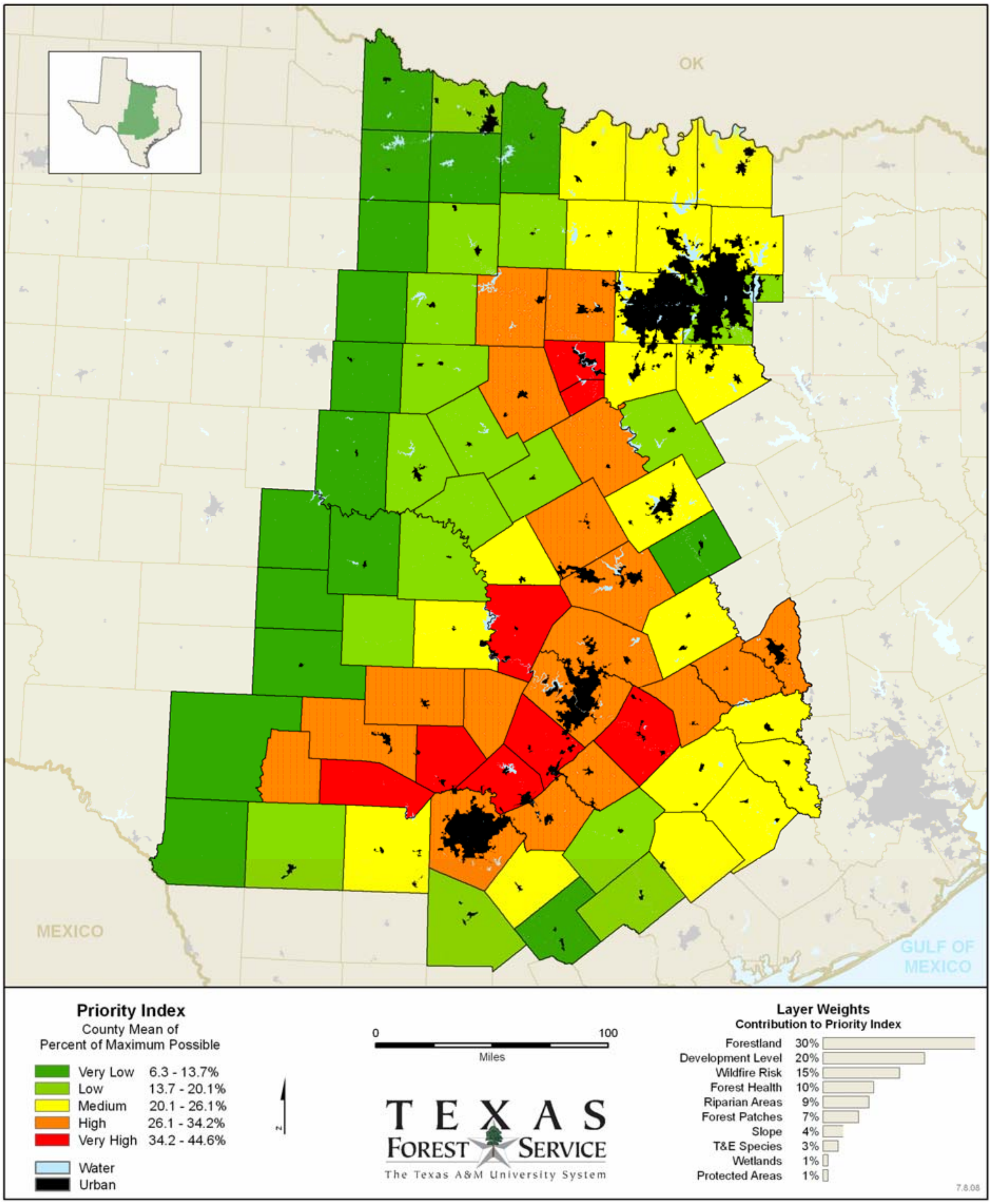
Texas Invasives Web Page (www.texasinvasives.org)
Texas Wildlife Plan (www.tpwd.state.tx.us/publications/pwdpubs/pwd_pl_w7000_1187a/)

Map 2-a
Central Texas Woodlands Conservation



Map 2-b

Central Texas Woodlands Conservation



Issue 3
Sustainability of Forest Resources in East Texas

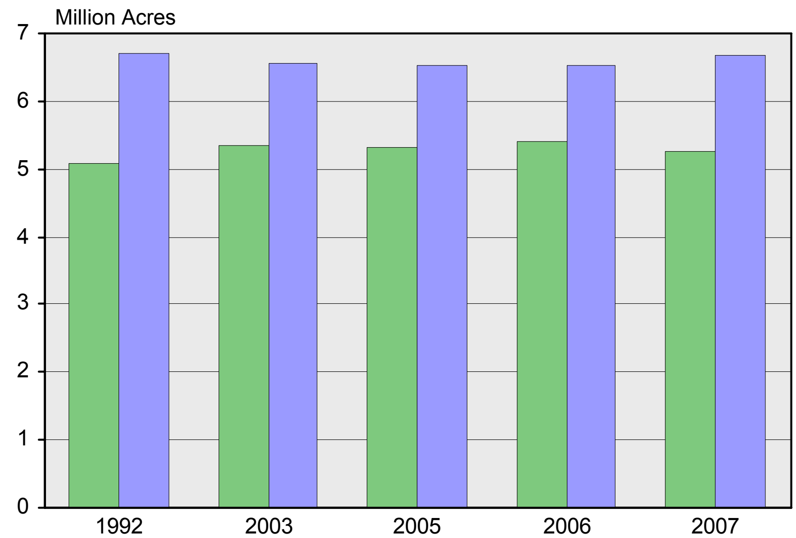
Issue Description

Since the 1800s, the forests of East Texas have provided immeasurable opportunities for the people of this state. Employment, financial return, cultural stability, recreational opportunities, economic growth, and environmental sustainability are just a few of the benefits from forest land. The pressure on this resource has grown with the population and is creating a changing landscape. The challenge is to conserve these working forests while at the same time protecting this valuable heritage and enhancing the benefits derived from the resource.

For decades, the East Texas Pineywoods was a place loggers cut trees (Figure 18), hunters harvested game, and campers and hikers enjoyed nature. While these activities are still paramount to many, new opportunities for this resource are changing rapidly. Not only do the forests continue to meet traditional needs, but the land itself has become increasingly valuable for many other uses. While the FIA data show steady to marginal increases in acres of forest land (Figure 19), growth of metropolitan areas has converted larger and larger acres of forest land as well as fragmented forest lands into smaller ownerships. This trend will only continue as the population of the state increases.

Figure 18
Logging in East Texas

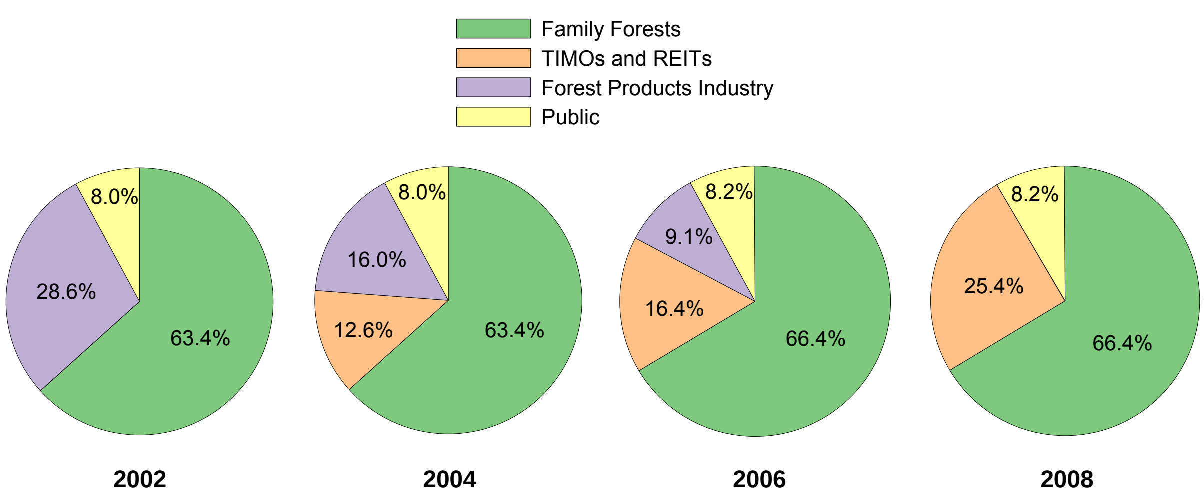
Figure 19
Area of Timberland in East Texas by Region for 1993, 2003, 2005, 2006, and 2007



	1992	2003	2005	2006	2007
Northeast Texas	5.071	5.341	5.326	5.392	5.260
Southeast Texas	6.703	6.544	6.534	6.536	6.678

Rapid change is also occurring in the ownership of timberlands in East Texas (Figure 20). For more than 50 years, family forest owners controlled over 60 percent of East Texas forest land, forest industry owned approximately 35 percent, and the remainder was controlled by the National Forest System or other public ownership. Since 2000, industry has divested all of its land and it is now controlled by investors such as Timberland Investment Management Organizations (TIMOs) and Real Estate Investment Trusts (REITs). This change has resulted in a shift in the perception of long-term land management and brought to discussion the future of traditional forestry in Texas.

Figure 20
Changes in Timberland Ownership in East Texas



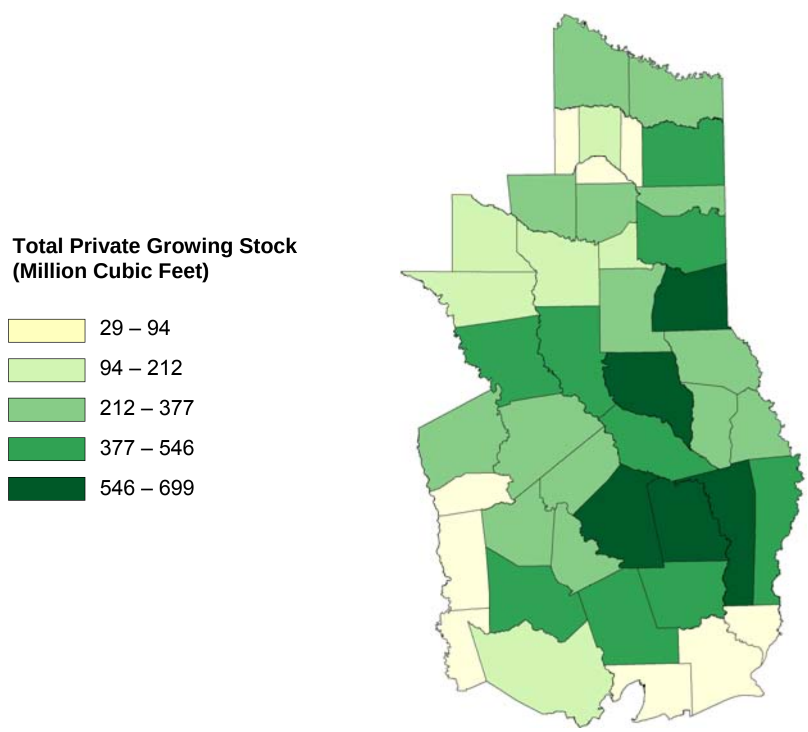
Manufacturing has also changed over the past decade (Table 7). A number of less efficient facilities have closed, including the South's first newsprint mill in Lufkin. The adjustment to these competitive economic times requires more emphasis on highly efficient, modern operations to keep pace with the demands of energy costs, product markets, and company stockholders.

Table 7
Number of Mills in 1982 and 2003

Mill Type	1982	2008
Small Sawmill	56	36
Large Sawmill	20	14
Plywood (Pine Veneer) Mill	8	3
Oriented Strand Board (OSB) Mill	0	4
Hardwood Veneer Mill	2	1
Paper and Paperboard Mill	7	4
Wood Treating Plant	27	10

According to Texas Forest Service interpretation of current FIA data, the Southeast Texas region enjoys a surplus of timber supply capable of supporting a large, new oriented strand board (OSB) mill or large sawmill (Figure 21). Expanding existing production and attracting new business to the area are critical if the industry is to contribute additional economic growth of East Texas. Working with local leadership, economic development partners, and forestland owners is integral in developing new opportunities for prospective industrial investors.

Figure 21
Total Private Growing Stock in East Texas, 2006



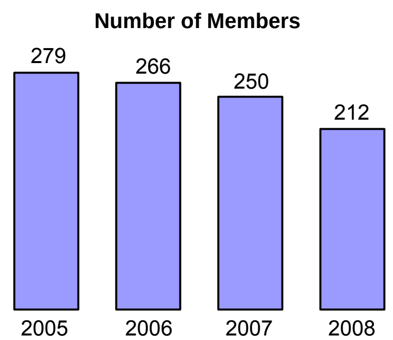
Another look at FIA data reveals a trend that could impact sustainability. According to analysis of FIA data in Northeast Texas, annual harvest removals on pine timberland is beginning to exceed annual growth (Table 8). This marginal sustainability could be problematic if there is a continued lack of reforestation. Even if harvest rates remain the same, long-term potential for forest economic development in Northeast Texas could be jeopardized.

Table 8
Average Annual Growth and Removal of Pine in Northeast Texas, 2002-2006

Measure	Amount
Growth	221.4 thousand cubic feet
Removal	223.1 thousand cubic feet
Growth − Removal	-1.7 thousand cubic feet
Growth ⁄ Removal	99.2 percent

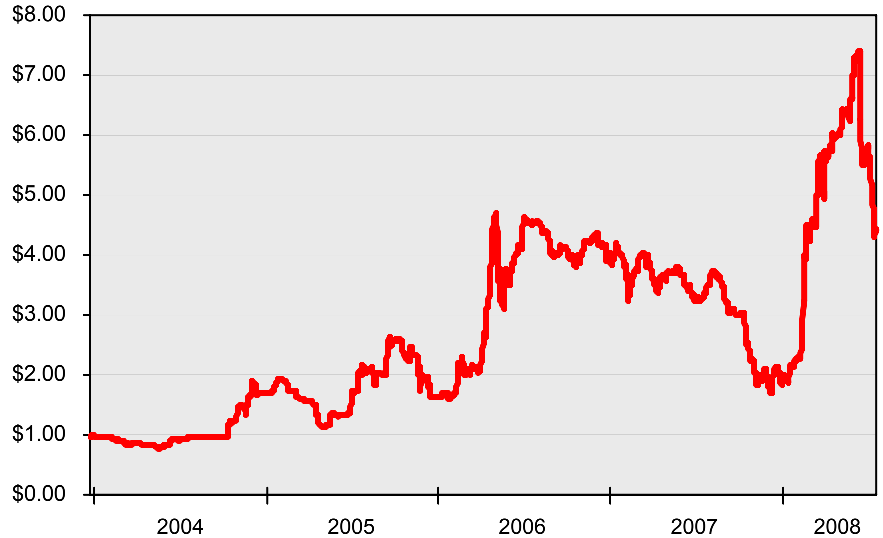
Maintaining logging capacity is a difficult challenge. Logging has a proud history in East Texas, and for many in the business, it has been feast or famine. Today's logging operation depends on significant capital investment. As roundwood markets become more competitive and energy costs continue to rise, loggers are getting squeezed, resulting in fewer available options to deliver raw materials to manufacturing facilities as evidenced by a declining membership in the Texas Logging Council (Figure 22). This could impact the investment in more traditional uses of forest products.

Figure 22
Decline in Membership of Texas Logging Council from 2005 to 2008



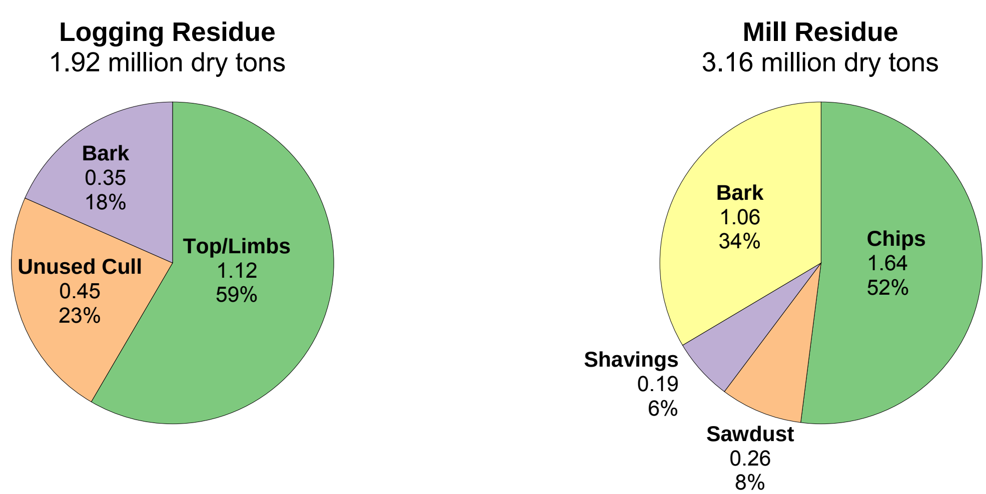
To improve the financial return on timberland investments, landowners are beginning to look at other, less traditional markets for their forest products. Most recently, the sale of carbon credits has become a viable opportunity for those invested in forestry (Figure 23). While still in its infancy, it appears the carbon market, as it emerges to address climate change, has potential to grow into a profitable addition to long-accepted forestry activities. Texas Forest Service must continue to work with the major players involved in refining this issue to ensure this becomes a realized opportunity for the timberland owners of the region.

Figure 23
Historical Price Trends of Chicago Climate Exchange (CCX) Carbon Financial Instruments



Commercial interest in woody biomass is another non-traditional market that has economic potential for East Texas landowners. Rising fuel costs and importance given to renewable energy sources have cast the spotlight on alternative forms of energy. Dependence on foreign energy has long been a source of concern for state and national policy owners. The recent increases in fuel costs have magnified these concerns. For decades, wood waste has been used to provide some of the energy needs for timber industry manufacturing on-site; however, it now is being considered as a viable alternative for mainstream energy production to the electric grid as an alternative to natural gas and coal (Figure 24). Opportunities also exist for production of bio-diesel and ethanol for the manufacturing and transportation industry. Both private and public organizations must work together to develop renewable sources of energy, including cellulose.

Figure 24
Annual Logging and Mill Residues in East Texas, 2005



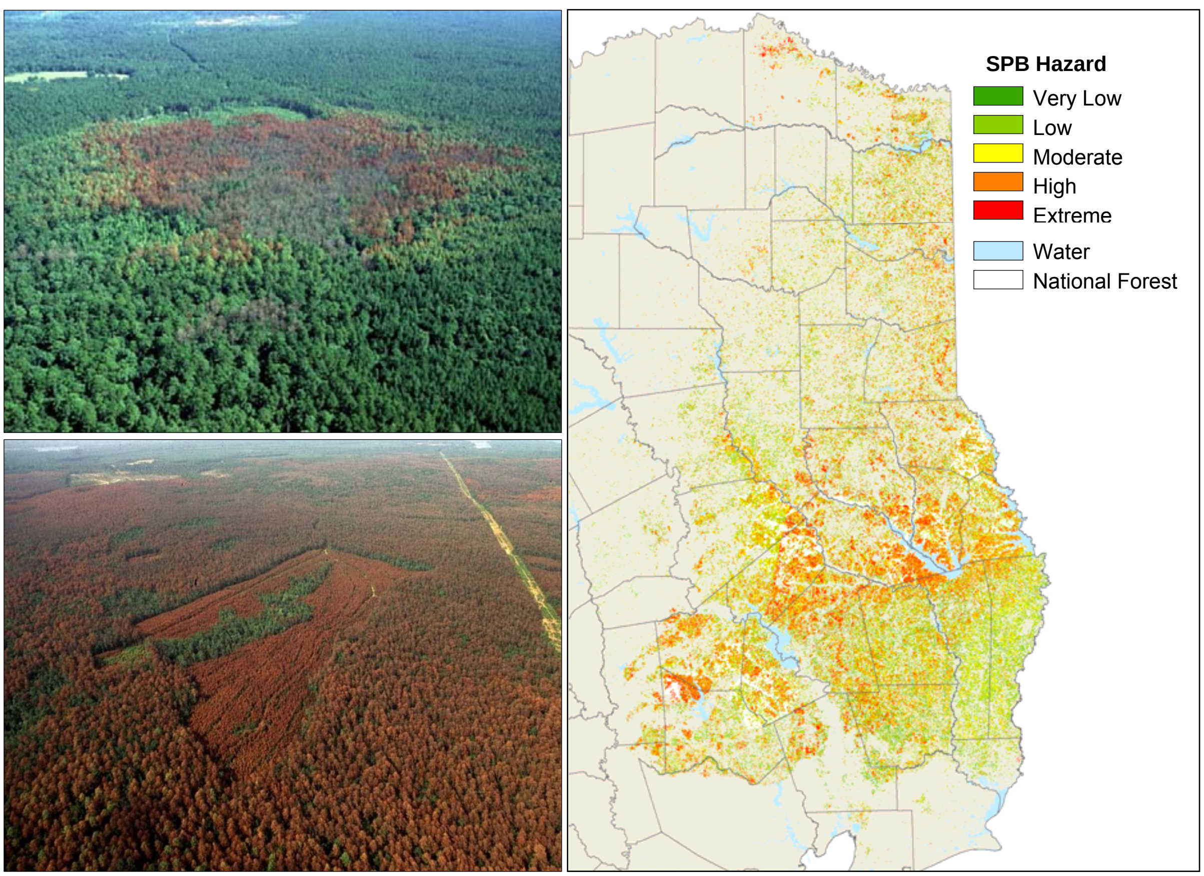
Wildfire and pests pose a threat to the long-term health and productivity of East Texas forest lands. The sale of corporate forests to timberland investors resulted in a loss of industrial fire and pest suppression resources. Coupled with shrinking state and federal budgets, agency ability to deal with long-term and extreme wildfire occurrence or outbreaks of the southern pine beetle have been adversely affected. At the same time, local volunteer fire service has also experienced significant challenges as well, including frequent turnover and loss of membership. Collaborative work with local, State, and Federal entities is crucial to implement prevention projects as well as effective and efficient suppression programs.

Forest pests, especially the southern pine beetle (SPB), can have a devastating impact on the timber resource. Measures must continue to be taken to prevent widespread outbreaks and keep infestations small. Of particular concern are federal lands, which account for less than six percent of the total timberland acreage, but can serve as a breeding ground for devastating infestations. The majority of the pine forests on federal lands in East Texas are over 60 years of age, rendering them highly susceptible to SPB outbreaks (Figure 24). In the early 1990s, this was demonstrated with large, uncontrolled infestations on several wilderness areas that spilled into the surrounding National Forest and private ownerships. Policies must be developed to protect the integrity of the wilderness concept, with heavy consideration for the potential impact on all of the forest resources of the region, regardless of ownership.

Figure 24

Uncontrolled Infestations and Hazard Map for Southern Pine Beetle in Texas

Hazard Map Source: USDA Forest Service, Forest Health Technology Enterprise Team, Fort Collins, CO

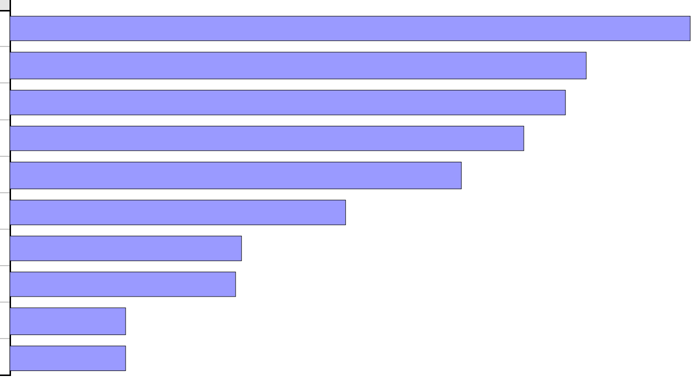


Invasive non-native plants are problematic to the health and productivity of forest ecosystems. Many invasive species such as Chinese tallow and Chinese privet have been around for decades, while others like Japanese climbing fern and giant Asian dodder have only recently begun to encroach on the East Texas landscape. Of particular note is the conversion of previously forested tracts to residential subdivisions. New residents can unknowingly introduce non-native and aggressive plants into the region, resulting in an impact on the health of our forest ecosystems.

East Texas now boasts more than 200,000 family forestland owners. While many invest in property for traditional, commercial forestry reasons, there are a growing number of individuals who own property for other reasons, such as environmental protection, recreation, ruralism, escapism, and viewing wildlife (Table 9). Historically, government forestry programs have been geared toward traditional timber management. While the economic opportunity should never be discounted or neglected, forestry must embrace these newer concepts. To ensure the relevance of forestry programs, resource professionals and programs must be re-tooled to meet the needs of this new landowner.

Table 9
Reasons for Owning Family Forests

Rank	Reason	Percentage of Responses
1	Aesthetics	65
2	Privacy	55
3	Family Legacy	53
4	Protection of Nature	49
5	Land Investment	44
6	Part of Home Site	32
7	Hunt and Fish	22
8	Other Recreation	21
9	Timber	11
10	Firewood	11

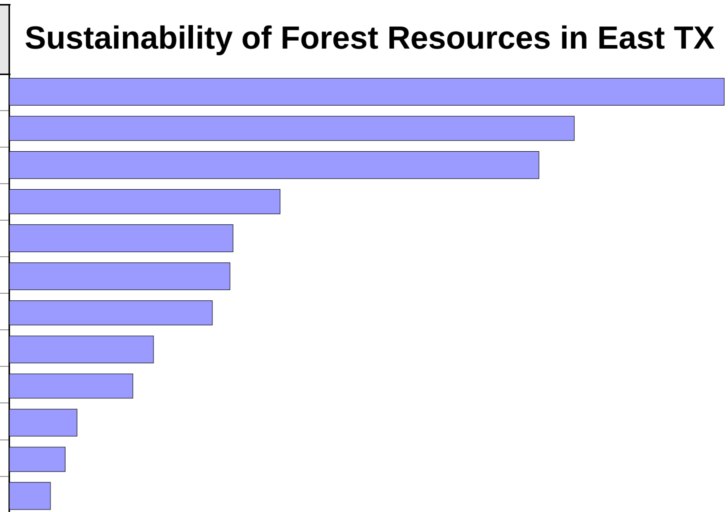


Spatial Analysis

Twelve layers from the Southern Forest Land Assessment were identified as important to the sustainability of the East Texas forest resource. Layer ranking and weighting is based on both statistical hard data (e.g. FIA) and anecdotal reasoning (Table 10). These layers reflect relative importance of the key issues impacting the long-term health and productivity of the forests of the region.

Table 10
Layers and Layer Weights Used in Overlay Analysis for Sustainability of Forest Resources in East Texas

Layer Rank	Layer Name	Layer Weight
1	Forestland	22.6
2	Development Level	17.9
3	Forest Health	16.8
4	Wildfire Risk	8.6
5	Forest Patches	7.1
6	Priority Watersheds	7.0
7	Site Productivity	6.4
8	Riparian Areas	4.6
9	Public Drinking Water	3.9
10	Protected Areas	2.1
11	Wetlands	1.8
12	T&E Species	1.3
	TOTAL	*100*



Results

Results from the spatial analysis are shown in Maps 3-a and 3-b. Map 3-a identifies high priority areas on a 30-meter pixel basis while Map 3-b identifies high priority areas on a county basis. Very high priority areas include 2.8 million acres, which is all forestland, and makes up 14.0 percent of East Texas.

Table 11
Area within Each Priority Class by Forest and Non-Forest for the Sustainability of Forest Resources in East Texas Issue

Priority	Forest	Non-Forest	*TOTAL*
	- - - - - - - - - - - - - - - acres	- - - - - - - - - - - - - - - -	
Very High	2,850,833	0	2,850,833
High	5,323,134	766	5,323,900
Medium	3,775,005	278,092	4,053,097
Low	402,462	3,953,357	4,355,820
Very Low	0	3,786,993	3,786,993
TOTAL	12,351,434	8,019,209	20,370,643

Conclusion

Traditional opportunities in forest economic development still exist in East Texas, especially in Southeast Texas, with its surplus of timber supply. However, Northeast Texas risks falling into a non-sustainable scenario with pine timber. Rapid change in timberland ownership, mill closures, maintaining logging capacity, and wildfire and pests pose significant challenges for East Texas. Fortunately, many new opportunities exist for East Texas, including carbon credits and woody biomass.

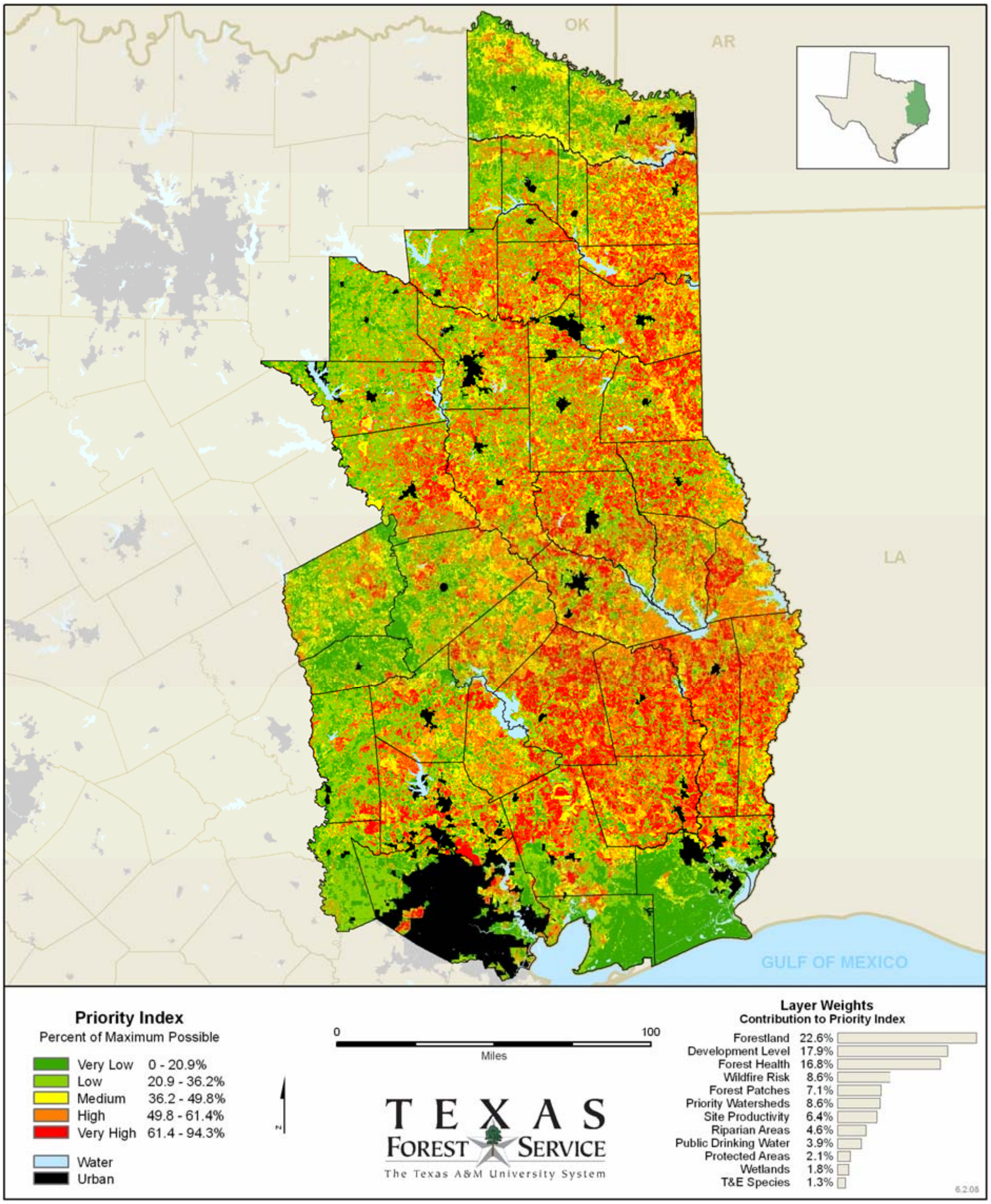
References

Billings, R.F., L.A. Smith, and M. Murphrey. 2006. How to prevent southern pine beetle infestations: A guide to cost sharing thinning operations in East Texas. Texas Forest Service Publication 3/06/5000. 19 p.

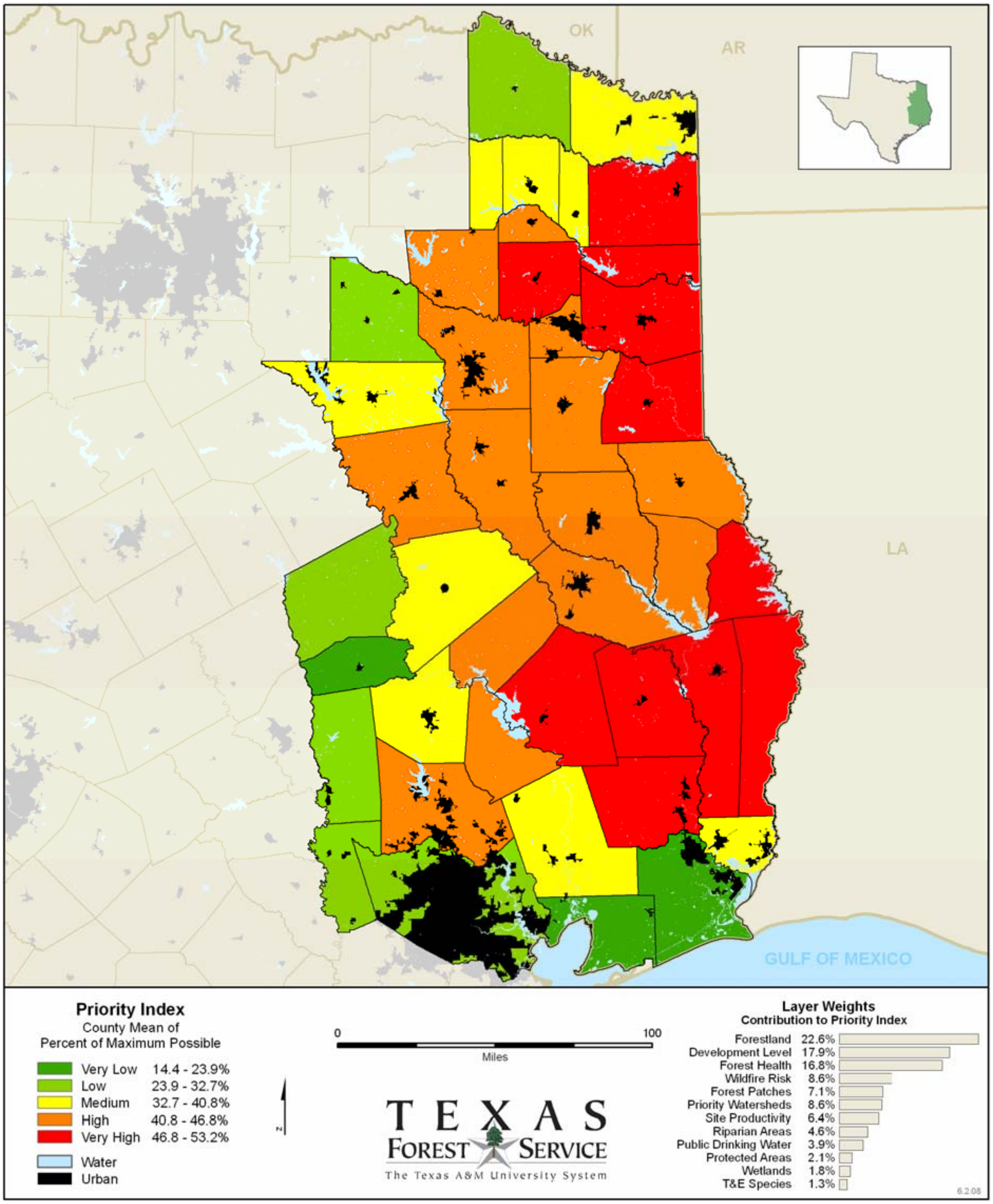
Texas Forest Service. 2006. Economic impact of the Texas forest sector, 2004. Texas Forest Service publication, 14 p. http://txforestservice.tamu.edu/uploadedfiles/sustainable/econdev/economic_impact2004.pdf

Xu, W. and B. Carraway. 2007. Biomass from logging residue and mill residue in East Texas, 2005. Texas Forest Service publication, 10 p. http://txforestservice.tamu.edu/uploadedFiles/Sustainable/econdev/TXloggingmillresidue2005.pdf

Map 3-a
Sustainability of Forest Resources in East Texas



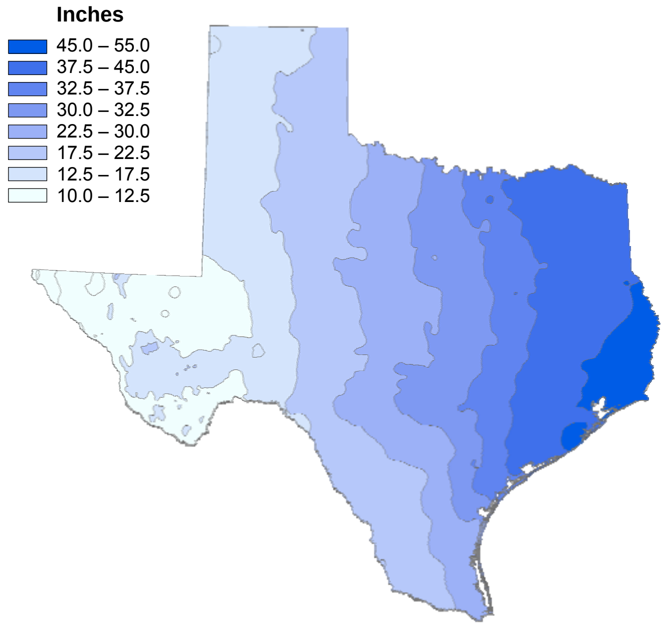
Map 3-b
Sustainability of Forest Resources in East Texas



Issue 4
Water Quality and Quantity

Description
Due to the rainfall pattern, most freshwater resources in Texas originate in the eastern portion of the state (Figure 25), making forests and wetlands a critical factor in meeting water needs. Forests produce the cleanest water of any land use, providing numerous public benefits, including absorbing rainfall, reducing flooding, recharging aquifers, and providing habitat for wildlife. Studies have shown that riparian forests and wetlands can trap over 80 percent of sediment and nutrients, as well as reduce peak flood periods by 50 percent (Cooper *et al.*, 1987).

Figure 25
Annual Precipitation for Texas



To protect, maintain, and enhance the high quality water and other public benefits produced by forestlands, Texas Forest Service established the Best Management Practices (BMP) program. In 1989, a comprehensive set of voluntary conservation practice guidelines, or BMPs, were developed to prevent or minimize threats to water quality from forestry operations. Improperly-conducted forestry operations have the potential to negatively impact water quality. Since these guidelines were created, Texas Forest Service staff has effectively promoted their importance through logger training, landowner education, and public outreach, a strategy promoted by the Texas Wildlife Plan. Monitoring conducted by Texas Forest Service shows that 92 percent of operations conducted across all forestlands in this region currently utilize these practices (Simpson *et al.*, 2005). These educational efforts will have to be expanded, as forest industry, a long time supporter of BMPs, has divested its timberland in Texas.

With the Texas population exploding, increased demands have already been placed on clean water resources. Compounding this problem is the associated development and increase in impervious cover in areas where forest once existed, leading to declines in water quality. These declines can be mitigated through careful watershed planning and conservation design, a method in which land is developed in a manner that protects the natural environment features. Other solutions include establishing forests around drinking water sources and riparian areas, restoring wetlands to their original condition, and developing ecosystem service markets and incentives for private landowners to conserve their working forest landscapes. According to the Texas Wildlife Plan, restoring just 1 percent of a watershed to appropriately-located wetlands can reduce runoff of nitrates and herbicides by up to 50 percent (Robinson, 1995).

Outside of East Texas, water supplies are already limited. This problem is intensified by population growth in this region far exceeding that of East Texas, where most of the state's water supply is located. Climatologists, as noted earlier in this document, are predicting the state will experience 15 to 20 more years of prolonged drought conditions. With these threats to the water supply, state, regional, and local planners are faced with the question, *"How can we provide water to Texans in the future?"*

One solution may be to control non-native and invasive vegetation that has become established along waterways in this region (Figure 26). Ashe juniper, mesquite, tamarisk, and other brush species are estimated to consume over 3.5 trillion gallons of water each year in Texas (http://www.tsswcb.state.tx.us/en/brushcontrol). Managing this vegetation properly could allow for a significant recovery of water that would otherwise be lost.

Figure 26
Aerial View of Tamarisk (Salt Cedar) Established Along West Texas Waterways
Photos by Texas AgriLife Extension Service

Aquifer recharge zones must also be protected to ensure groundwater resources are not depleted or contaminated. Disturbing these areas can reduce percolation into the aquifer as well as cause it to become polluted. Karst topography, characteristic of the Hill Country, offers little to no filtering capacity, allowing water to flow unimpeded through cracks, crevices, and caves directly into groundwater (Figure 27). With approximately 60 percent of the Texas water supply coming from groundwater, it is imperative to protect these critical zones.

Figure 27

Caves and Limestone Bedrock are Typical Characteristics of Karst Topography

Photos by Hughes Simpson

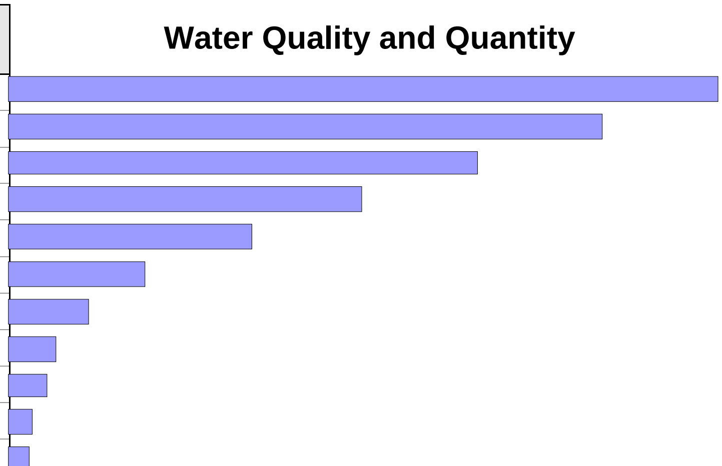
Spatial Analysis

A geospatial model was developed to determine the highest priority areas in which Cooperative Forestry efforts should be directed to protect water quality and quantity. Eleven data layers from the Southern Forest Land Assessment were used in the model analysis (Table 12), with each one weighted according to its perceived relative importance to this issue. The following data layers and weights were used: Priority watersheds (26.1%), Public drinking water supply (21.9%), Riparian areas (17.3%), Wetlands (13.0%), Forestland (9.0%), Proximity to public lands (5.0%), Forest patches (3.0%), Development level (1.8%), Forest health (1.4%), Wildfire risk (0.9%), and Slope (0.8%).

Table 12

Layers and Layer Weights Used in Overlay Analysis for Water Quality and Quantity

Layer Rank	Layer Name	Layer Weight
1	Priority Watersheds	26.1
2	Public Drinking Water	21.9
3	Riparian Areas	17.3
4	Wetlands	13.0
5	Forestland	9.0
6	Protected Areas	5.0
7	Forest Patches	3.0
8	Development Level	1.8
9	Forest Health	1.4
10	Wildfire Risk	0.9
11	Slope	0.8
	TOTAL	*100*



Results

Results of the overlay analysis are show in Maps 4-a and 4-b. Results on a 30-meter pixel level are shown in Map 4-a. Results summarized by county are shown in Map 4-b. High priority areas comprise 5.8 million acres, or 3.6 percent of the total. Forestland makes up 94.8 percent of these high priority areas.

Table 13
Area within Each Priority Class by Forest and Non-Forest for the Water Quality and Quantity Issue

Priority	Forest	Non-Forest	*TOTAL*
	- - - - - - - - - - - - - - -	acres - - - - - - - - - - - - - - - -	
Very High	5,525,623	301,017	5,826,639
High	10,331,460	3,597,889	13,929,349
Medium	6,488,803	16,075,056	22,563,859
Low	2,556,620	27,182,858	29,739,479
Very Low	0	90,966,859	90,966,859
TOTAL	24,902,506	138,123,679	163,026,186

Conclusion

The geospatial analysis identified two primary areas in which future efforts should be concentrated—East Texas and the Balcones Escarpment region of Central Texas. These efforts include expanding the education and technical assistance functions of the BMP program, exploring opportunities for conservation development and ecosystem service markets, controlling non-native and invasive riparian vegetation, and protecting drinking water intakes and groundwater recharge zones from contamination. Focusing attention on these priority areas can help sustain our water resources, ensuring the high quality of life that Texans enjoy.

References

Cooper, J.R.; J.W. Gilliam; R.B. Daniels and W.P. Robarge. 1987. Riparian areas as filters for agricultural sediment. Journal of Soil Science Society of America 57:416-420

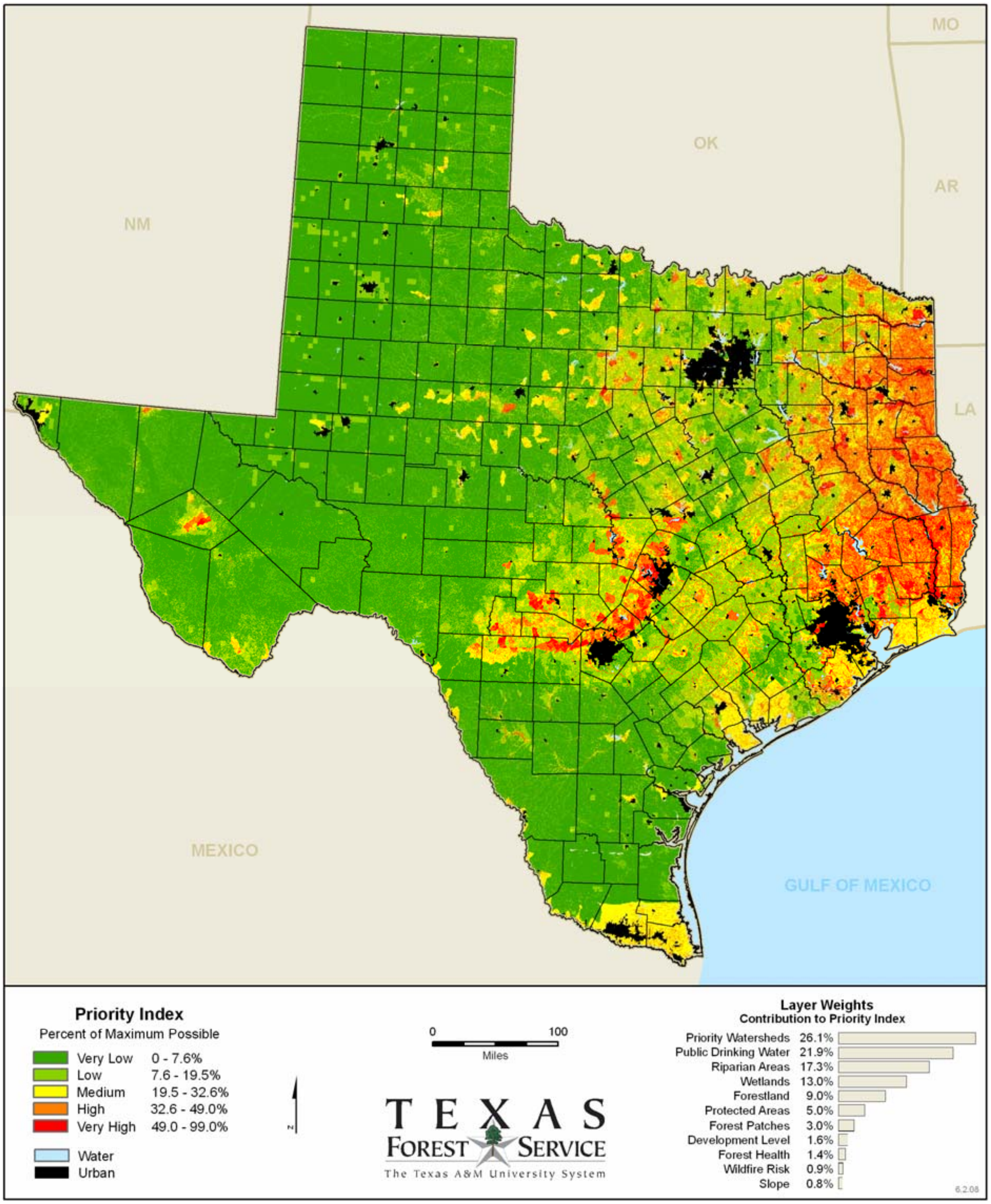
Robinson, A. 1995. Small and seasonal does not mean insignificant: why it's worth standing up for tiny and temporary wetlands. Journal of Soil and Water Conservation 50(6):586-590.

Simpson, H., J. Donellan, and S. Harrington. 2005. Voluntary implementation of forestry best management practices in East Texas. Texas Forest Service Forest Resources Development Best Management Practices Project.

Website references

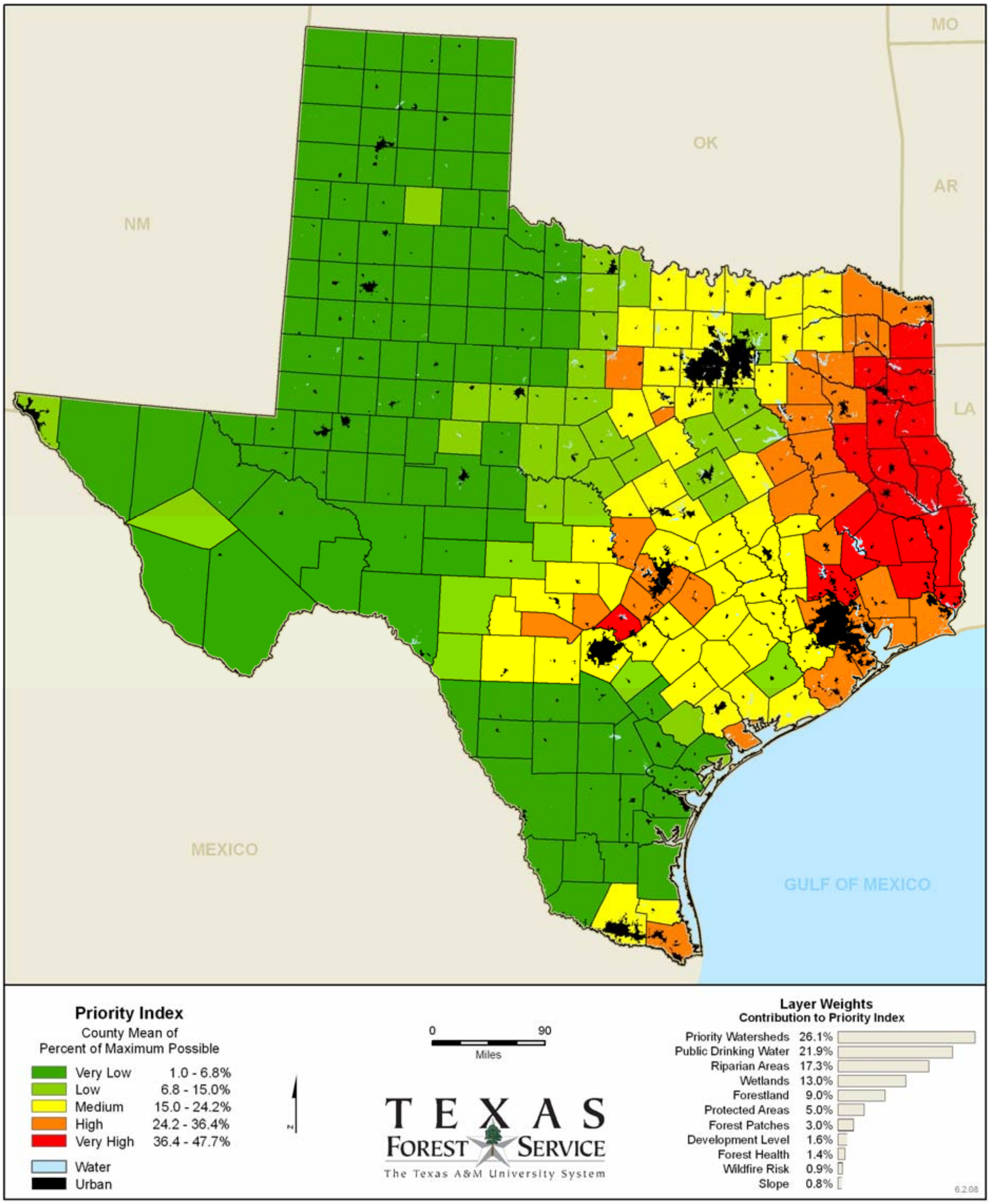
http://www.tsswcb.state.tx.us/brushcontrol
http://www.twdb.state.tx.us/wrpi/swp/swp.htm

Map 4-a
Water Quality and Quantity



Map 4-b

Water Quality and Quantity



Issue 5
Wildfire and Public Safety

Description of Issue

A primary role of government is to help ensure the safety of its citizens. Since its inception in 1915, Texas Forest Service has been tasked with the responsibility for wildfire suppression, defending both the property and lives of Texas citizens. Beginning in the 1990s, Texas Forest Service has provided incident management teams in response to all-hazard incidents that threaten the citizens of Texas.

For Texas these are growing issues. Since 1996, the state has experienced significant fire seasons in 8 of the past 12 years. Both the 2006 and 2008 fire seasons consumed more than a million acres. Additionally, the majority of wildfires threaten homes. Once primarily a rural issue, wildfires are now clearly a statewide threat. Spatial analysis of the 2005 and 2006 fire seasons shows 85 percent of fires occurred within two miles of a community. In recent years, wildfires have threatened and, in some cases, burned through small towns and large cities alike, destroying hundreds of homes.

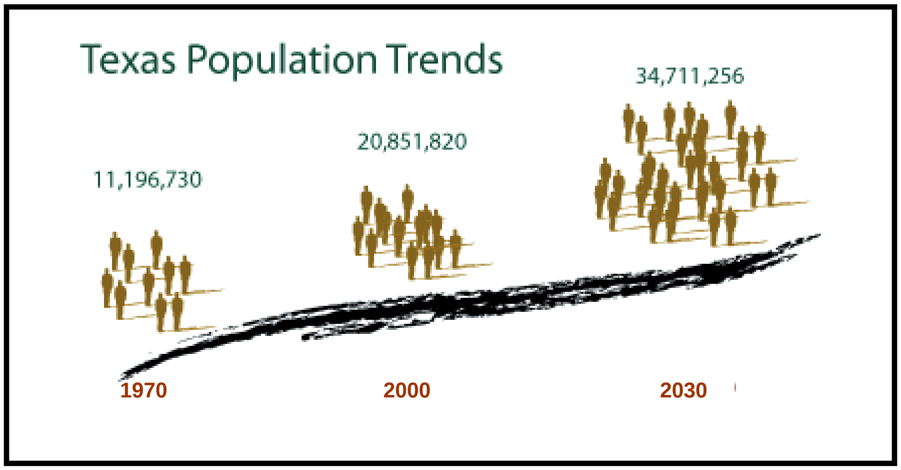
Three primary factors are combining to create these intense fire seasons—population growth, changing land use, and increasing drought frequency.

Non-wildfire disaster response has become commonplace in Texas as well. Along with California and Florida, Texas is one of the top three natural disaster states in the nation. Hurricanes, floods, tornados, and other events requiring state and local disaster response continue to occur with increasing frequency. Over the past five years, Texas Forest Service has been called on by the state to provide incident management teams for non-wildfire disasters at an average of nearly six activations per year. This is twice the response rate for all-hazard mobilizations during the previous five years. Population growth and land use changes are significant causal factors for these disasters as well.

Population Growth

Since 1970, the population of Texas has doubled (Figure 28). While few new communities have been created, many communities and cities have expanded into undeveloped "wildland" with little or no regard for wildland fire protection principles. Fire occurrence statistics show that over 95 percent of wildfires occurring in Texas are human caused. For wildland fires, this continued population growth correlates into both an increase in the number of fires and an increased population and values at risk once a wildfire starts.

Figure 28
Population Trends for Texas from 1970 to 2030
Source: U.S. Census Bureau 2000



Population growth has a tremendous impact on all types of disaster response, not just wildfires. Disasters are measured in human impact (people displaced, homes and lives lost). A natural phenomenon, such as a flood or tornado, becomes a disaster when people's lives are affected. Add to this the potential for human-caused disasters, and a direct correlation becomes evident between population growth and the increase in occurrence and severity for all types of incidents requiring state disaster response and support.

Land Use Changes

Land use patterns have changed over the past century, resulting in significantly more vegetation and fuels available to burn. The town of Cross Plains in North Central Texas was devastated by fire on December 27, 2005. In the early 1900s, this area was used by share croppers and farmers, and little or no vegetation remained around the homes, farms, and ranches in the community.

By 2005, a town of 1,076 people had sprung up with the typical Texas landscape—tall grass, trees and other vegetation—surrounding the homes. The devastating fire in December 2005 claimed two lives and destroyed 116 homes (Figure 29).

The town of Cross Plains is an example of what happens when a community finds itself in the way of wildfire. There are currently 14,506 communities in Texas deemed to be at risk to the destructive potential of a devastating wildfire. Surprisingly, many populated areas are more at risk, due to the increased number of human-caused fires.

Figure 29
Cross Plains and the Devastating Fire of 2005
Photos from Texas Forest Service files

Land use changes are also being impacted by expansion of urban, suburban, and rural communities. As the population grows, communities are expanding into previously undeveloped or "wildland" areas at a record pace. Over the last few decades, expansion of these wildland-urban interface (WUI) areas—where homes and other human development meet or intermingle with undeveloped land—has significantly impacted all emergency response and disaster management activities. In many areas, community expansion has outpaced local infrastructure, stretching capabilities of fire, police, and other local emergency services.

For wildfires, the WUI creates an environment where fire can move readily between structural and vegetative fuels, increasing the likelihood that wildfires will threaten structures and people.

Drought
In 1999, by analyzing weather data from the past 100 years, Texas Forest Service identified a distinctive drought cycle occurring in Texas. Three separate 25- to 30-year drought periods were recognized, with the last drought beginning in the 1950s and ending in the late 1970s. During a drought cycle, rainfall and wet periods continue to occur; however, drought and extremely dry conditions occur with greater frequency and intensity. Drought becomes the "normal" pattern rather than the exception. The more frequent and intense droughts result in dryer vegetation that is more likely to ignite and will burn more readily, increasing fire occurrence, intensity, and size.

Coordination and Resources
Under the leadership of Texas Forest Service, Texas has a tiered strategy for fire response to meet this risk. This involves local fire departments, Texas Forest Service and other state agencies, as well as firefighters and equipment from across the nation.

Local fire departments are the first responders to wildland fires in Texas. They are the first line of defense. However, if they determine that their capacity to control a fire is exceeded, suppression assistance is requested from Texas Forest Service. This may occur quickly or over time after a fire has grown large and becomes destructive.

In Texas, even a moderately-sized wildfire may involve from 2 to 10 fire departments, numerous pieces of county equipment, local law enforcement, emergency medical services, and resources from Texas Forest Service, Department of Public Safety, Texas Department of Transportation, Texas National Guard, Governor's Division of Emergency Management, and multiple out-of-state cooperators. All of these responders need to be organized before a fire starts to maximize safety and effectiveness.

Since 1998, Texas has brought in more than 19,229 personnel, 547 aircraft, 891 engines, and 593 dozers for wildfire suppression (not including the 17,304 personnel brought in during the Space Shuttle Columbia Recovery in 2003). These resources have been vital to fire suppression efforts in recent fire seasons. Without out-of-state resources, the wildfires would not have been suppressed. However, there are disadvantages to continuing to mobilize national resources. Aerial firefighting equipment and firefighting personnel are not always readily available and there is a three- to five-day lag time in mobilizing out-of-state resources. In addition, national mobilization costs generally three to four times greater per unit than Texas resources.

Spatial Analysis
The Level of Concern output layer from the Southern Wildfire Risk Assessment (SWRA), which was also used as an input data layer for the Southern Forest Land Assessment, was used to identify priority areas across the landscape for focusing wildfire efforts. Information on Level of Concern is provided in the overview on the SWRA and in Appendix A.

Results
Level of Concern classified into five priority classes is shown in Maps 5-a and 5-b. Maps 5-a shows results on a 30-meter pixel basis and Map 5-b shows results when pixel data are

summarized by county. Very high priority lands include 15.1 million acres, or 8.9 percent of the total. Forestland comprises 18.4 percent of these high priority areas (Table 14).

Table 14
Area within Each Priority Class by Forest and Non-Forest for the Wildfire and Public Safety Issue

Priority	Forest	Non-Forest	*TOTAL*
	- - - - - - - - - - - - - - - acres	- - - - - - - - - - - - - - - -	
Very High	2,779,639	12,357,487	15,137,126
High	2,901,512	14,987,033	17,888,545
Medium	3,018,113	22,294,429	25,312,542
Low	6,153,619	51,841,046	57,994,665
Very Low	10,539,565	42,527,107	53,066,672
TOTAL	25,392,448	144,007,102	169,399,550

When summarized by county, the highest priority counties included 16 counties in the panhandle; Hardin, Jasper, Newton, and Tyler counties in Southeast Texas; Upshur County in Northeast Texas; Parker and Hood counties west of Fort Worth; and Wichita County in North Central Texas.

State Response Plan

For the past decade, Texas Forest Service has been developing, using, and refining its operations under the Texas Wildfire Protection Plan (TWPP), a coordinated, interactive effort utilizing multiple components:

- Predictive Services/Assessment and Monitoring
- Mitigation, Prevention, and Reduction of Risk
- Planning and Preparedness
- Local Capacity Building
- Rapid Initial Response and Suppression of Wildfires

The TWPP is a proven interagency emergency response model emphasizing ongoing analysis and aggressive response based on the identified risk factors.

Conclusion

Texas Forest Service remains a small agency with a large and expanding mission. Current spatial analysis from the SWRA shows approximately a third of the state's landmass (58.3 million acres) at significant risk from wildland fires.

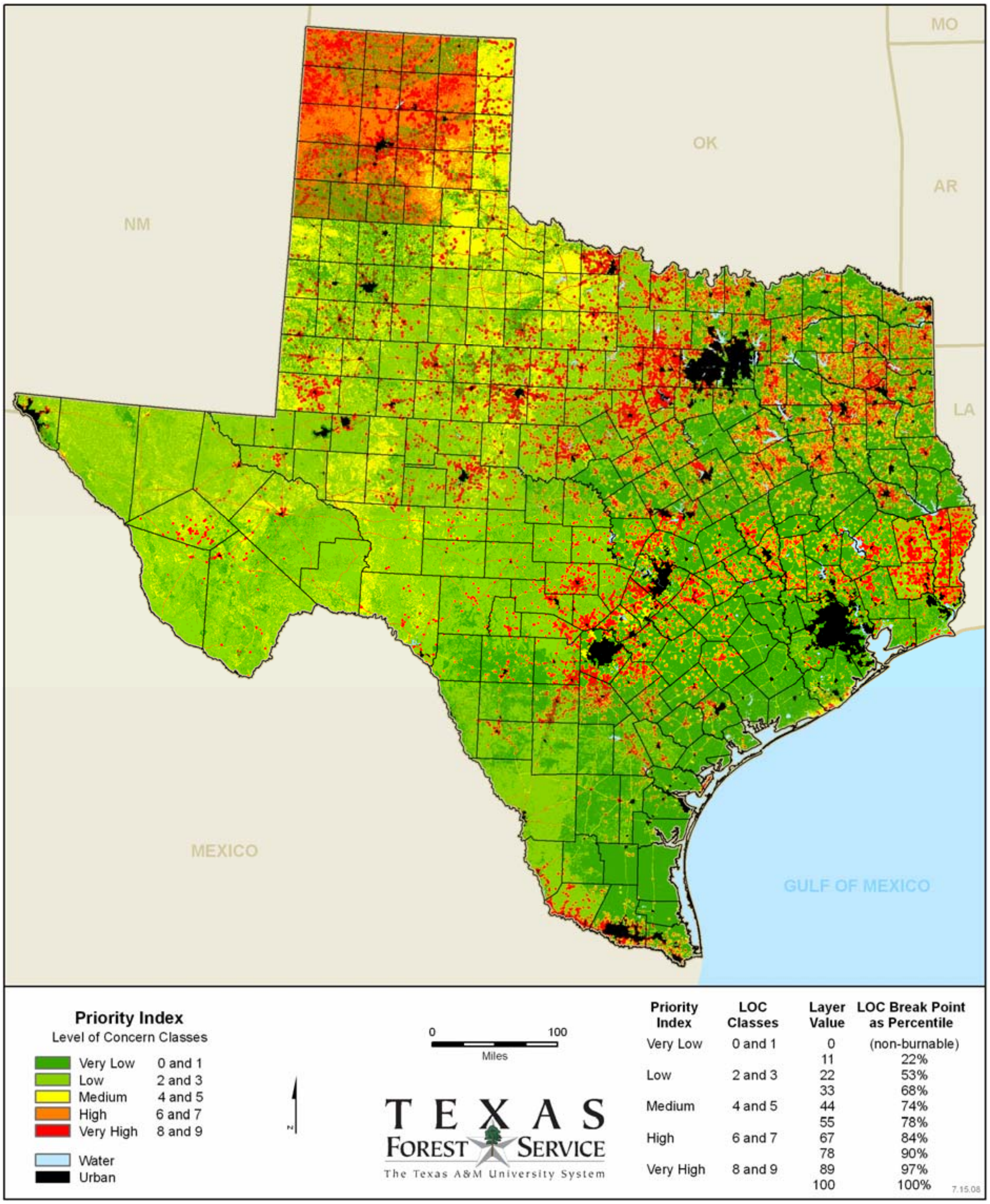
Texas is one of the top three disaster states in the nation. For the State of Texas and the Texas Forest Service, demand for wildfire and all-hazard emergency response will continue to grow with the population.

To meet these needs Texas Forest Service must continue to implement and develop programs under the Texas Wildfire Protection Plan with an emphasis on:

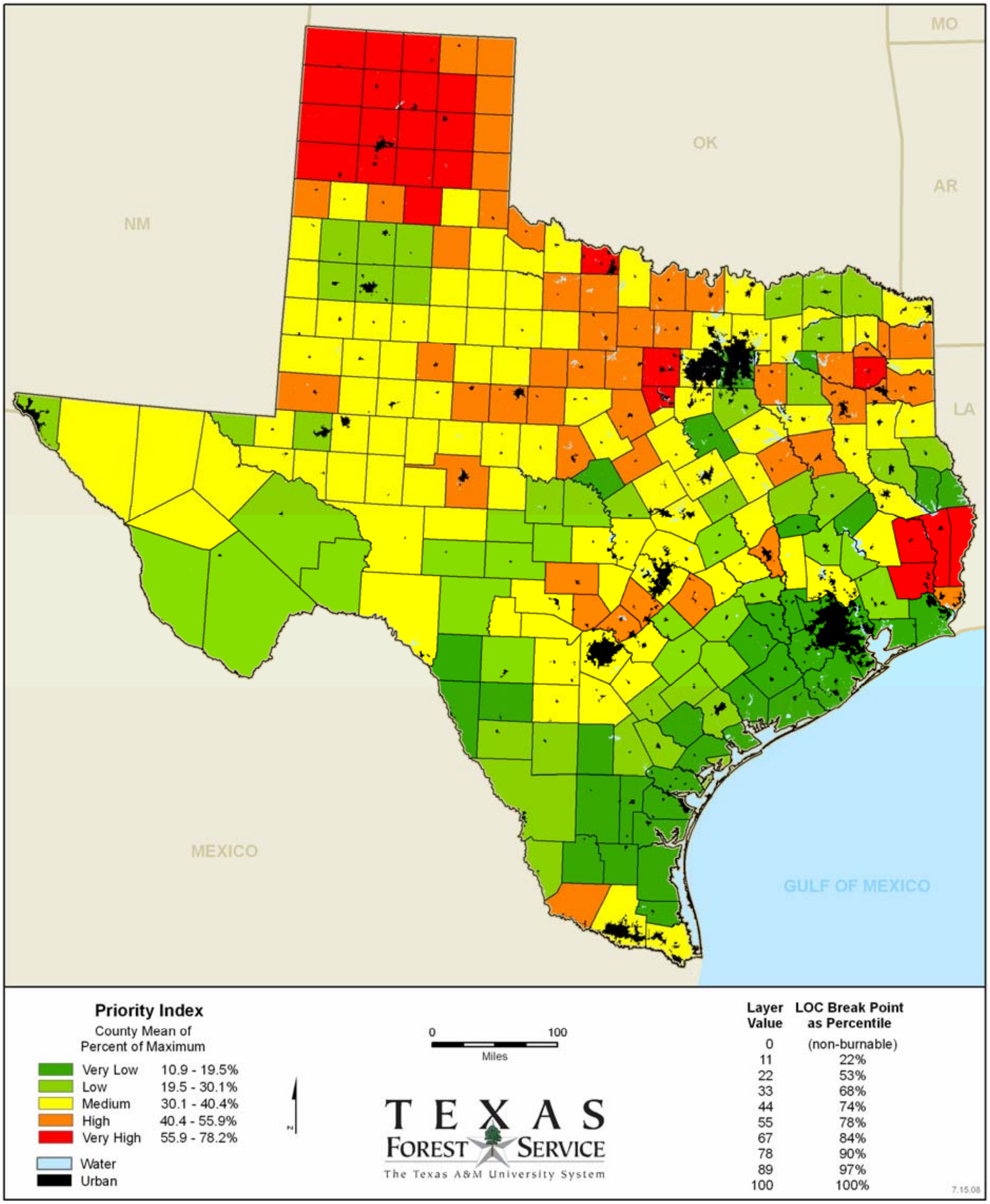
- Science-based risk and trend analysis to guide development of effective programs and initiatives
- Prevention, risk reduction/mitigation, rapid response, and other cost-effective, proactive efforts focused on addressing identified causal factors
- Coordinated state and community-level programs with a broad cross-section of cooperating parties
- Integrated projects whose results impact multiple priorities
- Strong local support and ownership that supports transition to a long-term community project with minimal state guidance
- Public outreach, education, and training
- Development of response resources and coordinated response efforts
- Automated and publicly available information and tools

The public safety challenges facing Texas Forest Service are significant. While the primary causal factors cannot be eliminated, it is unacceptable to wait for the logical outcome to unfold on the citizens of Texas. To effectively mitigate risks will require continuous, high-level situational awareness coupled with large, ongoing, proactive initiatives in prevention, mitigation, preparedness, capacity building, and rapid response.

Map 5-a
Wildfire and Public Safety



Map 5-b
Wildfire and Public Safety



Issue 6
Urban Forest Sustainability
Rapid Population Growth and Land Use Changes Threaten Urban Forestry Sustainability

Trees and forests in urban areas represent valuable natural and cultural resources. Traditional methods for calculating these values have focused on the replacement cost of individual trees (Guide for Plant Appraisal, 2003), but newer computer models (American Forests' CityGreen; USDA Forest Service's UFORE and STRATUM) can also evaluate the functional values of trees in cities, including air pollution removal, energy savings, stormwater runoff, and carbon sequestration and storage. Other values that have been assigned to urban trees include real estate values, recreation, health benefits, psychological well-being, and aesthetic appeal (Figure 30). These other values are perhaps harder to quantify but are no less real to the residents of our cities and towns.

Figure 30
Community Trees Provide Shade and Many Other Benefits Where Citizens Live, Work, and Play

This wide range of benefits is key to understanding the role urban trees and forests play in improving quality of life. Urban forest sustainability can be described as the measure of how well the network of trees, forests, and related natural resources contribute to human quality of life in cities. But conversely, program delivery can focus on particular places where sustainability is low, using the restorative powers of trees—their functional values—to help solve landscape-scale problems that affect millions of people, including urbanization, air quality, water quality, climate change, energy consumption, and natural disasters of all types.

In addition to the three broad national themes established by the USFS for state and local programs, the Urban Forestry Committee of the National Association of State Foresters (NASF) has established five specific urban forestry goals that link to the national themes (Table 15).

Table 15
U&CF Goals and National Themes

Urban & Community Forestry (U&CF) Goals	National Theme
1. Reduce the impacts of urbanization on forest landscapes	Conserve Working Forests
2. Moderate the impacts of catastrophic events	Protect Forests From Harm
3. Protect and improve air and water quality	Enhance Public Benefits
4. Mitigate climate change	Enhance Public Benefits
5. Conserve energy	Enhance Public Benefits

In Texas, the analysis of urban forest sustainability focused on these five goals and identified priority landscapes where state programs and local projects can have the greatest positive impact.

However, the concept of sustainability also applies to the people and programs that care for urban trees and forests. Since the establishment of state urban forestry programs following the Cooperative Forestry Assistance Act (1978) and major federal funding boosts provided by subsequent Farm Bills (1990), states have actively sought to establish and grow community forestry programs at the local level. Currently, states measure program outputs and outcomes in terms of four key elements for local program sustainability: (1) professional staff, (2) an inventory and management plan, (3) local policy or ordinance, and (4) having a local advocacy group (Community Accomplishment Reporting System annual summaries, 2005-2007). Using this data, a sixth U&CF goal of building capacity at the local level was included in the spatial analysis.

Thus, the analysis of the Urban Forest Sustainability issue included separate analyses for six sub-issues that were aligned with the national U&CF goals.

Spatial Analysis

The Southern Forest Land Assessment (SFLA 2008, in press) uses a weighted overlay analysis of 13 geographic layers to derive a map of priority forestlands across the southern states. But since the goal of the SFLA was to characterize and prioritize rural lands according to their importance to State & Private Forestry programs, urban lands were intentionally disregarded. For the Texas Statewide Assessment of Forest Resources, however, it is important to characterize the condition, trends, and priority landscapes across all ownerships and types of land in the state—including urban lands.

Though the SFLA focused on rural lands, the SFLA layers do provide valuable information for analyzing urban landscapes. For example, understanding where forests or riparian areas exist within urban areas might be critical to achieving one or more of the national U&CF

goals. Certainly, they represent useful data layers and a starting place for the U&CF analysis. Most were incorporated without adjustment.

One SFLA layer that was adjusted to reflect a particular dynamic in urban areas was the Development Level layer. This layer characterizes the projected change in housing density between 2000 and 2030, and can be scaled to focus on one kind of development pressure or another. For the SFLA, those layer values focused on the transition of undeveloped, rural lands to housing with fairly low densities in 2030. For the Urban Forest Sustainability issue, Texas Forest Service issue leaders captured changes within the ‘urban’ housing densities and de-emphasized changes occurring on rural landscapes. Table 16 shows the layer value scheme used for Development Level in the Urban Forest Sustainability (UFS) issue analyses.

Table 16
Layer Value Scheme for Development Level for Urban Forest Sustainability†

		2030														
		UP	Rural						Exurban				SU	Urban		
	2000	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
UP	1	0	20	30	40	50	60	70	80	90	100	100	100	100	100	100
Rural	2		0	20	30	40	50	60	70	80	90	100	100	100	100	100
	3			0	20	30	40	50	60	70	80	90	100	100	100	100
	4				0	20	30	40	50	60	70	80	90	100	100	100
	5					0	20	30	40	50	60	70	80	100	100	100
	6						0	20	30	40	50	60	80	100	100	100
	7							0	20	30	40	50	60	90	100	100
Exurban	8								0	20	30	40	60	80	100	100
	9									0	20	30	60	80	100	100
	10										0	20	50	80	100	100
	11											0	40	70	100	100
SU	12												0	70	100	100
Urban	13													0	90	100
	14														0	90
	15															0

† UP = Undeveloped Private SU = Suburban

Several other data sources can also inform the analyses for one or more of the six sub-issues. In particular, urban forestry practices at the local level often involve planting or protecting trees near other infrastructure. Understanding the relative proportion of basic land cover types, such as tree canopy, impervious cover, and space available for planting new trees (“plantable space”) in a community, can be critical to prioritizing activities in one place versus another. The most recent National Land Cover Database (NLCD 2001) contains layers for urban areas with values for percent tree canopy and percent impervious cover for each 30-meter pixel. From these two layers a third layer can be derived for percent plantable space (formula: 100 – percent tree canopy – percent impervious = percent plantable space) and a fourth layer derived reflecting the absence of tree canopy (formula: 100 – percent tree canopy = percent absence of tree canopy). In this manner, pixels in urban areas can be assigned values for one or more of these four layers to give priority for a particular UFS sub-issue.

Besides these basic land covers, urban areas are also distinctly different from rural landscapes because they are more densely populated. Two layers used in these analyses were created from U.S. Census 2000 data for each incorporated city, town, village, and U.S.

Census Designated Place (CDP) in Texas. The first layer classified the total 2000 population of each place into five categories. The second used population density for each census block group and classified them into 11 groups, using a logarithmic scale.

Finally, several UFS sub-issues required data from other sources: the Texas Commission on Environmental Quality (TCEQ) map for air quality non-attainment; the U.S. Environmental Protection Agency (EPA) data on impaired waterways; the National Oceanic & Atmospheric Administration (NOAA) risk maps for hurricane, tornado, and ice storm damage; and program capacity data from the USFS Community Accomplishment Reporting System (CARS). A new layer for the growth zones outside city limits (in Texas called an "extraterritorial jurisdiction") was constructed from information provided by the Texas Attorney General's office.

Each layer was normalized so that pixels had values between 0 and 100. For a particular sub-issue, each layer was also weighted to reflect its importance to the issue relative to the other layers in the analysis. Finally, the layers were combined in a model that added the pixel values for each layer in proportion to the weighting scheme for the particular sub-issue. The resulting output produced a pixel-value map and a priority landscape map for census places that shows the cities and towns with the highest priority for U&CF programs and projects to help solve the problem identified by the sub-issue.

UFS Sub-Issue 1: Reduce the impacts of land-use change, fragmentation, and urbanization on forest landscapes

Texas is a desirable place to live and work. Its population is projected to grow an additional 40 percent between 2000 and 2030, to 33 million people (U.S. Census). The impact of this rapid growth shows up on the landscape as urbanization—the conversion of rural open space to urban uses. In 1982, 6.3 million acres (3.8%) of the state's non-federal land area were classified as 'developed'; by 1992, 'developed' land had increased to 7.7 million acres (4.7%); and in 2003, the figure had grown to more than 9.6 million acres (5.9%) (NRCS-Natural Resources Inventory)—a rate of more than 430 acres per day (http://www.nrcs.usda.gov/technical/NRI/maps/tables/t5846.html; http://www.nrcs.usda.gov/technical/NRI/2003/statereports/table1.html). A recent study in the Houston metropolitan region documented a 51 percent increase in residential and urban land cover types between 1992 and 2000, with a corresponding loss of 485 square miles (17.4%) of forestlands (Houston's Regional Forest, 2005, p.18).

Forest fragmentation is another result of urbanization. Unpopulated tracts of forest, suitable for timber harvesting or prescribed burning, become bisected by new roads, separated by housing subdivisions, or divided into smaller parcels. Small towns and rural areas experiencing development pressure often see conflict between owners of traditional agricultural and forest lands and new homeowners wanting a more suburban lifestyle, resulting in increased demand for education and assistance from state forestry agencies.

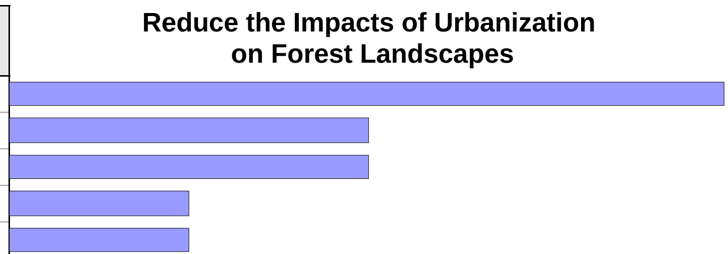
One challenge in Texas is the limited authority that growing communities have over the development process outside city limits. While municipal governments may choose to plan for the protection of natural resources inside the city through their development code, tools to address growth in the "extra-territorial jurisdiction" (ETJ)—the zone outside city limits in which they have the legal right to annex land—are often very limited. Managing growth by county governments outside the ETJ is even more limited. One common result of this gradient of development restrictions from urban to rural lands is that new construction often flows to areas with lower costs, both for land and for lack of regulation.

To analyze this challenging sub-issue of reducing the impacts of urbanization on forest landscapes in Texas, four of the available SFLA data layers were chosen and prioritized as follows. The Development Level layer received the greatest weight (40%) because housing density changes represent the primary force of change acting on forestland (20%). The forest patch layer is included (20%) to add priority for forest tracts larger than 500 acres, since the effect of development on these lands is fragmentation. Protected Areas, or Proximity to Public Land, confers a measure of priority (10%) because private lands between city boundaries and protected public lands could provide "green infrastructure" connections between natural areas and nearby cities.

Finally, to evaluate more land area than current place boundaries, a fifth layer was created to represent growth zones outside city limits, based on the Texas rules for the width for each community's ETJ. The smallest communities (5,000 or less in population) have a 0.5-mile ETJ and the largest cities (100,000 or more in population) have a 5-mile ETJ, with three intermediate classes (1-, 2-, and 3.5-mile). This layer received a weight of 10 percent (Table 17).

Table 17
Layer Weights for UFS Sub-Issue 1–Reduce the Impacts of Urbanization on Forest Landscapes

Layer Rank	Layer Name	Layer Weight
1	Development Level	40
2	Forestland	20
3	Forest Patches	20
4	Protected Areas	10
5	Growth Zone	10
	TOTAL	*100*



Results

High-priority areas in Texas where U&CF activities and projects could help reduce the impacts of urbanization on forest landscapes are shown in Map 6-a and 6-b. On a 30- by 30-meter pixel basis, 591 thousand acres are considered very high priority, which represent 3.2 percent of the total (Table 18). Of these high priority acres, 96 percent is forestland.

Table 18
Area within Each Priority Class by Forest and Non-Forest for UFS Sub-Issue 1—Reduce the Impacts of Urbanization on Forest Landscapes

Priority	Forest	Non-Forest	*TOTAL*
	- - - - - - - -	acres	- - - - - - - -
Very High	568,893	22,266	591,159
High	1,203,058	1,159,822	2,362,880
Medium	1,162,068	2,284,718	3,446,786
Low	316,367	4,396,340	4,712,707
Very Low	0	7,458,942	7,458,942
TOTAL	3,250,387	15,322,087	18,572,474

The very high priority communities identified represent the top 150 communities (top 10%) in which efforts should be focused to provide the greatest impact (Map 6-b). Table 19 lists the top 15 communities (top 1%) by population.

Table 19
Top 15† Communities for UFS Sub-Issue 1 Priority

Place Name	Place Type	Population 2000
Austin	City	656,562
Plano	City	222,030
Lewisville	City	77,737
College Station	City	67,890
The Woodlands	Census Designated Place	55,649
Missouri City	City	52,913
Flower Mound	Town	50,702
Euless	City	46,005
Allen	City	43,554
Grapevine	City	42,059
DeSoto	City	37,646
Conroe	City	36,811
Spring	Census Designated Place	36,385
Atascocita	Census Designated Place	35,757
Huntsville	City	35,078

† Top 15 of top 10 percent by place mean after being sorted by place population

Potential U&CF activities that could be used to address this sub-issue in the high-priority communities identified include:

- Provide technical assistance to regional, county, and municipal planning groups to create sound land-use policies and ordinances
- Support inclusion of "green infrastructure" principles and methods in community comprehensive plans
- Support local land trusts to locate and protect high-value forest landscapes
- Participate in regional open space planning efforts

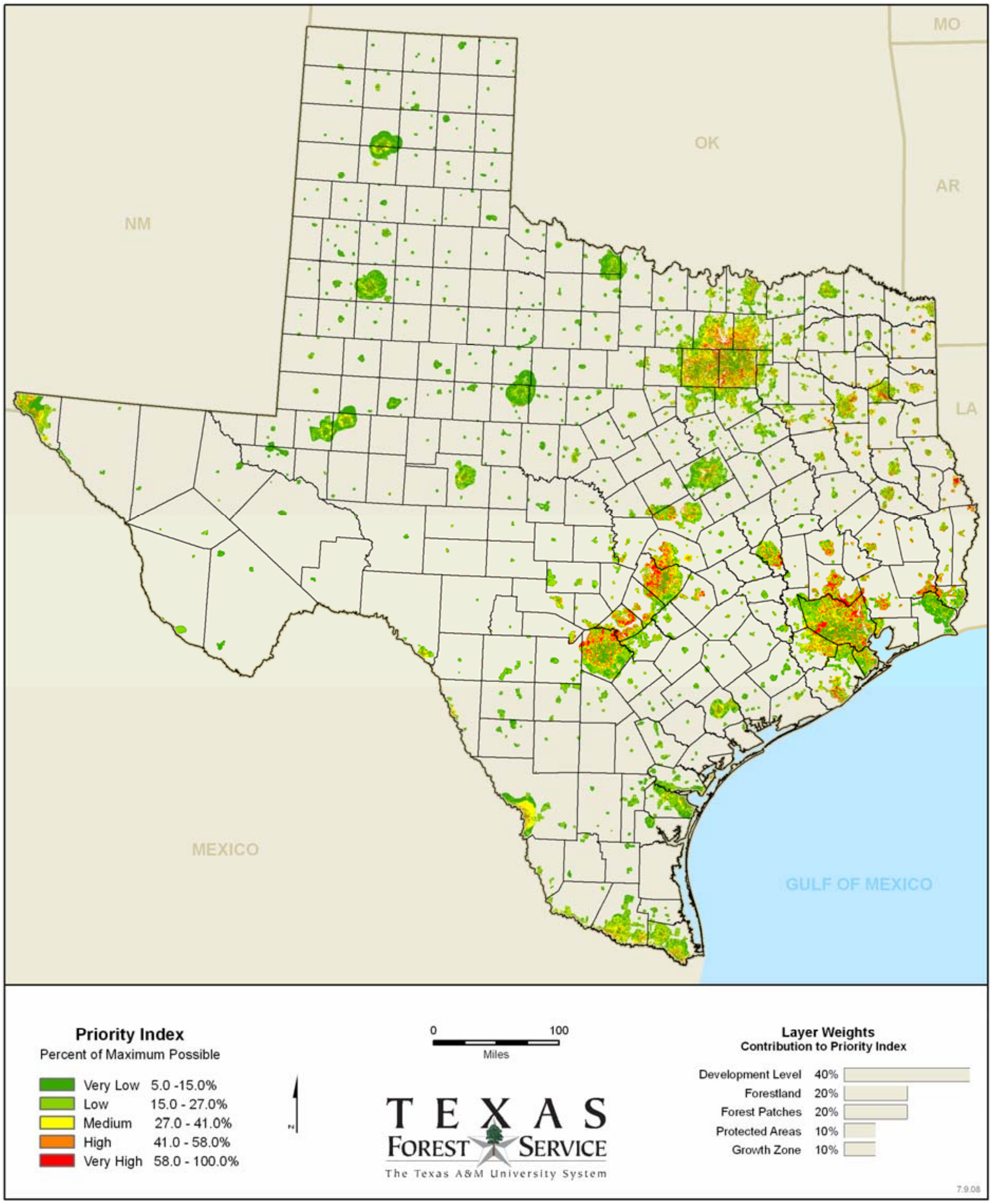
Map 6-a

Urban Forest Sustainability

Sub-Issue 1

Reduce the Impact of Urbanization on Forest Landscapes

U.S. Census Places plus Growth Zone as defined by Extra-territorial Jurisdiction



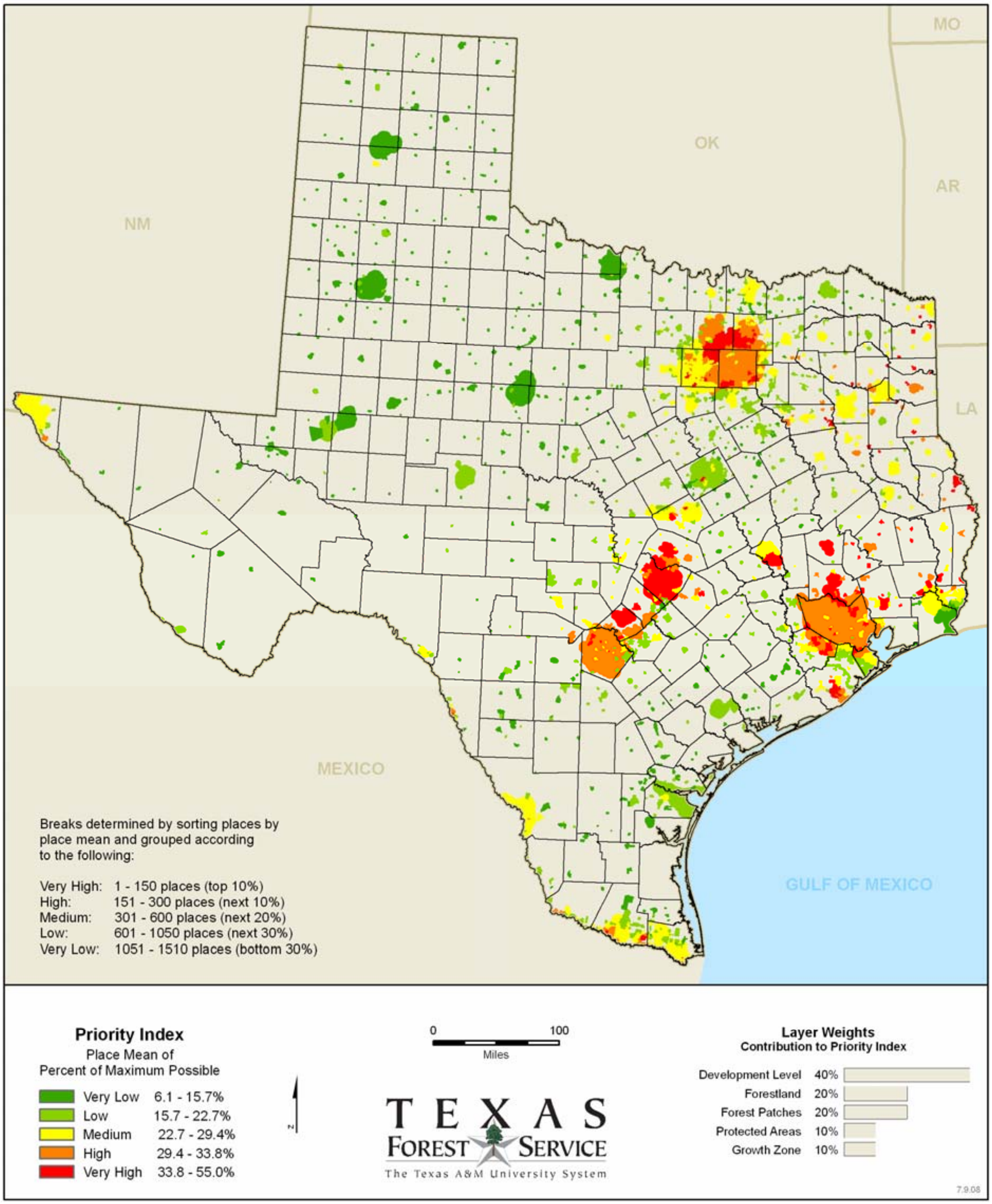
Map 6-b

Urban Forest Sustainability

Sub-Issue 1

Reduce the Impact of Urbanization on Forest Landscapes

U.S. Census Places plus Growth Zone as defined by Extra-territorial Jurisdiction



UFS Sub-Issue 2: Moderate the impacts of catastrophic events

Urban trees and forests are subject to the extreme forces of nature, just like rural forest landscapes. The difference is that urban trees have high values because of their location near buildings and other infrastructure, as well as high costs for removal following a storm event. More importantly perhaps, storm damage to trees in cities has an immediate impact on public safety because trees bring down power lines, damage homes, and block roadways for emergency vehicles and evacuation. For example, following Hurricane Rita in September 2005, more than 8.7 million cubic yards of woody debris were removed from the affected area at a cost of $128 million (U.S Army Corps of Engineers).

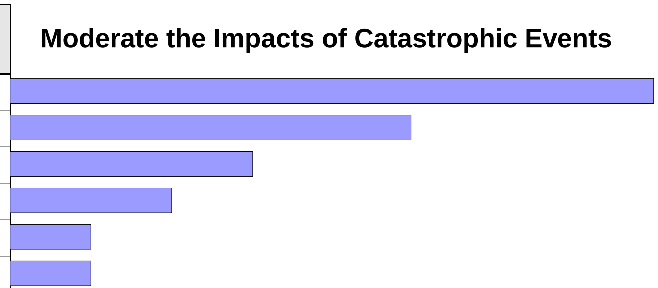
While natural events such as hurricanes, tornados, and ice storms are not preventable, managers of urban trees and forests can take steps to prepare for such an event before it occurs. Selecting tree species for plantings that are less susceptible to breakage, using pruning practices that result in stronger trunks and branches, and promoting cultural practices that encourage strong root systems are all ways to grow a storm resistant tree population. Incorporating a woody debris management plan into the city's emergency response plan is critical to managing an event and recovering federal aid that might result from a disaster declaration.

Wildfires can result in losses as dramatic as a tornado, but they are different in significant ways. Fires often consume vegetation on site, leaving less of an immediate debris problem; and, they are largely preventable. State forestry agencies across the country invest significant resources in wildland-urban interface areas to educate residents about fire danger throughout the year, help them manage fire fuels around homes, and develop emergency plans for fire suppression and evacuation.

To analyze this sub-issue spatially, six data layers were weighted according to their importance in locating priority communities in Texas (Table 20). Tree canopy (40%) represents the natural resource at risk from disaster and includes forestlands when an area the size of about an acre exhibits at least 20 percent canopy. Population density (10%) expresses the human values at risk from disaster events and the storm risk layers express the likelihood of each type of storm affecting an area in Texas. Higher weights were placed on the hurricane (25%) and ice storm (15%) layers because these events usually affect multiple communities at the same time, with severe damage to trees even during modest events. Fires (5%) and tornados (5%) most often impact single communities on a single day.

Table 20
Layer Weights for UFS Sub-Issue 2–Moderate the Impacts of Catastrophic Events

Layer Rank	Layer Name	Layer Weight
1	Tree Canopy	40
2	Hurricane Risk	25
3	Ice Storm Risk	15
4	Population Density by Block Group	10
5	Wildfire Risk	5
6	Tornado Risk	5
	TOTAL	*100*



Results

High-priority areas in Texas where U&CF activities and projects could help moderate the impacts of catastrophic events are shown in Maps 7-a and 7-b. Very high priority areas (on a pixel basis) comprise 689 thousand acres, which is 9.2 percent of the total area in US Census Places (Table 21). Of these acres, 69.1 percent is forestland.

Table 21
Area within Each Priority Class by Forest and Non-Forest for UFS Sub-Issue 2—
Moderate the Impacts of Catastrophic Events

Priority	Forest	Non-Forest	*TOTAL*
	- - - - - - - - - - - - - - - acres - - - - - - - - - - - - - - - -		
Very High	475,851	212,965	688,816
High	356,903	335,108	692,011
Medium	140,367	2,569,530	2,709,897
Low	72,475	1,934,333	2,006,808
Very Low	10,853	1,391,377	1,402,230
TOTAL	1,056,450	6,443,312	7,499,762

The very high priority communities identified represent the top 150 communities (top 10%) in which efforts should be focused to provide the greatest impact. Table 22 lists the top 15 communities (top 1%) by population.

Table 22
Top 15[†] Communities for UFS Sub-Issue 2 Priority

Place Name	Place Type	Population 2000
Houston	City	1,953,631
Pasadena	City	141,674
Beaumont	City	113,866
Tyler	City	83,650
Baytown	City	66,430
Galveston	City	57,247
The Woodlands	Census Designated Place	55,649
League City	City	45,444
Texas City	City	41,521
Conroe	City	36,811
Spring	Census Designated Place	36,385
Atascocita	Census Designated Place	35,757
Lufkin	City	32,709
Cedar Hill	City	32,093
La Porte	City	31,880

[†] Top 15 of top 10 percent by place mean after being sorted by place population

Potential U&CF activities that could be used to address this sub-issue in the high priority communities identified include:

- Enhance state and local pre- and post-event response, damage assessment, and recovery
- Incorporate urban and community forestry elements into local emergency response plans
- Increase implementation of ongoing urban forest risk management practices
- Develop programs for early detection and rapid response for invasive insects and diseases

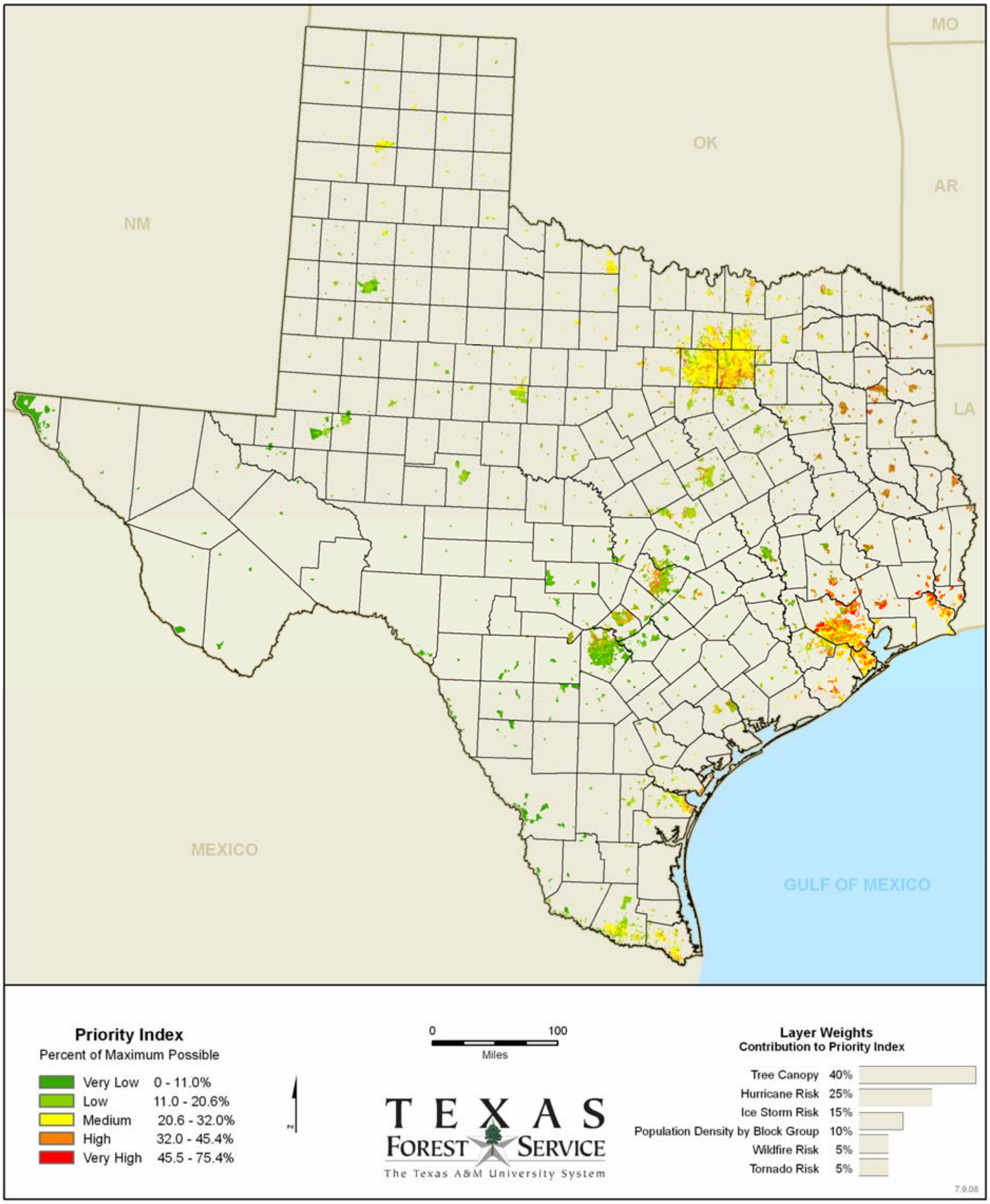
Map 7-a

Urban Forest Sustainability

Sub-Issue 2

Moderate the Impacts of Catastrophic Events

U.S. Census Places



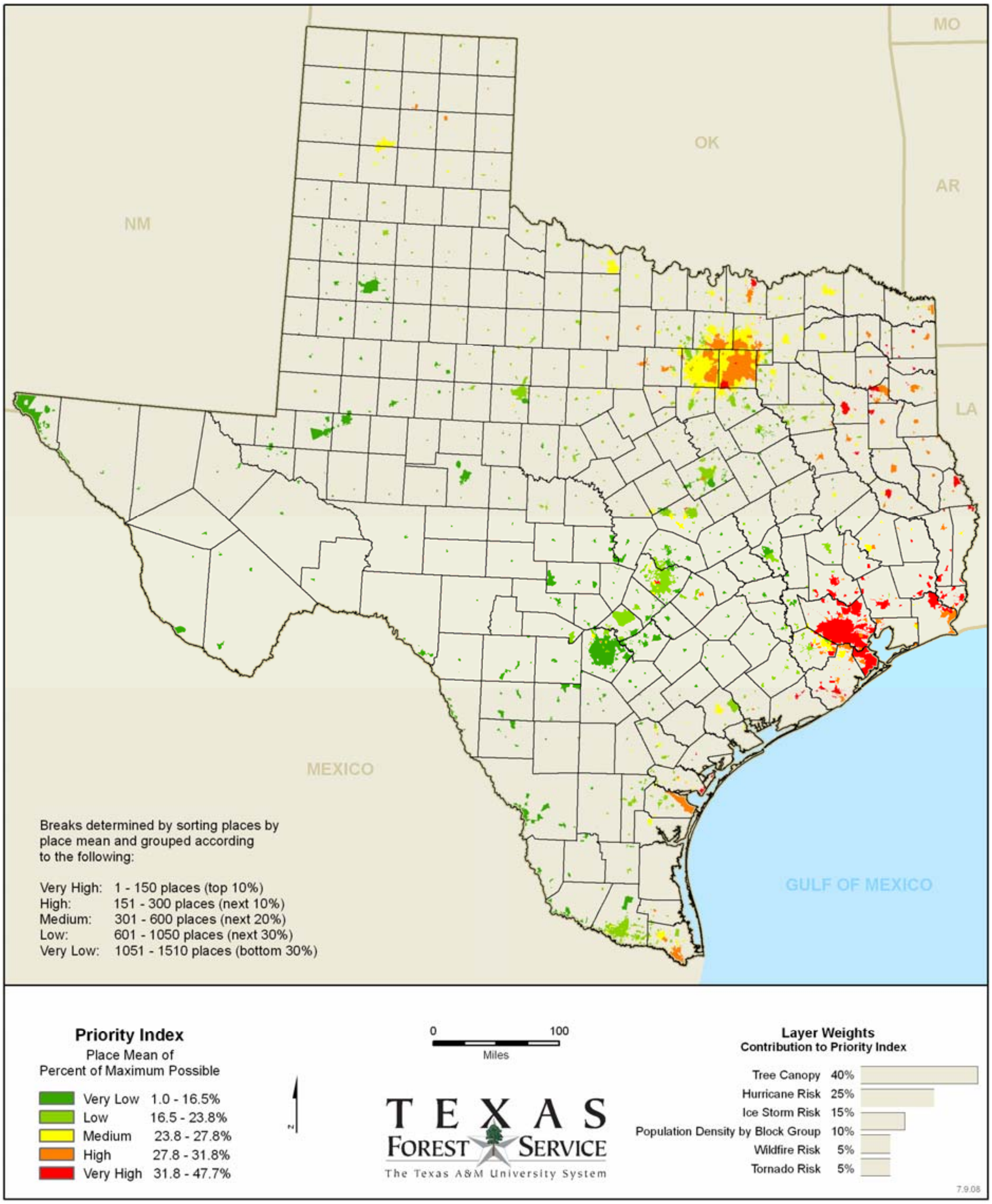
Map 7-b

Urban Forest Sustainability

Sub-Issue 2

Moderate the Impacts of Catastrophic Events

U.S. Census Places



UFS Sub-Issue 3: Protect and improve air quality

Ground-level ozone (O_3)—the primary ingredient in "smog"—is formed when nitrous oxides (NO_x) from vehicle exhaust and industrial smokestacks combine with volatile organic compounds (VOC) in the presence of sunlight and heat. VOCs come from manmade sources like gasoline vapors and chemical solvents, as well as native vegetation like trees. Ground-level ozone is a particularly harmful chemical affecting airways and lung tissue, especially for children, asthmatics, and the elderly. The secondary impacts include reduced visibility and damage to vegetation, crops, and buildings. (EPA: http://www.epa.gov/groundlevelozone/health.html)

Urban areas around the country are routinely cited as having the worst air quality, particularly from ground-level ozone. Under the Clean Air Act (1990 amended), the EPA is charged with setting limits for pollutants and regulating the sources of those pollutants through state regulatory authorities. The basic federal standard is now 75 parts per billion, averaged over an 8-hour period (the 8-hour standard). In Texas, the Texas Commission on Environmental Quality (TCEQ) prepares State Implementation Plans (SIP) for regions of the state where measurements exceed the federal standard—deemed "non-attainment" areas. A second level of "near non-attainment" identifies counties that have air quality problems that will exceed the federal standard if nothing is done to prevent them. Most of these areas are developing "Early Action Compact" plans similar to the SIP process, but designed to keep these areas from falling out of compliance. SIPs are formally approved and enforced by EPA, with penalties that include the withholding of federal transportation funds for the region.

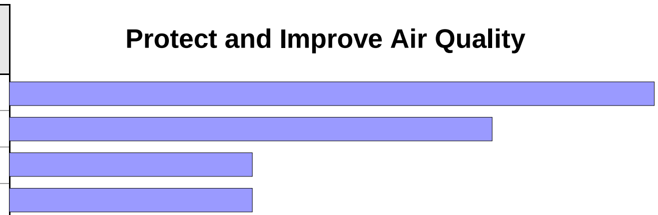
Trees and vegetation contribute to both the problem and the solution to air quality in and around our cities. Certain tree species (oaks, pines, sweetgum) emit VOCs from their leaves that add to the VOCs in the region (called "biogenic" emissions). In heavily forested areas of Texas, these biogenic emissions can be quite significant, accounting for 30 percent of all VOCs emitted (TCEQ: http://www.tceq.state.tx.us/implementation/air/areasource/Sources_of_Air_Pollution.html#Biogenic). On the other hand, trees transpire water from their leaves during photosynthesis, which in turn cools the air and reduces the rate of the chemical reaction that forms ozone in the first place. In addition, trees actually pull ozone out of the air as particles that cling to leaf surfaces.

The net effect of urban trees on regional air quality is generally a positive one. In the Houston area, trees removed a total of $146 million worth of ozone in 2000 (TFS: *Houston's Regional Forest* 2005). Adding new trees to mitigate ground-level ozone has been accepted by the EPA in SIPs around the country as a voluntary measure for meeting federal air quality standards. It is also logical to predict that preserving existing tree canopy would prevent the worsening of regional air quality, but state regulatory agencies and EPA have been reluctant to accept that argument in a SIP.

To locate the priority landscapes in Texas that would benefit from tree programs that plant or protect trees, four data layers were selected and weighted as follows (Table 23). Since increasing tree canopy is now a voluntary measure in many SIPs, Absence of Tree Canopy (40%) identifies communities with a greater potential for adding trees; the EPA Nonattainment Area (30%) identifies Texas counties exceeding federal air quality standards; Population Density by Block Group (15%) shows the human values at risk from poor air quality; and Development Level (15%) expresses the potential for additional tree losses and increased population over the next 30 years.

Table 23
Layer Weights for UFS Sub-Issue 3—Protect and Improve Air Quality

Layer Rank	Layer Name	Layer Weight
1	Absence of Tree Canopy	40
2	Ozone Nonattainment Area	30
3	Population Density by Block Group	15
4	Development Level (Urban)	15
	TOTAL	*100*



Results

High-priority areas in Texas where U&CF activities and projects could help protect or improve air quality are shown in Maps 8a and 8b. On a 30- by 30-meter basis, 2.1 million acres of U.S. Census Places is considered very high priority (Table 24). This represents 28.6 percent of the total. Forestland makes up 1.6 percent of these high priority areas.

Table 24
Area within Each Priority Class by Forest and Non-Forest for UFS Sub-Issue 3—Protect and Improve Air Quality

Priority	Forest	Non-Forest	*TOTAL*
	- - - - - - - - - - - - - - -	acres - - - - - - - - - - - - - - -	
Very High	34,354	2,113,582	2,147,936
High	181,508	1,798,024	1,979,533
Medium	363,389	2,305,795	2,669,184
Low	273,960	177,079	451,039
Very Low	203,239	48,852	252,091
TOTAL	1,056,450	6,443,333	7,499,784

The very high priority communities identified represent the top 150 communities (top 10%) where efforts should be focused to provide the greatest impact. Table 25 lists the top 15 communities (top 1%) by population.

Potential U&CF activities that could be used to address this sub-issue in the high priority communities identified include:

- Develop SIP language for voluntary or enforceable measures to increase or prevent the destruction of tree canopy
- Help communities in non-attainment areas set tree planting goals and develop plans to achieve them
- Develop policies at the local level that reduce the loss of existing urban tree canopy

- Promote the planting of suitable tree species with large leaf surface areas to capture pollutants

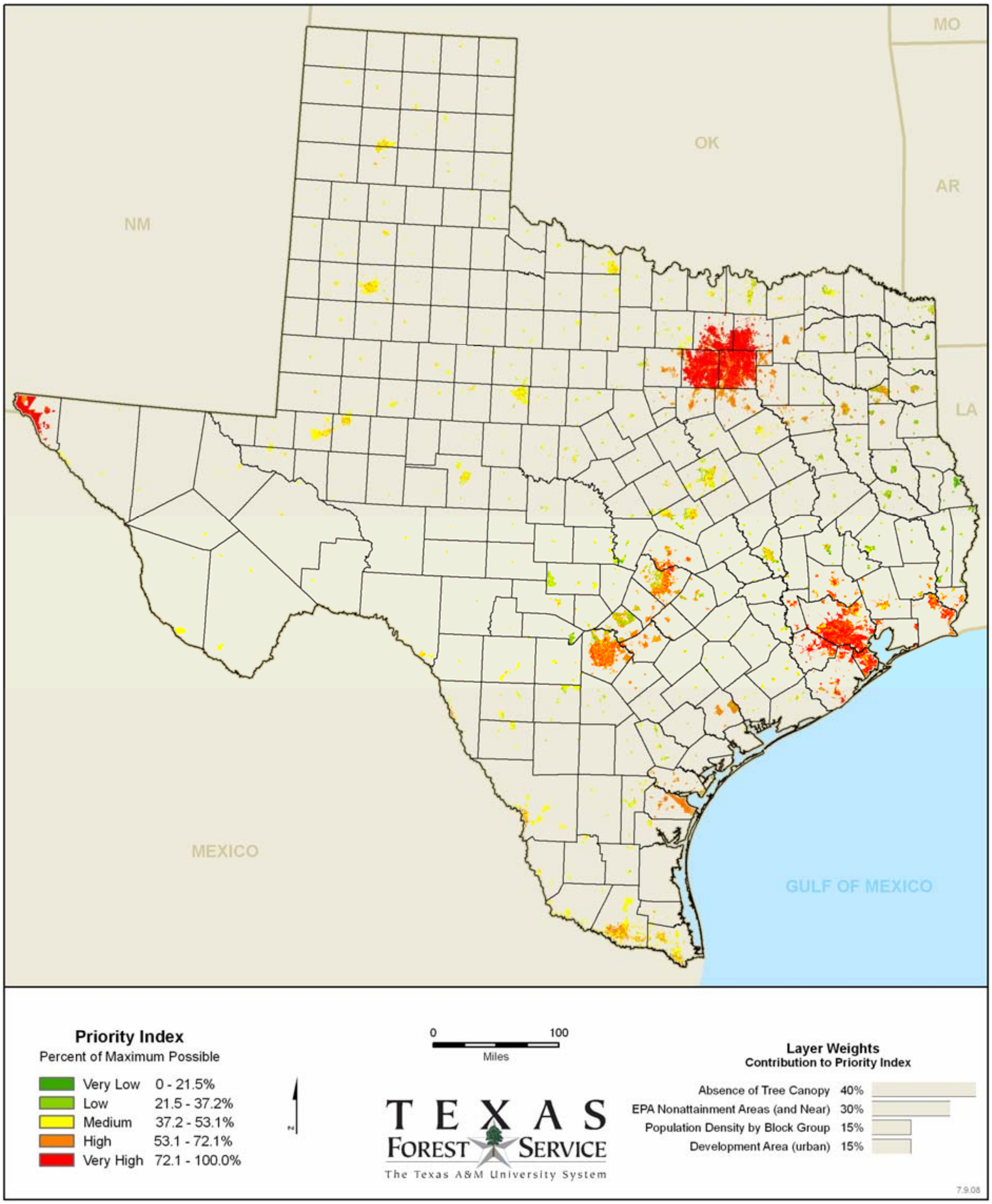
Table 25
Top 15[†] Communities for UFS Sub-Issue 3 Priority

Place Name	Place Type	Population 2000
Dallas	City	1,188,580
El Paso	City	563,662
Fort Worth	City	534,694
Arlington	City	332,969
Plano	City	222,030
Garland	City	215,768
Irving	City	191,615
Pasadena	City	141,674
Grand Prairie	City	127,427
Mesquite	City	124,523
Carrollton	City	109,576
Richardson	City	91,802
Denton	City	80,537
Lewisville	City	77,737
Sugarland	City	63,328

[†] Top 15 of top 10 percent by place mean after being sorted by place population

Map 8-a
Urban Forest Sustainability
Sub-Issue 3
Protect and Improve Air Quality

U.S. Census Places



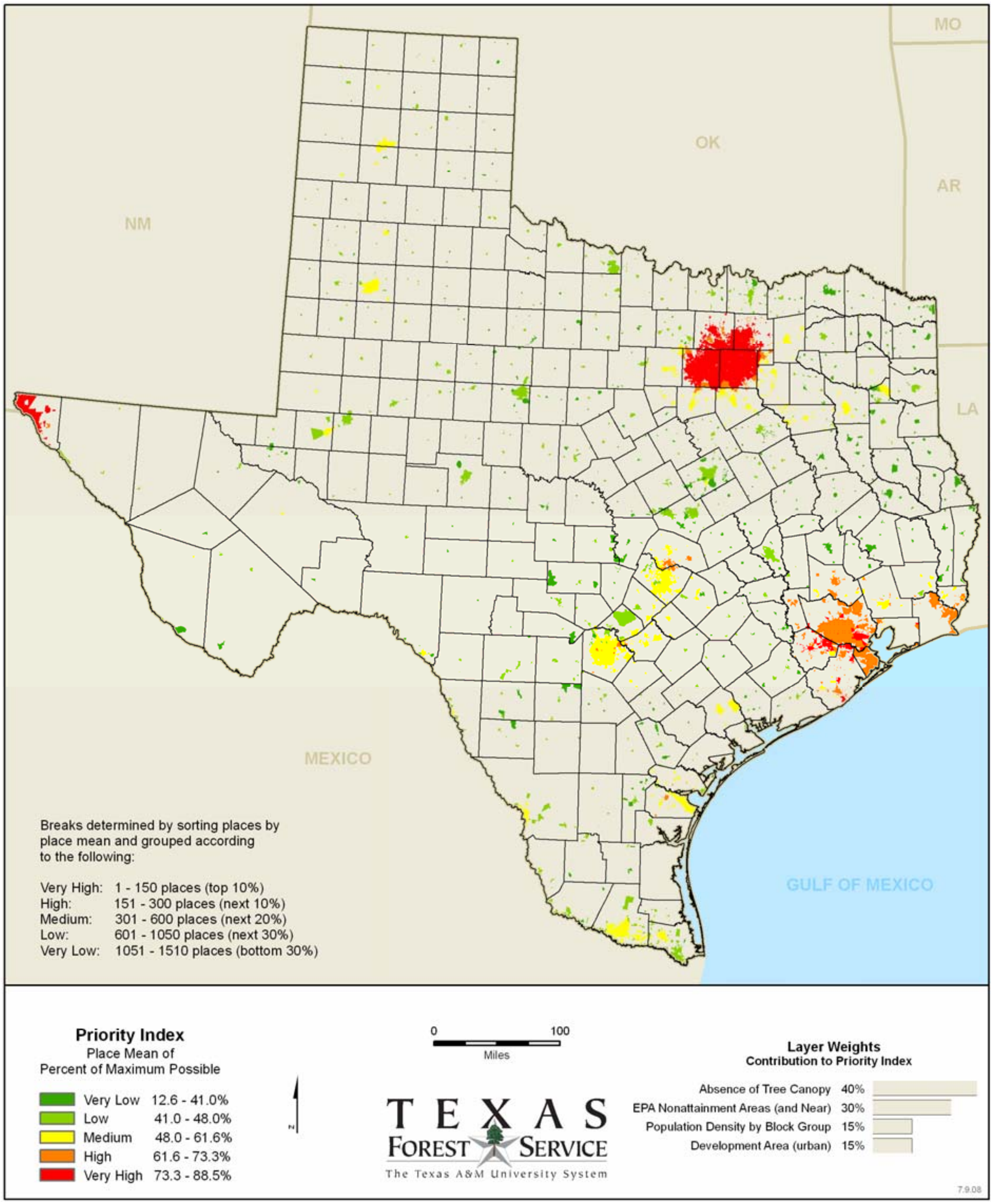
Map 8-b

Urban Forest Sustainability

Sub-Issue 3

Protect and Improve Air Quality

U.S. Census Places



UFS Sub-Issue 4: **Protect and improve water quality**

Texas weather is highly variable, both seasonally and geographically, with average annual precipitation ranging from less than eight inches in El Paso to more than 48 inches in Beaumont. Rain events can be quite dramatic, such as the event on July 25-26, 1979 in Alvin, TX, when a U.S.-record 43 inches of rain fell over a 24-hour period (Texas Almanac). In 2007, during an historic wet summer, the town of Marble Falls received as much as 18 inches of rain in just three hours (http://science.howstuffworks.com/texas-rain.htm/printable).

Most rain events are more moderate, but any time rain falls on the impervious surfaces of our cities, it picks up debris, chemicals, sediment, and other pollutants and delivers them to either a city stormwater system or directly to a stream, lake, or river—often a source of public drinking water. The impacts of this urban non-point source pollution can be significant and removing it from drinking water is both mandatory and costly.

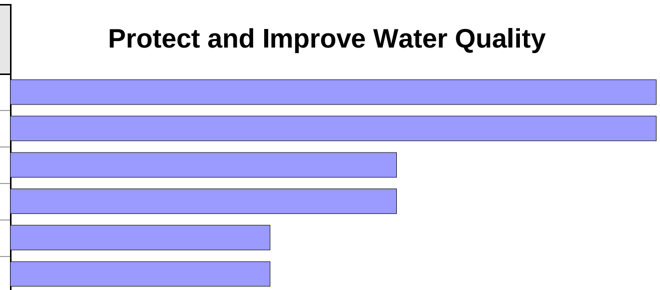
Recent studies have documented the benefits of urban trees in reducing the amount of stormwater that enters a watershed following a rain event (American Forests, USFS). Leaves and branches intercept and hold rain droplets, reducing volume and delaying peak flows; rooting space occupied by trees increases infiltration rates and the holding capacity of soil; tree canopies reduce the impact of raindrops on barren soil, thus reducing erosion; and transpiration by leaves moves water from the soil back to the atmosphere, reducing the amount of water entering surface water bodies (USFS: *Interior West Community Tree Guide*, 2007).

Trees and forests in urban areas also provide a valuable buffer for streams by filtering chemicals from subsurface flows through the soil. In particular, nitrogen and phosphorus from fertilizers are actively removed from water in the upper layers of the soil as it moves through the roots of trees in a forested buffer zone. Forest soils also serve as sponges that hold significant amounts of stormwater, allowing it to infiltrate and reducing peak runoff and flash flooding.

To locate priority landscapes in Texas that would benefit from trees and forests to protect or improve water quality, six of the available data layers were weighted as follows (Table 26). Public Dinking Water Supply (25%) and Impaired Watersheds (10%) represent the highest priority watersheds that would benefit from urban trees; Imperviousness (25%) represents the primary source of water quality problems in a city; Forestland (15%) and Riparian Areas (10%) in cities show critical areas where protection or restoration activities might achieve long-term benefits; and Development Level (15%) expresses the likelihood of additional impervious surfaces over the next 30 years.

Table 26
Layer Weights for UFS Sub-Issue 4—Protect and Improve Water Quality

Layer Rank	Layer Name	Layer Weight
1	Public Drinking Water	25
2	Imperviousness	25
3	Forestland	15
4	Development Level (urban)	15
5	Impaired Watersheds	10
6	Riparian Areas	10
	TOTAL	*100*



Results

High-priority areas in Texas where U&CF activities and projects could help protect or improve water quality are shown in Maps 9-a and 9-b. Very high priority areas (on a pixel basis) include 610 thousand acres, or 8.1 percent of the total area of U.S. Census Places (Table 27). Of these, forestland comprises 34.8 percent.

Table 27
Area within Each Priority Class by Forest and Non-Forest for UFS Sub-Issue 4—Protect and Improve Water Quality

Priority	Forest	Non-Forest	*TOTAL*
	- - - - - - - - - - - - - - -	acres - - - - - - - - - - - - - - -	
Very High	212,151	397,891	610,042
High	292,823	1,119,084	1,411,907
Medium	323,371	1,364,433	1,687,804
Low	228,105	1,763,916	1,992,022
Very Low	0	1,798,772	1,798,772
TOTAL	1,056,451	6,444,096	7,500,547

The very high priority communities identified represent the top 150 communities (top 10%) in which efforts should be focused to provide the greatest impact. Table 28 lists the top 15 communities (top 1%) by population.

Potential U&CF activities that could be used to address this sub-issue in the high priority communities identified include:

- Work with local stormwater and public works managers to calculate the value of community trees on water quality
- Develop municipal watershed policies that protect forestland parcels and forested riparian zones
- Create local programs that revegetate critical riparian zones
- Promote the planting of suitable street trees with large leaf surface areas to shade impervious surfaces and intercept rainfall

Table 28
Top 15[†] Communities for UFS Sub-Issue 4 Priority

Place Name	Place Type	Population 2000
Pasadena	City	141,674
Brownsville	City	139,722
McAllen	City	106,414
Baytown	City	66,430
Sugar Land	City	63,328
Harlingen	City	57,564
Missouri City	City	52,913
Edinburg	City	48,465
Pharr	City	46,660
League City	City	45,444
Mission	City	45,408
Texas City	City	41,521
Pearland	City	37,640
Spring	Census Designated Place	36,385
Atascocita	Census Designated Place	35,757

[†] Top 15 of top 10 percent by place mean after being sorted by place population

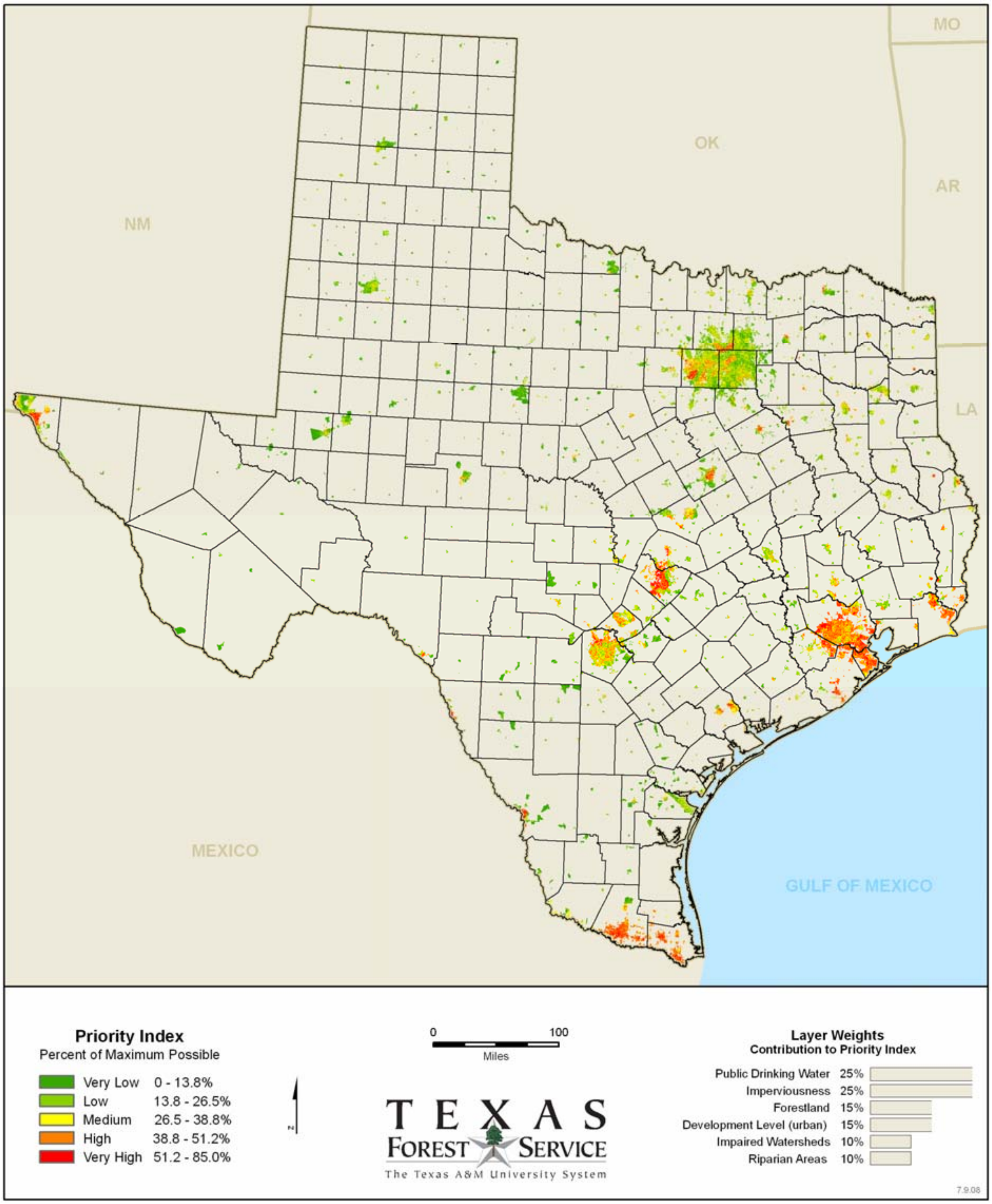
Map 9-a

Urban Forest Sustainability

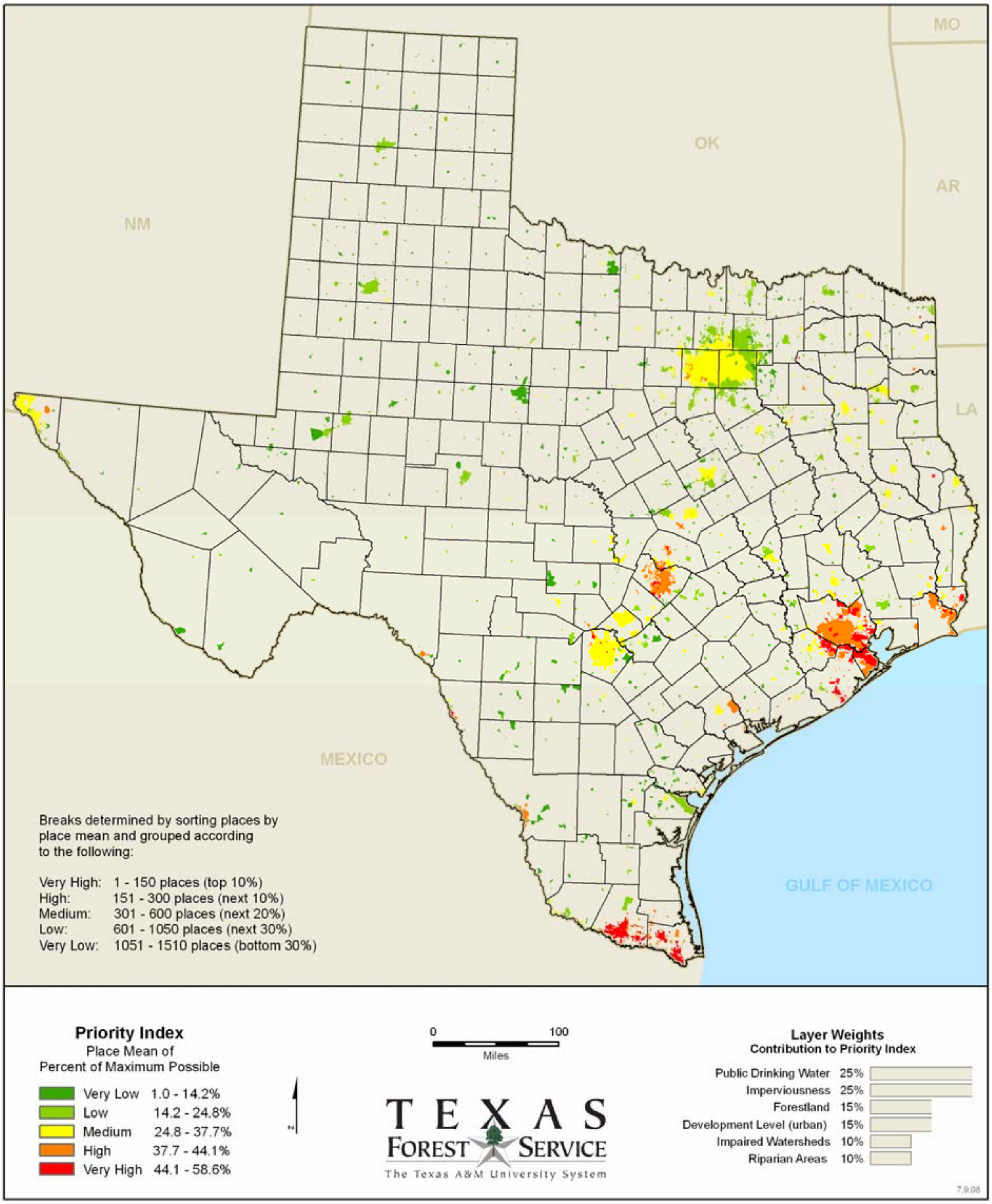
Sub-Issue 4

Protect and Improve Water Quality

U.S. Census Places



Map 9-b
Urban Forest Sustainability
Sub-Issue 4
Protect and Improve Water Quality
U.S. Census Places



UFS Sub-Issue 5: Mitigate climate change & conserve energy

The Intergovernmental Panel on Climate Change (IPCC) has concluded that global concentrations of carbon dioxide, methane, and nitrous oxide (the primary greenhouse gases) have increased as a result of human activities since 1750 and now far exceed pre-industrial levels. The primary reasons for these increasing levels are the burning of fossil fuels and land-use change. As a result, this segment of the scientific community predicts rising sea levels, loss of sea ice, and increased frequency of drought, heat waves, and heavy precipitation events over the next century. (IPCC, 2007*: Summary for Policymakers. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*). http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_SPM.pdf

Even if the projected impacts of this "greenhouse effect" do not materialize, Texas cities in the summer are already uncomfortable places, with temperatures regularly reaching 95 to 100˚F on many days. In the summer of 1980, the Dallas/Fort Worth area experienced 42 consecutive days over 100˚F and the city of Wichita Falls hit an all-time high temperature of 117˚F (http://en.wikipedia.org/wiki/1980_United_States_heat_wave). Central sections of major cities often have so much impervious surface that they form "urban heat islands," with temperatures 2 to 10˚F hotter than nearby rural areas. This temperature difference results in increased peak energy use, higher air conditioning costs, increased air pollution levels, and heat-related illness or even death (EPA: http://www.epa.gov/heatisland/index.html). Any climate change that results in more days of extreme temperatures in Texas cities can only increase costs and risks to human health.

Trees can mitigate both the source and the effects of global climate change. Through the natural process of photosynthesis, trees remove carbon dioxide from the air and turn gaseous carbon into solid wood. Carbon locked up in living trees is considered storage and as trees grow larger each year they sequester additional carbon and add it to the stored carbon in their trunks, branches, and roots. In the eight-county Houston region, trees store 39.2 million tons of carbon, valued at $721 million. The rate of sequestration was calculated to be 1.6 million tons of carbon annually, valued at $29 million (Texas Forest Service, 2005: *Houston's Regional Forest*).

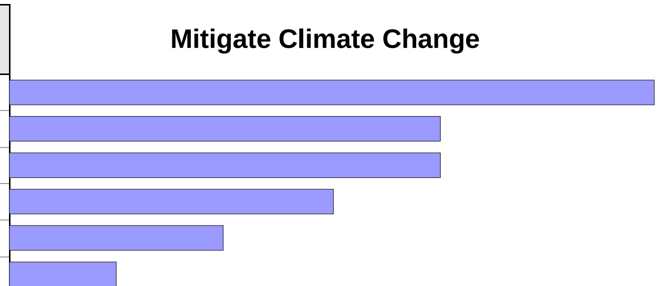
Trees can directly affect the consumption of energy used to cool buildings by shading windows and roof surfaces from direct sunlight. Studies have shown the benefits of strategically planted trees, particularly on the east-, south-, or west-facing sides of one- and two-story buildings (Sacramento Municipal Utility District: http://www.smud.org/residential/trees/index.html). The study in Houston calculated direct energy savings of $112 million annually, with an additional $5.4 million savings in avoided carbon emissions from power plants. Programs to strategically plant trees near unshaded homes may be the most significant contribution that urban forestry can make providing direct cost reductions for homeowners.

Trees also produce indirect effects that benefit our climate, at least at the local level. When planted near buildings and along streets, urban trees cool impervious surfaces that could result in a reduced "urban heat island" effect. They can combine to cool the air through the process of transpiration, although this effect is most noticeable in dry climate cities like El Paso rather than humid cities like Houston. Shade from trees over public spaces like sidewalks, streets, and parks makes a city more tolerable for outdoor activities during summer months, which is a significant indicator of quality of life for urban residents.

To analyze this sub-issue of mitigating climate change and improving energy efficiency, six of the available data layers were selected and weighted as follows (Table 29). Imperviousness (30%) represents the potential for urban heat islands to form; Population Density by Block Group (20%) describes the areas where energy use may be highest and would benefit the most from efficiency programs using trees. Forestland (20%) represents significant areas for carbon storage that may deserve protection, since the stored carbon in these areas is released as land is cleared for other uses. Development Level (15%) implies an increase in both population and housing, resulting in increased pressure on tree canopy, plantable space, and energy use. Cities with more Plantable Space (10%) have a greater need and opportunity to add trees for both climate change and energy efficiency measures. Finally, soils with higher Site Productivity (5%) represent higher priority tree-planting sites to sequester and store carbon.

Table 29
Layer Weights for UFS Sub-Issue 5—Mitigate Climate Change

Layer Rank	Layer Name	Layer Weight
1	Imperviousness	30
2	Population Density by Block Group	20
3	Forestland	20
4	Development Level (urban)	15
5	Plantable Space	10
6	Site Productivity	5
	TOTAL	*100*



Results

High-priority communities in Texas where U&CF programs and projects could mitigate the negative effects of climate change or improve energy efficiency are shown in Maps 10a and 10b. Very high priority areas (pixel basis) include 728,446 acres, which makes up 9.7% of the total (Table 30). Forestland comprises 24.6 percent of these very high priority areas.

Table 30
Area within Each Priority Class by Forest and Non-Forest for UFS Sub-Issue 5—Mitigate Climate Change

Priority	Forest	Non-Forest	*TOTAL*
	- - - - - - - - - - - - - - - -	acres - - - - - - - - - - - - - - - -	
Very High	179,513	548,933	728,446
High	336,702	1,048,382	1,385,085
Medium	465,589	1,323,904	1,789,493
Low	74,618	1,490,104	1,564,722
Very Low	0	2,031,770	2,031,770
TOTAL	1,056,422	6,443,094	7,488,517

The very high priority communities identified represent the top 150 communities (top 10%) in which efforts should be focused to provide the greatest impact. Table 31 lists the top 15 communities (top 1%) by population.

Table 31
Top 15† Communities for UFS Sub-Issue 5 Priority

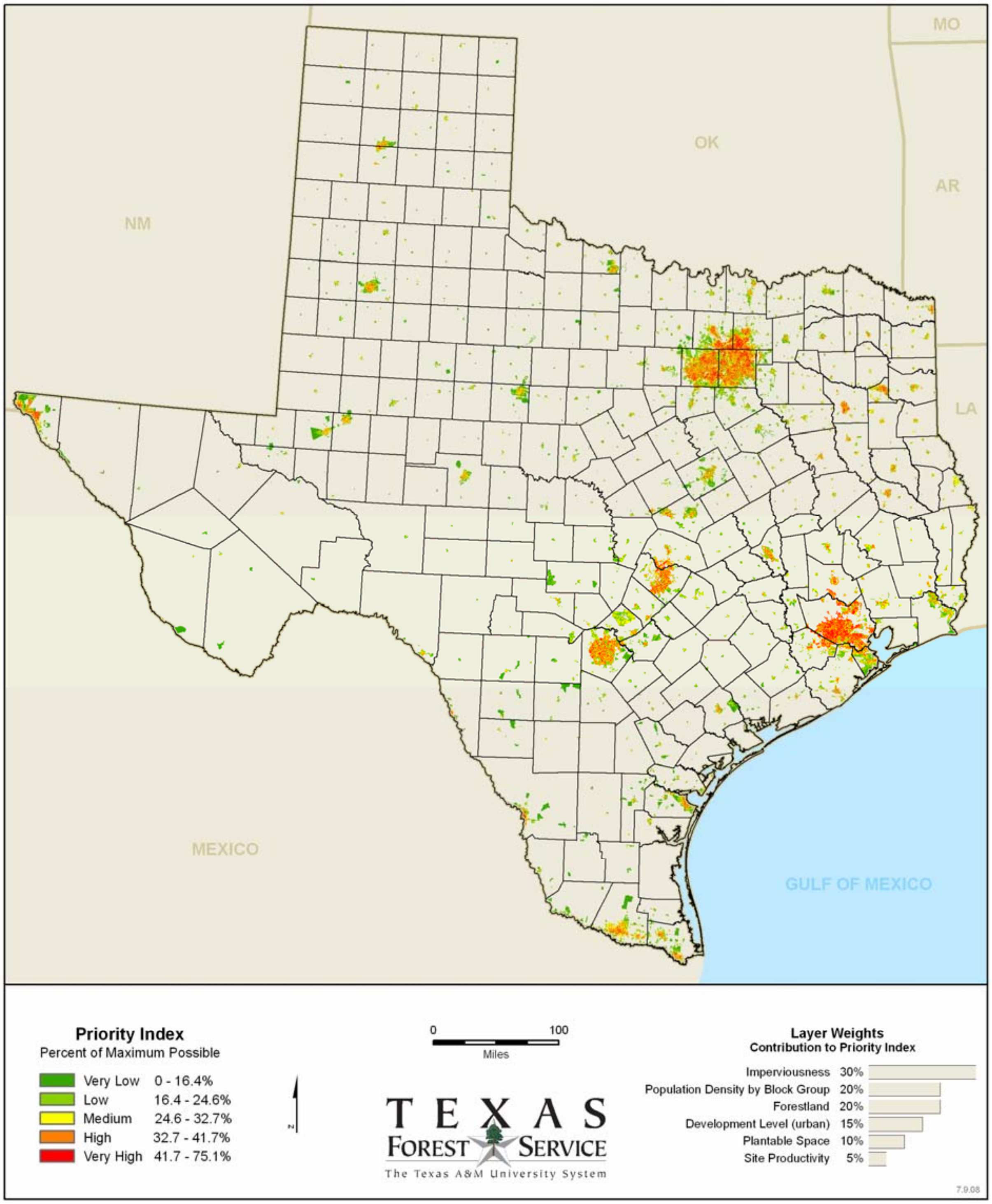
Place Name	Place Type	Population 2000
Houston	City	1,953,631
Dallas	City	1,188,580
San Antonio	City	1,144,646
Austin	City	656,562
Arlington	City	332,969
Plano	City	222,030
Garland	City	215,768
Irving	City	191,615
Pasadena	City	141,674
Mesquite	City	124,523
Carrollton	City	109,576
McAllen	City	106,414
Richardson	City	91,802
Tyler	City	83,650
Lewisville	City	77,737

† Top 15 of top 10 percent by place mean after being sorted by place population

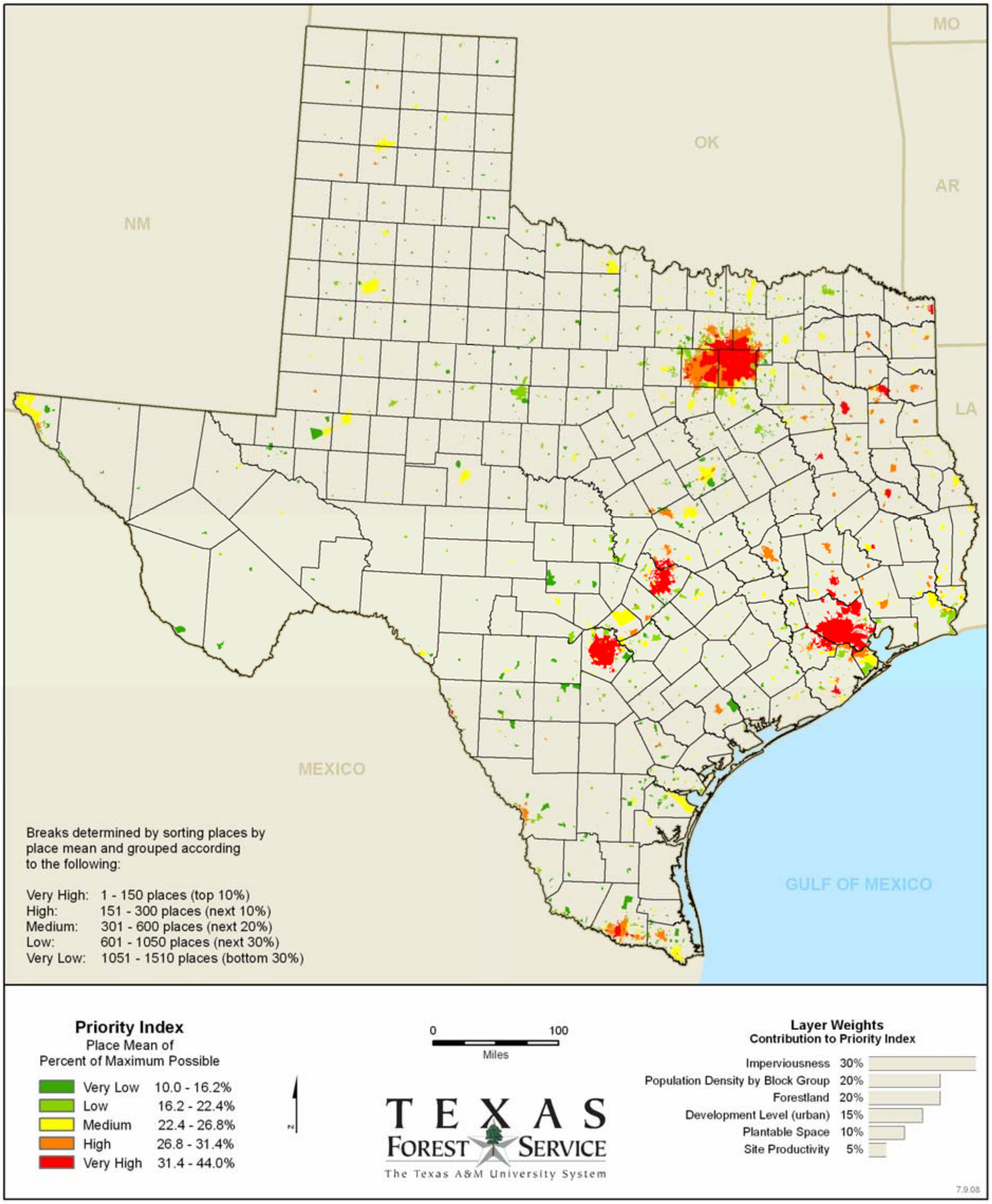
Potential U&CF activities that could be used to address this sub-issue in the high priority communities identified include:

- Help communities develop tree-planting goals for carbon storage and the plans to achieve them
- Support local non-profit groups and energy companies with programs to plant trees near homes for energy efficiency
- Develop best management practices (BMPs) for replacing concrete and asphalt with trees to break up or reduce the size of urban heat islands

Map 10-a
Urban Forest Sustainability
Sub-Issue 5
Mitigate Climate Change and Conserve Energy
U.S. Census Places



Map 10-b
Urban Forest Sustainability
Sub-Issue 5
Mitigate Climate Change and Conserve Energy
U.S. Census Places



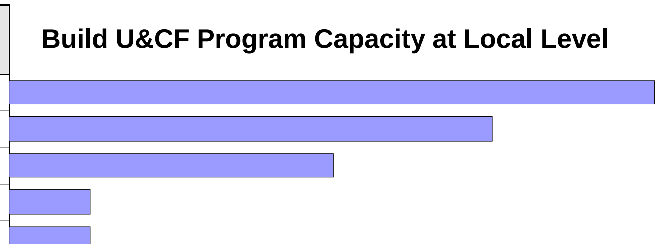
UFS Sub-Issue 6: Build U&CF program capacity at the local level

State forestry agencies have worked for more than two decades to provide technical, financial, and educational assistance in order to create the infrastructure for communities to deliver U&CF programs to their citizens. This annual assistance has led to certain organizational milestones that communities accumulate over time. Four performance measures are tracked annually for each community in the state and reported in the Community Accomplishment Reporting System (CARS) developed by the USFS: professional staffing, tree ordinances, management plans based on scientific inventories, and tree advocacy groups that provide citizen support. When a community achieves all four of these key measures, it is considered to be actively managing its urban forest resource.

In developing state strategic plans and annual work plans, Texas Forest Service staff considered the total population of a community, since active U&CF programs in larger communities serve more people. The goal in the current analysis was to identify the largest communities in Texas with the fewest of the four key measures. For this reason, total population of each community was weighted the heaviest of the five layers (40%). Of the four key measures, some are more important than others as communities strive towards the goal of program sustainability. Having a professional staff forester or arborist in charge of a community's tree program is the best indicator of a sustainable program; large cities without such a position should receive priority attention (30%). Similarly, not having a management plan to follow (20%), not having ordinances or policies that govern city trees (5%), and not having a citizen advisory group for support (5%) all add a level of priority to the analysis. The layer-weighting scheme for this sub-issue is shown in Table 32.

Table 32
Layer Weights for UFS Sub-Issue 6—Build U&CF Program Capacity at the Local Level

Layer Rank	Layer Name	Layer Weight
1	Total Population (place)	40
2	No Professional Staff	30
3	No Management Plan	20
4	No Tree Ordinance	5
5	No Advocacy Group	5
	TOTAL	*100*



Results

High-priority communities in Texas where state U&CF assistance can lead to local program sustainability are shown in Map 11. Very high priority areas (pixel basis) include 550,208 acres, or 7.3 percent of the total (Table 33). Of these very high priority areas, forestland comprises 6.3 percent.

Table 33
Area within Each Priority Class by Forest and Non-Forest for UFS Sub-Issue 6—Build U&CF Program Capacity at Local Level

Priority	Forest	Non-Forest	*TOTAL*
	- - - - - - - -	acres - - - - - - - -	
Very High	34,908	515,300	550,208
High	114,736	690,137	804,874
Medium	123,420	632,674	756,094
Low	552,964	3,013,527	3,566,491
Very Low	230,798	1,599,494	1,830,292
TOTAL	1,056,827	6,451,132	7,507,959

The very high priority communities identified represent the top 13 communities (top 1%) (Table 34) in which efforts should be focused to provide the greatest public benefit.

Table 34
Top 13[†] Communities for UFS Sub-Issue 6 Priority

Place Name	Place Type	Population 2000
Lubbock	City	199,564
Irving	City	191,615
Laredo	City	176,576
Pasadena	City	141,674
Abilene	City	115,930
Beaumont	City	113,866
McAllen	City	106,414
Wichita Falls	City	104,197
San Angelo	City	88,439
Port Arthur	City	57,755
Harlingen	City	57,564
Galveston	City	57,247
Missouri City	City	52,913

[†] Top 13 includes all of highest priority class and are sorted by population

Potential U&CF programs that could be used to address this sub-issue in the high priority communities identified include:

- Provide cost-share grants for professional staff positions to lead a local U&CF program
- Support scientific inventory systems for public trees and help cities write effective management plans
- Continue to support the Tree City USA program and help communities develop a basic public tree care ordinance
- Assist cities with writing effective tree preservation ordinances
- Advise local tree groups on ways to coordinate efforts within cities to deliver tree planting and care information to citizens
- Create regional and statewide opportunities for continuing education, especially for municipal tree managers and their staff

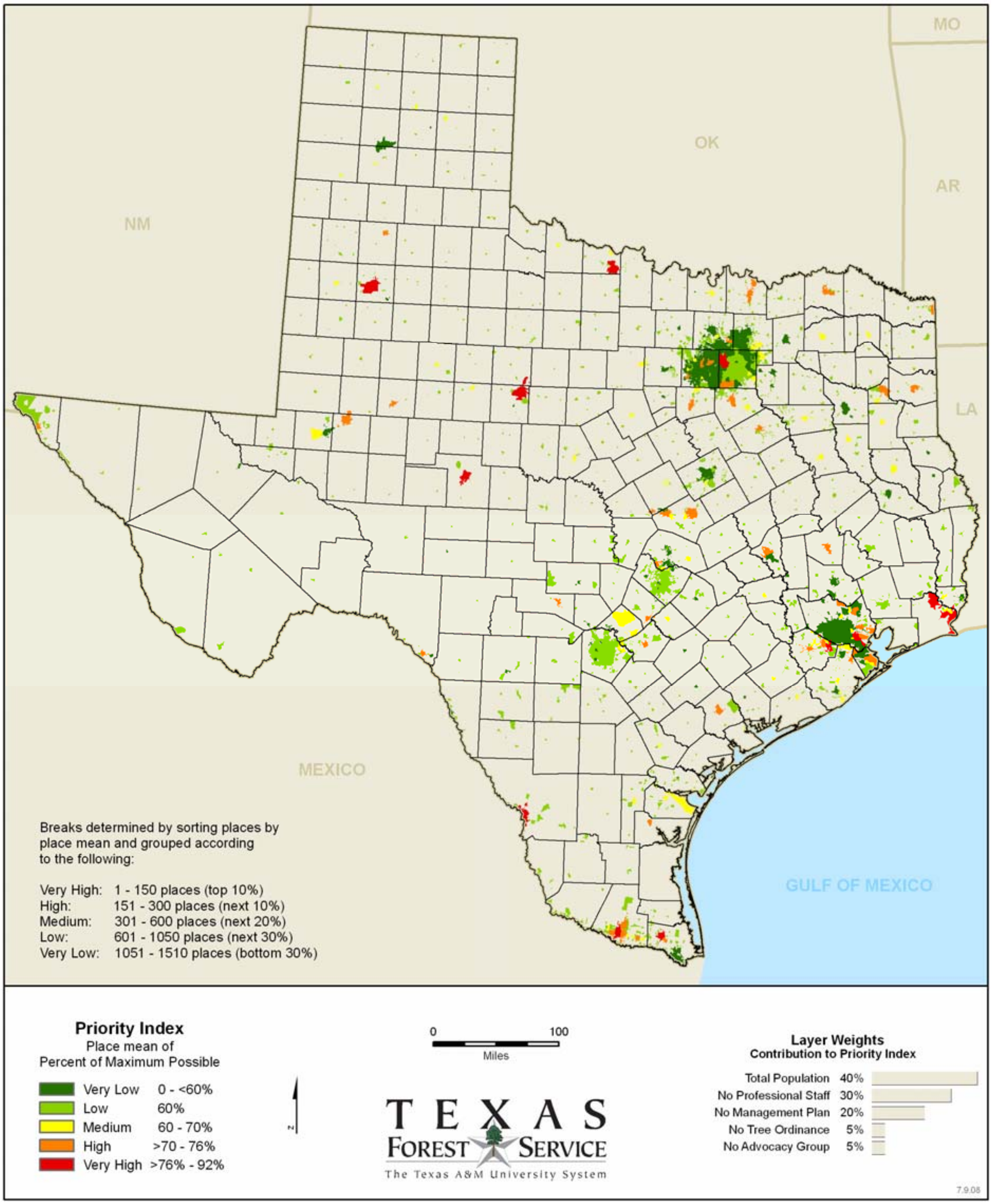
Map 11

Urban Forest Sustainability

Sub-Issue 6

Build U&CF Program Capacity at Local Level

U.S. Census Places



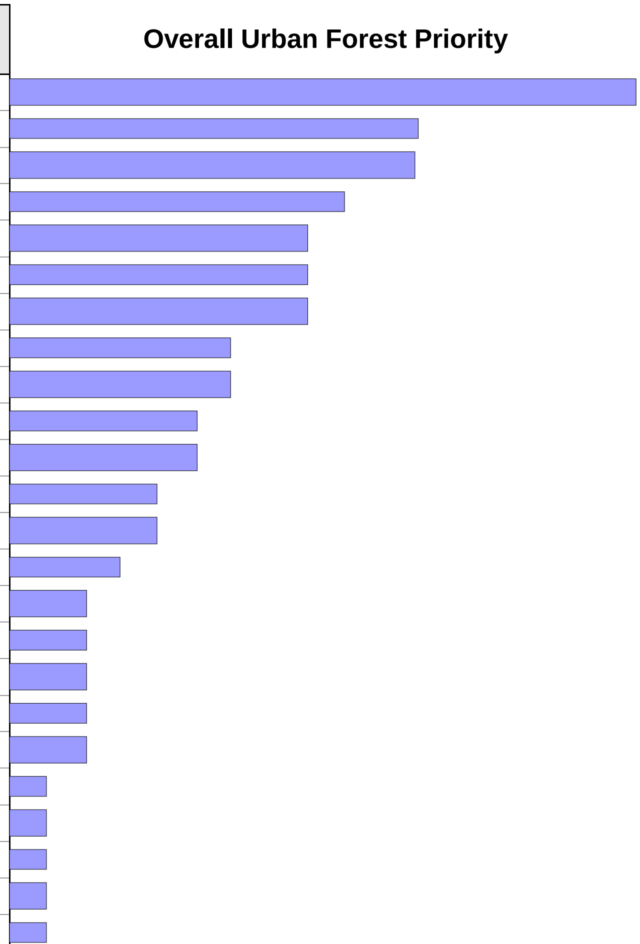
Combined Analysis for UFS Sub-Issues 1 through 6: Overall Urban Forest Priority

All of the analyses for the previous six sub-issues averaged pixel values across established boundaries for census places in Texas. This allows Texas Forest Service staff to prioritize communities in order to focus future assistance to solve complex resource problems in the urban landscape on a scale that field managers recognize. But cities and towns do not represent the entire urban landscape, at least as defined by the U.S. Census, which defines *urban* as urbanized areas and urban clusters, and one of the tasks for this state assessment was to develop a map that included all urban areas—including those outside the limits of cities, towns, or places.

To produce this new map, which coincidentally fills in the masked-out areas of the Southern Forest Lands Assessment (SFLA), all layers used to analyze the six UFS sub-issues were incorporated by simply adding the percentage values for layers from each sub-issue analysis and dividing by six. Table 35 shows the contribution of the layers towards this combined urban area analysis.

Table 35
Layer Weights for Overall Urban Forest Priority—Sub-Issues 1 through 6

Layer Rank	Layer Name	Layer Weight
1	Development Level (urban)	14.1
2	Imperviousness	9.2
3	Forestland	9.1
4	Population Density by Block Group	7.5
5	Tree Canopy	6.7
6	Absence of Tree Canopy	6.7
7	Total Population	6.7
8	Ozone Nonattainment Area	5.0
9	No Professional Staff	5.0
10	Hurricane Risk	4.2
11	Public Drinking Water	4.2
12	Forest Patches	3.3
13	No Management Plan	3.3
14	Ice Storm Risk	2.5
15	Protected Areas	1.7
16	Place Growth Zone	1.7
17	Impaired Watersheds	1.7
18	Riparian Areas	1.7
19	Planting Space	1.7
20	Wildfire Risk	0.8
21	Tornado Risk	0.8
22	Site Productivity	0.8
23	No Tree Ordinance	0.8
24	No Advocacy Group	0.8
	TOTAL	*100*



Results

Map 12 shows Overall Urban Forest Priority at the 30-meter pixel level. Values were classified into five classes, ranging from very high to very low, using Natural Breaks classification. Table 36 shows number of acres in each priority class for forest and non-forest. Very high priority areas include 538,046 acres, which is 11.8 percent of the total. Of these acres, forestland makes up 31.0 percent.

Table 36
Area within Each Priority Class by Forest and Non-Forest for Overall Urban Forest Priority

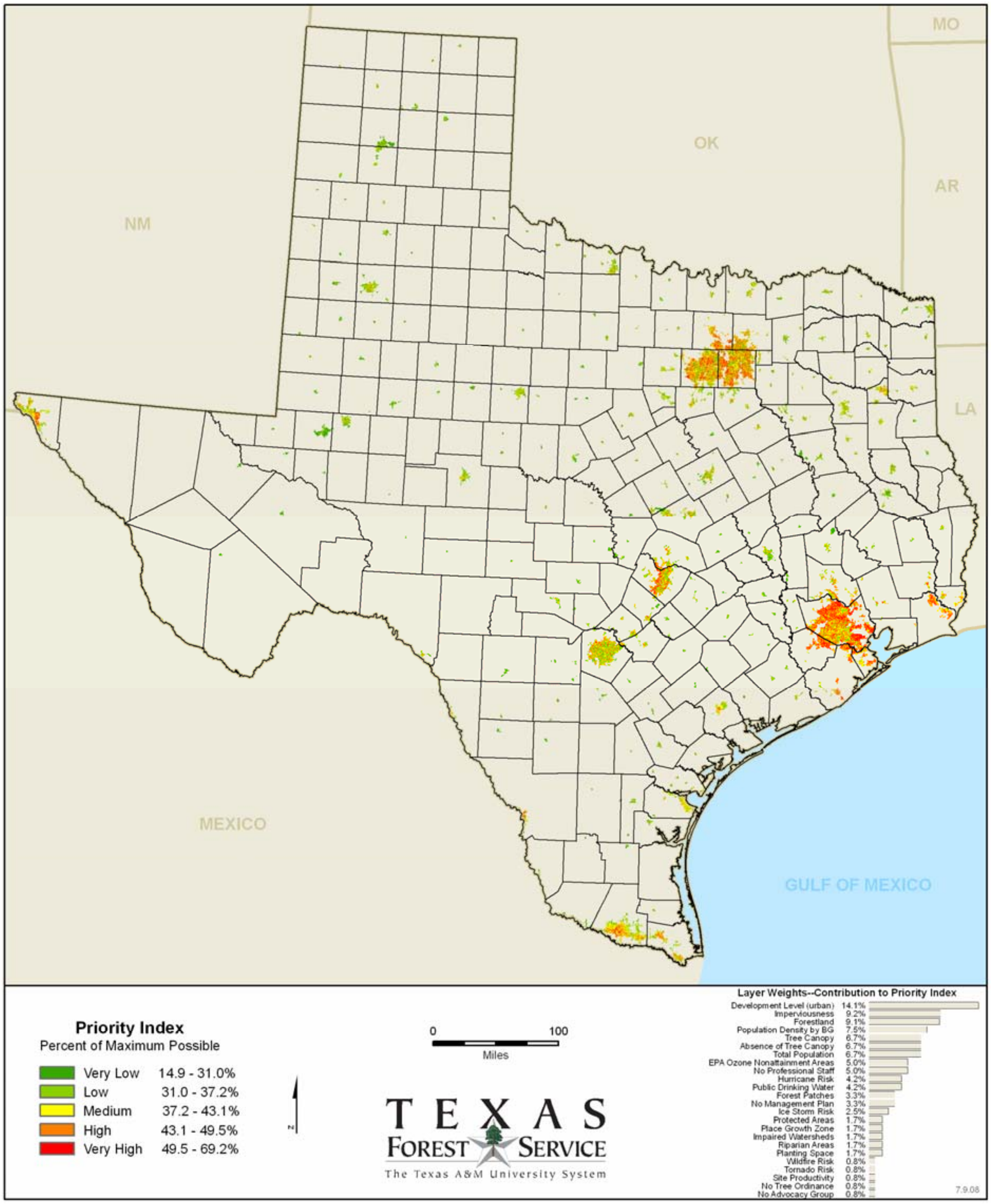
Priority	Forest	Non-Forest	*TOTAL*
	- - - - - - - - - - - - - - - -	acres - - - - - - - - - - - - - - - -	
Very High	166,542	371,504	538,046
High	148,246	861,564	1,009,811
Medium	110,152	1,084,745	1,1194,897
Low	51,076	1,126,891	1,177,967
Very Low	2,595	622,364	624,959
TOTAL	478,612	4,067,068	4,545,680

Conclusion

Urban forest sustainability is a broad concept that brings together several key environmental and social goals related to the urban landscape where people live, work, and play. The role of federal and state agencies is to help managers and policy-makers at the local level understand their part in acting locally to help solve regional or global problems. More detailed canopy studies are likely needed to calculate benefits of urban trees to society and help local managers plan for increasing tree cover.

At the same time, state agencies must continue to support the development of local capacity for U&CF to insure that issues like public tree management, local regulation, planning, and citizen involvement remain important ones for cities and towns across the state. Without those basic elements at the local level, it will be difficult to galvanize regional, statewide, or national support for measures that ultimately solve these major environmental challenges.

Map 12
Urban Forest Sustainability
Overall Urban Forest Priority
U.S. Census Urban Areas and Urban Clusters



Combined Rural and Urban Priority

A requirement for the development of a Statewide Assessment of Forest Resources for Redesign is that it include the entire state. The Southern Forest Land Assessment does not include urban areas. This is understandable since the SFLA, along with other SAP analyses around the nation, were focused on identifying important rural lands across the landscape. Including both rural and urban lands in one analysis is a difficult proposition since many of the objectives are different and the importance that managers place on the various resources is likely different between rural and urban areas. A simple way to do this was employed for this assessment.

The results of the overall urban analysis were overlaid on the rural results, thus filling the urban voids left in the rural analysis. By doing this, rural lands are compared to other rural lands and urban lands are compared with other urban lands. This works fine for a map showing results on a 30-meter basis. However, to summarize by a larger geographic area, such as county, watershed, or ecoregions, the two analyses cannot remain separate, since results for the geographic area, say county, must account for all pixels within that geographic area. To accomplish this, the rural and urban results were merged together (using Arc Toolbox's Mosaic to New Raster tool) to create one statewide raster with only open water masked.

The urban results used here were those from the Overall Urban Analysis given in the previous section and Map 12 using the layers and weights given in Table 35.

For the rural analysis, an updated SFLA for Texas was conducted. It made use of the four updated or redefined layers that were used in the other state assessment analyses including Priority Watersheds, Forest Health, Public Drinking Water, and Wildfire Risk. In addition, the layer weights used for the various ecoregions, or NLCD 2001 mapping zones (Figure 31), were those originally assigned by Texas without influence from Oklahoma or Louisiana for ecoregions that crossed state boundaries (Table 37).

Figure 31
NLCD 2001 Mapping Zones Used for Weighting Layers in Rural Analysis (Updated SFLA for Texas)

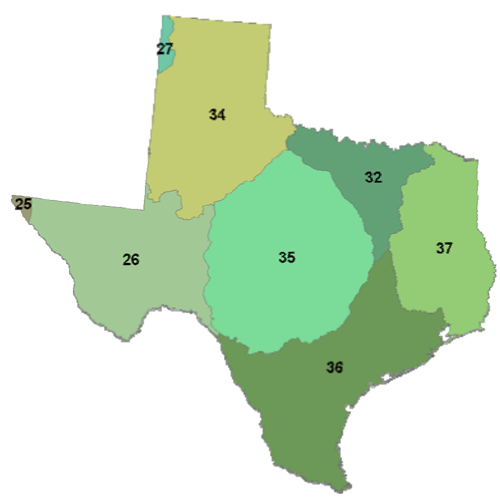


Table 37
Layer Weights by Ecoregion (NLCD 2001 Mapping Zone) Used for Rural Analysis (Updated SFLA for Texas) †

Mapping Zone	Forestland	Forest Patches	Priority Watersheds	Riparian Areas	Wetlands	Public Drinking Water	Site Productivity	Protected Areas	T&E Species	Slope	Development Level	Wildfire Risk	Forest Health
25	15	1	11	12	7	11	1	0	4	7	15	9	7
26	18	5	8	16	1	9	1	5	2	2	3	15	15
27	10	3	12	18	1	17	4	1	3	0	7	17	7
32	17	7	4	11	4	10	1	2	4	0	17	15	8
34	16	7	2	14	2	10	1	5	6	1	13	13	10
35	18	7	2	8	1	11	0	3	7	2	18	16	7
36	17	6	2	14	2	13	1	0	7	0	15	11	12
37a	16	7	4	10	3	10	9	3	2	0	15	9	12

† All layer weights within an ecoregions sum to 100

Results of the simple overlay of the two analyses are shown in Map 13-a. Very high priority areas include 9.6 million acres of rural land and 0.2 million acres of urban land for a grand total of 10.2 million acres, or 6.1 percent of the area (Table 38). Forestland makes up 94.4 percent of the very high priority areas.

Table 38
Area within Each Priority Class by Forest and Non-Forest for the Combined Rural and Urban Analysis When Rural and Urban Are Simply Overlain

Priority	Rural †			Urban ‡			*Grand Total*
	Forest	Non-Forest	*Total*	Forest	Non-Forest	*Total*	
	acres						
Very High	9,438,207	198,582	9,636,789	166,542	371,504	583,046	10,174,835
High	10,772,687	5,018,985	15,791,672	148,246	861,564	1,009,811	16,801,483
Medium	4,429,052	21,948,799	26,377,851	110,152	1,084,745	1,194,897	27,572,748
Low	258,125	38,342,519	38,600,644	51,076	1,126,891	1,177,967	39,778,611
Very Low	0	72,570,146	72,570,146	2,595	622,364	624,959	73,195,105
Total	24,898,071	138,079,030	162,977,102	478,612	4,067,068	4,545,680	167,522,782

† Rural analysis is updated SFLA for Texas ‡ Urban analysis Overall Urban Forest Priority described in previous section

When the rural and urban datasets are merged into one dataset and the results classified into five classes using Natural Breaks classification (map not shown), results are similar, though slightly different (Table 39). Very high priority areas include 11.8 million acres or 7.0 percent of the total. Forestland comprises 97.9 percent of these very high priority areas.

Table 39
Area within Each Priority Class by Forest and Non-Forest for the Combined Rural and Urban Analysis When Rural and Urban Datasets Are Merged (Mosaiced)

Priority	Forest	Non-Forest	*TOTAL*
	acres		
Very High	10,698,903	1,098,812	11,797,715
High	10,515,853	8,494,436	19,010,289
Medium	3,987,482	23,454,921	27,442,403
Low	168,071	36,202,964	36,371,035
Very Low	0	72,872,343	72,872,343
TOTAL	25,370,309	142,123,476	167,493,785

Results of the summarization by county on the merged analyses is shown in Map 13-b. There are 38 counties considered very high priority (Table 40). Of the 38 counties, 29 are in East Texas (76%).

Table 40
Very High Priority Counties in and County Means of Priority Index

County	County Mean of Priority Index	County	County Mean of Priority Index
Jasper	47.6	Rusk	40.2
Marion	47.2	Angelina	40.1
Tyler	47.2	Somervell	40.0
Polk	46.6	Cherokee	39.8
Hardin	46.0	Orange	39.8
Sabine	44.6	Anderson	39.4
Newton	44.2	Harris	39.3
Panola	43.9	Camp	39.3
Harrison	43.9	Wood	38.8
Upshur	43.8	Bandera	38.8
Comal	43.4	Smith	38.5
Cass	43.2	Liberty	38.0
Shelby	42.7	Kendall	37.9
Nacogdoches	41.5	Travis	37.9
San Augustine	41.4	Tarrant	37.6
San Jacinto	41.4	Trinity	37.5
Hays	40.9	Dallas	36.9
Montgomery	40.4	Hood	36.3
Gregg	40.3	Franklin	35.3

Results of the summarization by watershed (8-digit HUC) on the merged analyses is shown in Map 13-c. The Lower Neches watershed exhibited the highest priority index of the 23 watersheds that are considered to be very high priority (Table 41).

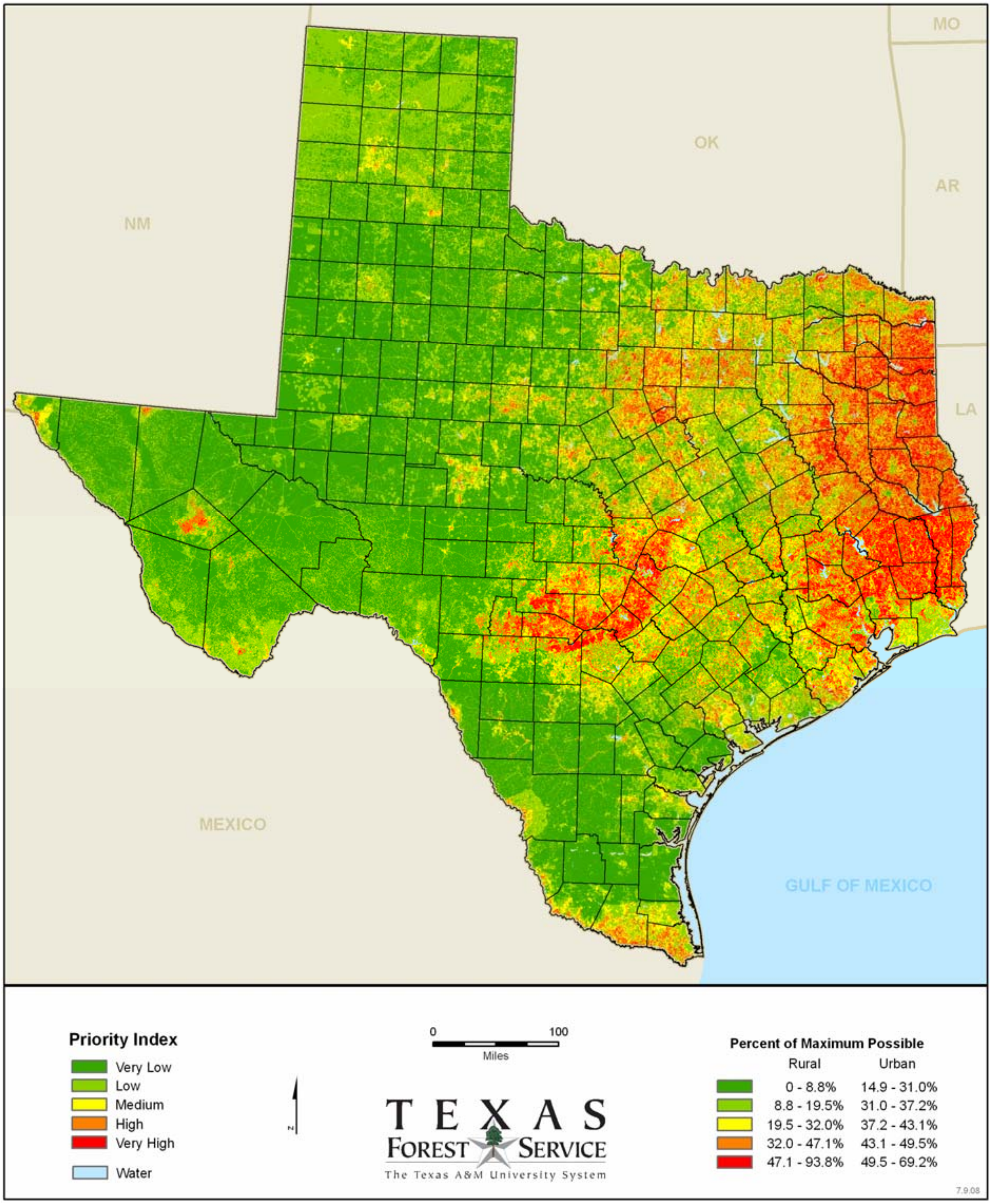
Table 41
Very High Priority 8-digit Watersheds and Watershed Means of Priority Index

Watershed	Watershed Mean of Priority Index	Watershed	Watershed Mean of Priority Index
Lower Neches	47.1	Middle Neches	40.0
Village	46.5	Upper Neches	39.9
Caddo Lake	44.8	Upper Angelina	39.9
Lower Sabine	44.1	East Fork San Jacinto	39.8
Pine Island Bayou	43.0	Lake ‘o the Pines	38.5
Little Cypress	42.9	West Fork San Jacinto	38.4
Toledo Bend Reservoir	42.7	Lower Trinity	37.9
Cross Bayou	42.6	Upper Guadalupe	36.3
Middle Sabine	42.3	Medina	35.9
Lower Angelina	42.2	Lower West Fork Trinity	35.4
Austin-Travis Lakes	41.5	Spring	35.2
Buffalo-San Jacinto	40.0		

Map 13-a

Rural and Urban Analyses Combined

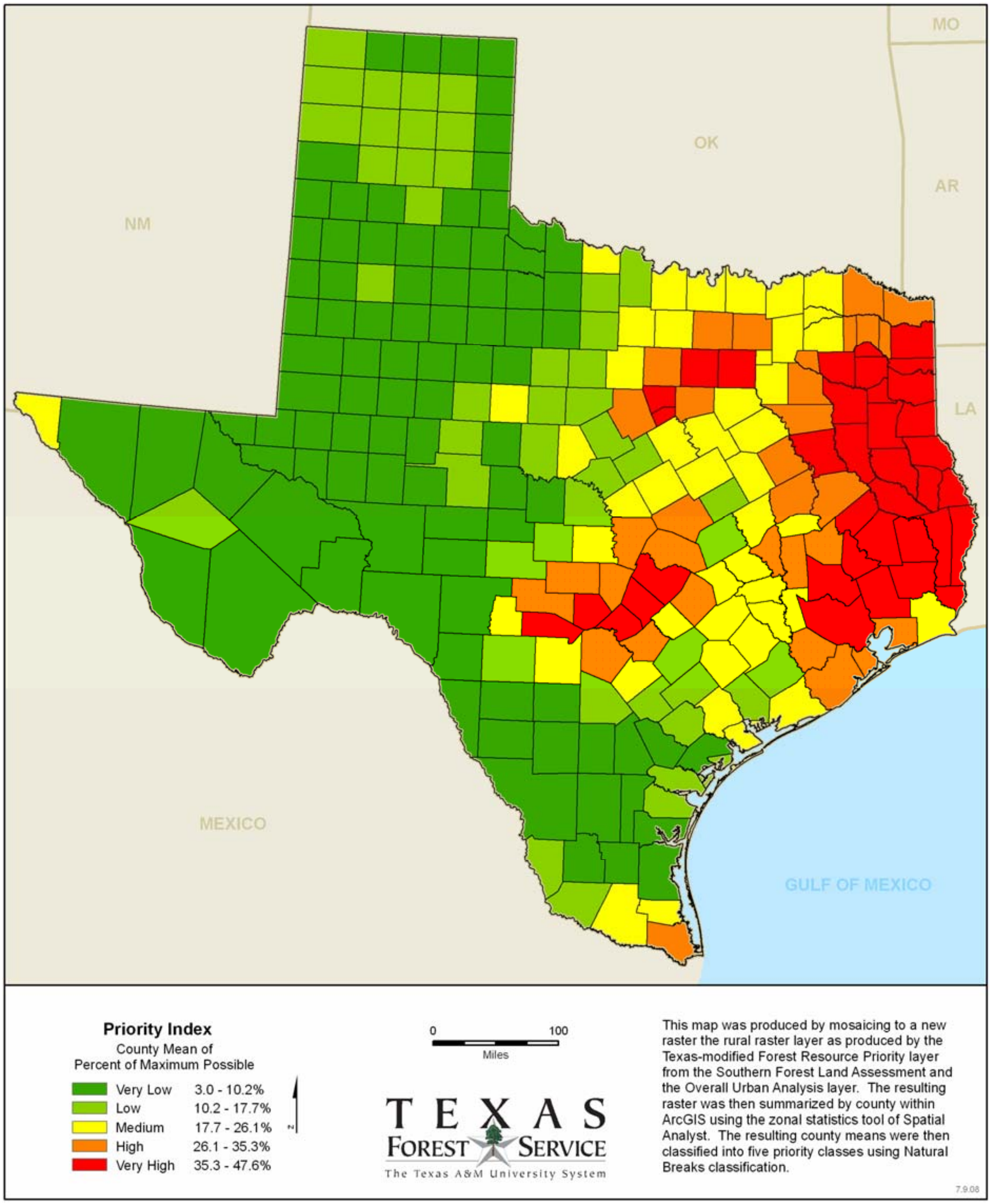
Urban Raster Overlaid on Rural Raster



Map 13-b

Rural and Urban Analyses Combined

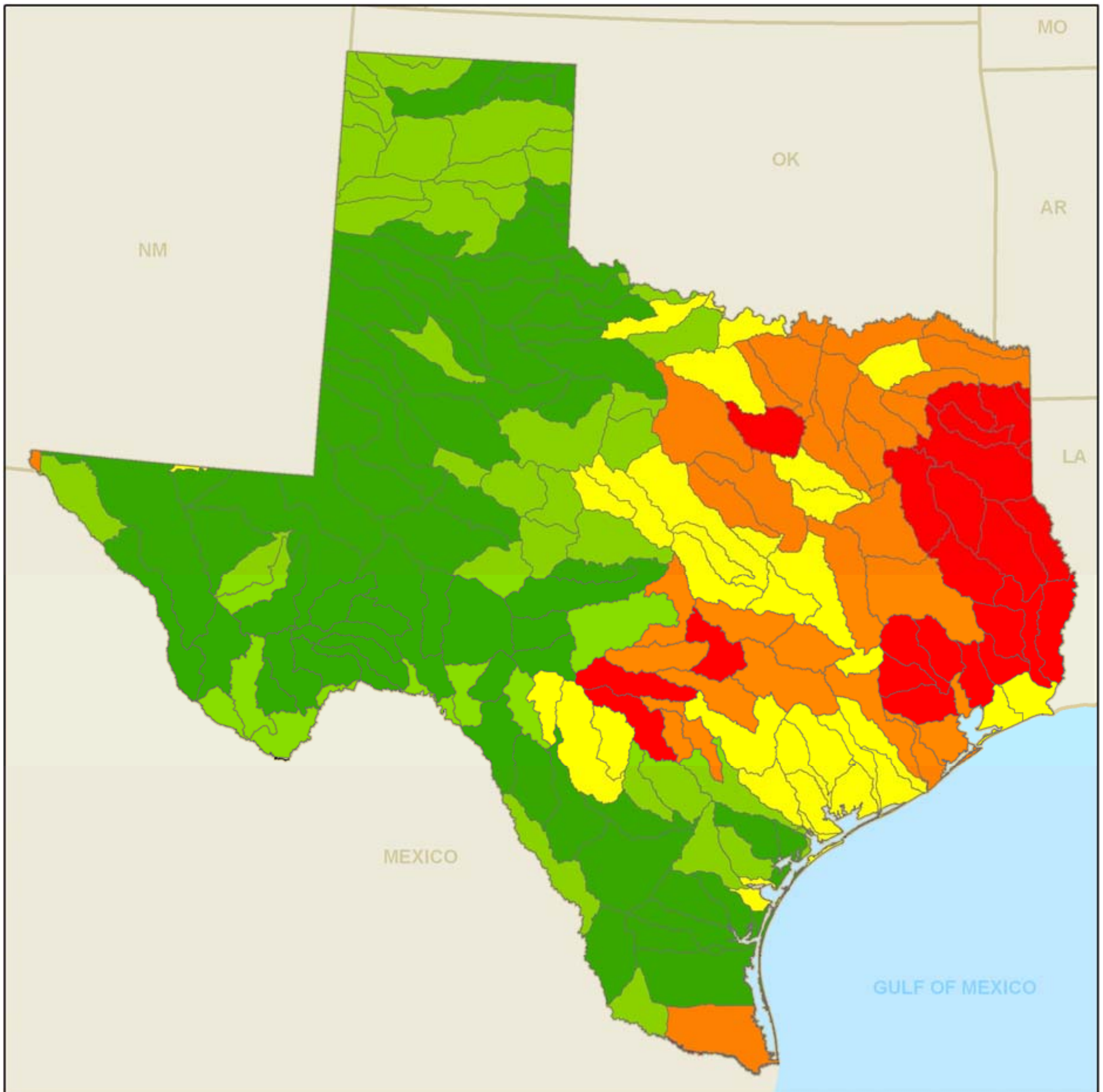
Rural and Urban Rasters Mosaiced to New Raster and Summarized by County



Map 13-c

Rural and Urban Analyses Combined

Rural and Urban Rasters Mosaiced to New Raster and Summarized by 8-digit Hydrologic Unit Code Watershed



Priority Index
Percent of Maximum Possible

- Very Low 4.0 - 9.7%
- Low 9.7 - 15.3%
- Medium 15.3 - 24.1%
- High 24.1 - 35.5%
- Very High 35.5 - 47.1%

0 100
Miles

TEXAS FOREST SERVICE
The Texas A&M University System

8-digit Hydrologic Unit Code Watersheds

Priority Index	Number of Watersheds	Percent of Area
Very High	25	10.9
High	34	16.5
Medium	32	13.2
Low	48	20.0
Very Low	69	39.2

7.11.08

Comparison with State Wildlife Action Plan †

The 2008 Farm Bill requires the statewide assessment of forest resources account for the state wildlife action plan, which is a congressionally-mandated comprehensive wildlife conservation strategy. These proactive plans examine the health of wildlife and prescribe actions to conserve wildlife and vital habitat before they become more rare and costly to protect.

The Texas Wildlife Action Plan was developed by the Texas Parks and Wildlife Department (TPWD) in 2005. The plan contains two sets of priorities: (1) terrestrial conservation priorities and (2) inland aquatic resources conservation priorities. TPWD chose the ecoregion scale (Gould's) as most appropriate for the terrestrial conservation priority analysis.

Primary factors used in the analysis were conserved status, level of threat, and biological value. Conserved status in each ecoregion was determined by using the percent of publicly-owned land, land owned by non-governmental conservation organizations, and large local parkland designated for conservation as well as the percentage of the region operated under TPWD wildlife management plans. Threat was determined by percentage of land converted to urban or agricultural use, fragmentation, and population growth projections. Biological value was determined by total vertebrate species richness as well as vascular plant species richness.

Several secondary factors were also used in determining the ranking of the 10 ecoregions. These included the percentage of land under the management systems of the Conservation Reserve Program (CRP), pastureland, commercial timberland, and rangeland; miles of road per acre in each ecoregion as a secondary indicator of land fragmentation; the percentage of vertebrate species of concern; and the number of rare plant species in each ecoregion.

TPWD weighted the conserved status, level of threat, and biological value equally and used these values to rank the ecoregions. Considering the secondary factors, TPWD categorized the ecoregions of the state into three tiers, or priorities: high, secondary, and tertiary ecoregions.

To compare the Texas Statewide Assessment of Forest Resources with the State Wildlife Action Plan, the merged (mosaiced) results of the Combined Rural and Urban Analysis were summarized by the 10 Gould ecoregions and classified into three classes using Natural Breaks classification (Map 13-d). Under the Assessment of Forest Resources, the Pineywoods was determined to be highest priority (Table 42). In comparison, the Wildlife Action Plan determined that Blackland Prairie, Gulf Coast Prairies and Marshes, and South Texas Plains to be the highest priority ecoregions (Tier I).

† Information on the State Wildlife Plan is taken from the Texas Comprehensive Wildlife Strategy: 2005 – 2010. Texas Parks and Wildlife Department. 2005. Accessed from http://www.tpwd.state.tx.us/publications/pwdpubs/pwd_pl_w7000_1187a/

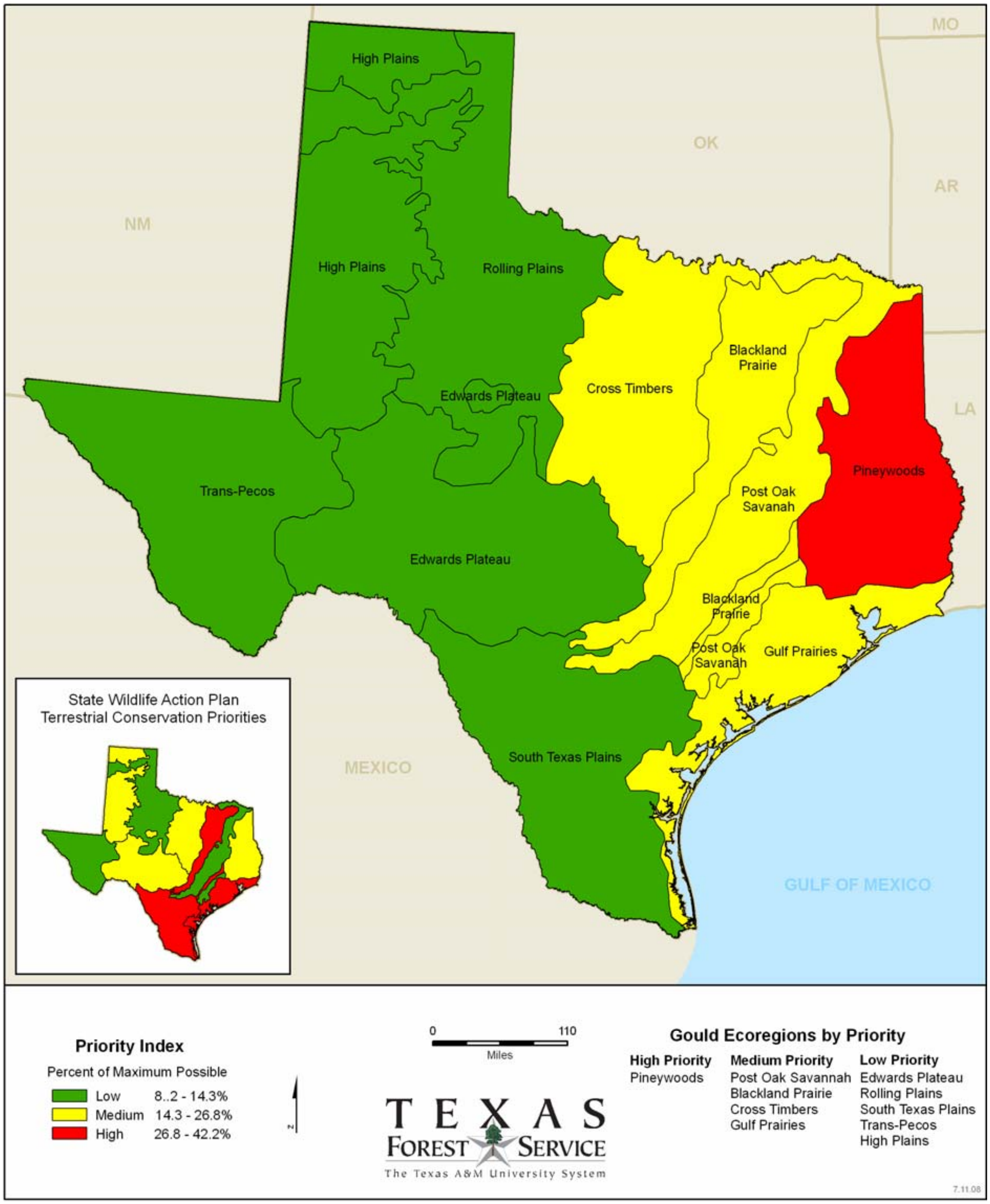
Table 42
Comparison of Priority Ecoregions between the Statewide Assessment of Forest Resources and the State Wildlife Action Plan

Ecoregion	Assessment of Forest Resources	Wildlife Action Plan
Pineywoods	High	Medium
Blackland Prairie	Medium	High
Post Oak Savannah	Medium	Low
Cross Timbers	Medium	Medium
Gulf Prairies	Medium	High
Edwards Plateau	Low	Medium
Rolling Plains	Low	Low
South Texas Plains	Low	High
Trans-Pecos	Low	Low
High Plains	Low	Medium

Map 13-d

Rural and Urban Analyses Combined

Rural and Urban Rasters Mosaiced to New Raster and Summarized by Gould Ecoregion



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Data Layers Used in Spatial Overlay Analyses

The Southern Forest Land Assessment provided thirteen of the input layers used in the overlay analyses conducted for this state assessment They are grouped into two major groups based on whether they are considered a threat to the resource or as a resource that provides richness as given below.

Richness
- Forestland
- Forest Patches
- Riparian Areas
- Wetlands
- Priority Watersheds
- Public Drinking Water
- Protected Areas
- T&E Species
- Slope
- Site Productivity

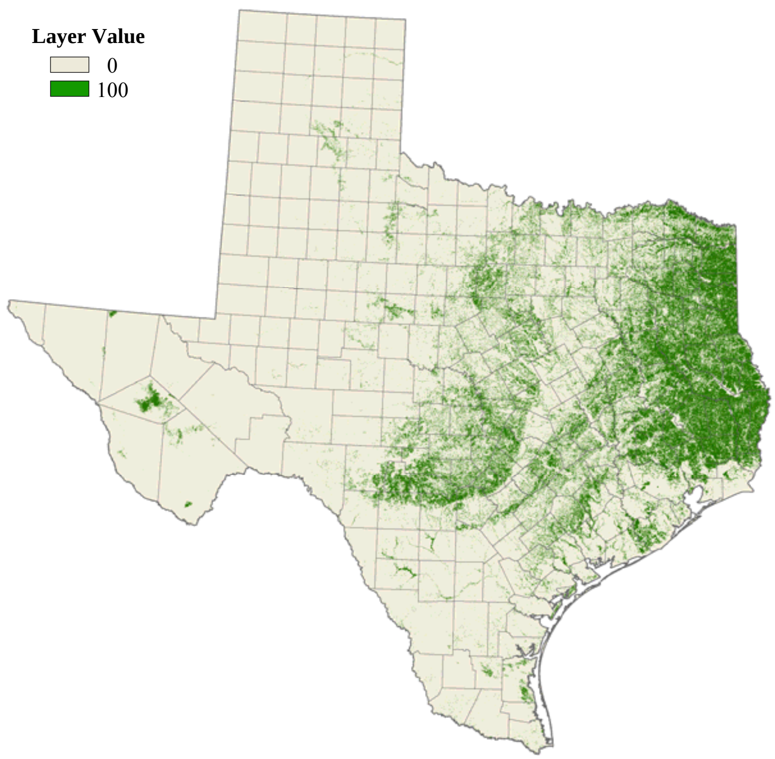
Threat
- Development Level
- Forest Health
- Wildfire Risk

Other layers used for the Urban Forest Sustainability issue were provided by the NLCD, NOAA, the USDA Forest Service CARS, and the EPA. They following is a description of each layer beginning with those from the SFLA The SFLA layers were used as is except for four—Priority Watersheds, Forest Health, Public Drinking Water, and Wildfire Risk—which were enhanced slightly as described below.

Forestland

The Forestland layer (Figure A-1) emphasizes lands with existing forest cover. Forested areas were derived from the 2001 National Land Cover Database (NLCD 2001) produced through a cooperative mapping effort of the Multi-resolution Lands Characteristics Consortium (MRLC). The NLCD 2001 data layer identifies 16 classes of land cover and was produced from Landsat 5 and 7 imagery. The NLCD 2001 dataset was reclassified to contain the following forested categories: Deciduous Forest (41), Evergreen Forest (42), Mixed Forest (43), Shrub/Scrub (52), and Woody Wetlands (90). For NLCD mapping zones 25, 26, 27, 32, 34, 35, and 36 in western Texas, land cover class 52 (Shrub/Scrub) was not included as forest. Forestland is shown Figure 1.

Figure A-1
Forestland



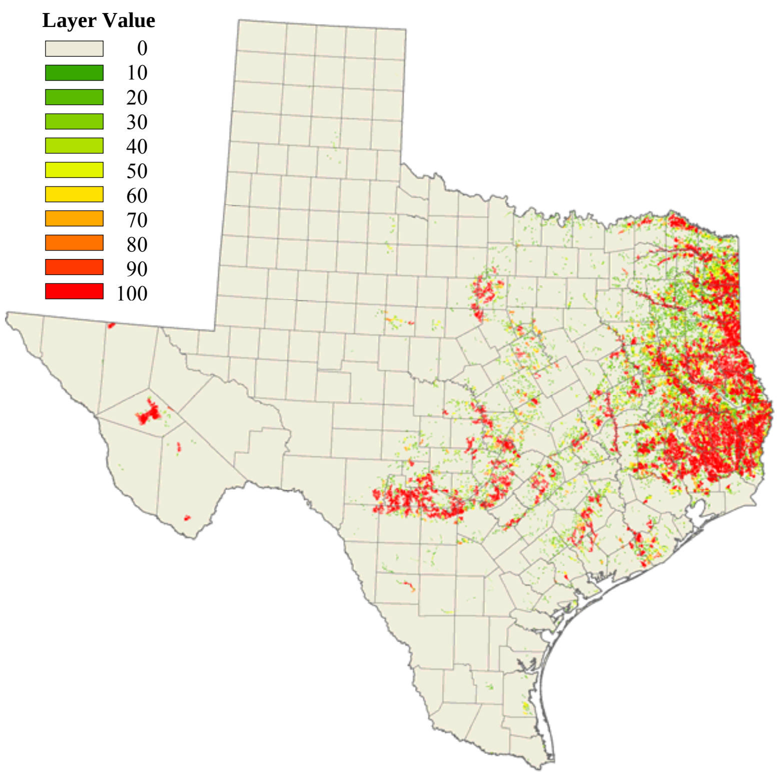
Forested Patches

The Forest Patches layer (Figure A-2) is intended to emphasize forest patches of ecologically- and/or economically-viable size. Forest patches were created by first subtracting from the Forestland layer a buffered (30 meters) rasterized road layer and then using the Region Group and Zonal Geometry tools within ArcGIS to group contiguous forest grid cells into patches. The road layer used was ESRI's U.S. Highways, which represents the major and minor highways of the U.S. These include Interstates, federal highways, state highways, major roads, and minor roads. This dataset is a subset of the Streets dataset and contains all Class 1, 2, and 3 road segments plus any other road segments necessary to provide network connectivity for the Class_Rte field. Values for grid cells are the area in square meters of the forest patch in which a cell belongs. For a cell to be contiguous with an adjacent cell, there must be at least one side common to both cells. Corners simply touching does not constitute contiguousness. The layer is further processed within the SFLA models to produce layer values ranging from 0 to100 based on patch size. The layer values scheme used is given in Table A-1.

Table A-1
Layer Value Scheme for Forest Patches

Layer Value	Patch Size (square meters)	Patch Size (acres)
0	< 2,019,382	< 500
10	2,019,382 – 4,042,809	400 – 999
20	4,042,810 – 6,066,237	1,000 – 1,499
30	6,066,238 – 8,089,665	1,500 – 1,999
40	8,089,666 – 10,113,093	2,000 – 2,499
50	10,113,094 – 12,136,521	2,500 – 2,999
60	12,136,522 – 14,159,949	3,000 – 3,499
70	14,159,950 – 16,183,377	3,500 – 3,999
80	16,183,378 – 18,206,805	4,000 – 4,499
90	18,206,806 – 20,230,233	4,500 – 5,000
100	> 20,230,233	> 5,000

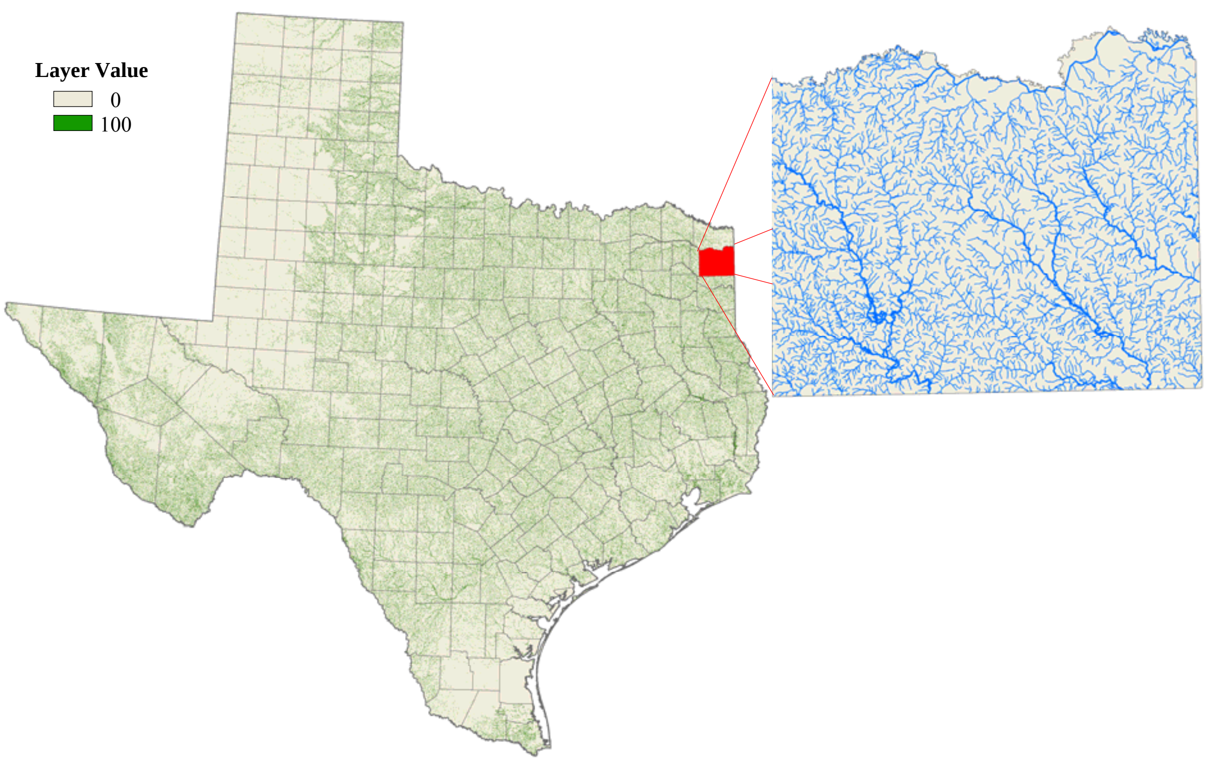
Figure A-2
Forest Patches



Riparian Areas

The Riparian Areas layer (Figure A-3) places importance on river and stream corridors where buffers of forest vegetative cover can have a positive or restorative effect on water quality and riverine ecosystems. The layer was created from the National Hydrography Dataset (NHD) flowline (high-resolution) data. Stream segments, or reaches, were buffered by one or two distances using the buffer tool within ArcGIS. The two buffer distances were applied to stream segments based on the Stralher stream order. An ArcInfo macro was run on the segments to determine stream order. Segments with stream orders of 1 through 4, i.e. stream segments closer to the headwaters, were buffered by 50 meters. All remaining segments were buffered by 100 meters. The data were rasterized to a 30-meter grid. The NHD is a feature-based database that interconnects and uniquely identifies water-related entities, such as industrial discharges, drinking water supplies, fish habitat areas, and wild and scenic rivers.

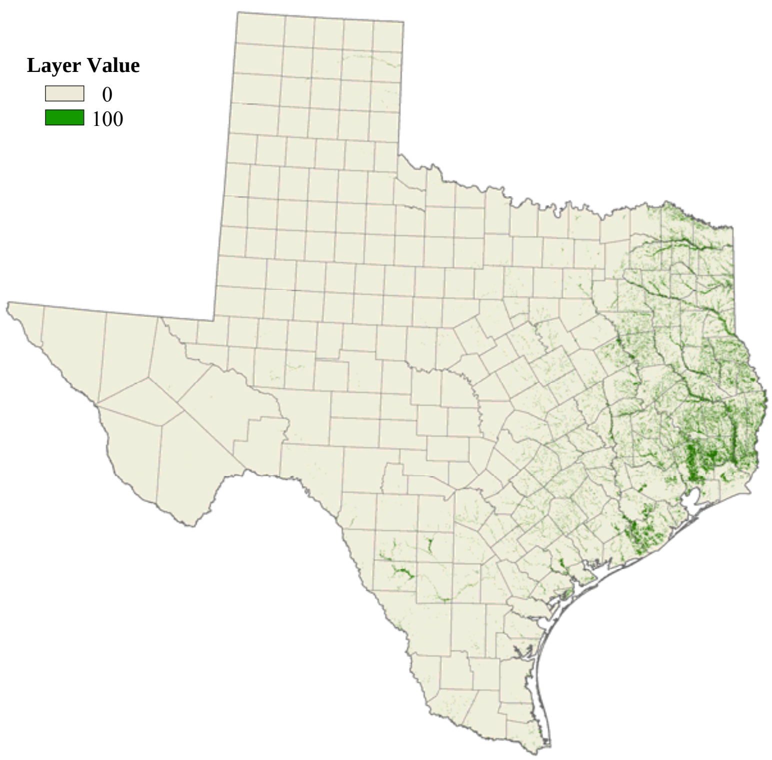
Figure A-3
Riparian Areas



Wetlands

The Wetlands layer (Figure A-4) identifies forested wetlands where planning and management can achieve a higher degree of protection for purposes including water quality and wildlife habitat. The forested wetlands layer were created by combining wetlands data from the National Wetlands Inventory (NWI) dataset and the 2001 NLCD. The NWI dataset represents the extent, approximate location, and type of wetlands and deepwater habitats in the conterminous U.S. These data delineate the areal extent of wetlands and surface waters as defined in Classification of Wetlands and Deepwater Habitats of the United States by Cowardin *et al.* The NWI class "freshwater forested/shrub wetland" was selected from the NWI dataset and converted to a 30-meter grid. The NLCD 2001 data were reclassified to contain only the woody wetlands (NLCD class 90). These datasets were then combined in such a way that the NWI data were used in their entirety for areas where available. Where NWI data were not available, NLCD 2001 data were used.

Figure A-4
Wetlands



Priority Watersheds

The Priority Watersheds layer (Figure A-5) emphasizes landscapes that impact long-term watershed function. The national SAP intent statement for this layer suggests priority watersheds can be those that are impaired or deforested, but could be measurably improved through planning and active management, or those that are currently productive, but somehow threatened.

A different Priority Watersheds layer was used for the Texas Statewide Assessment of Forest Resources than was used for the SFLA.

This layer was created using a combination of (1) percentage of riparian area forested within a 12-digit Hydrologic Unit Code (HUC) watershed and (2) percentage of same watershed forested. Percentages were rounded to the nearest 10 percent. A two-dimensional matrix with each of these measures was produced by combining the two measures using the Combine function within ArcGIS. A total of 121 classes resulted from this combining process.

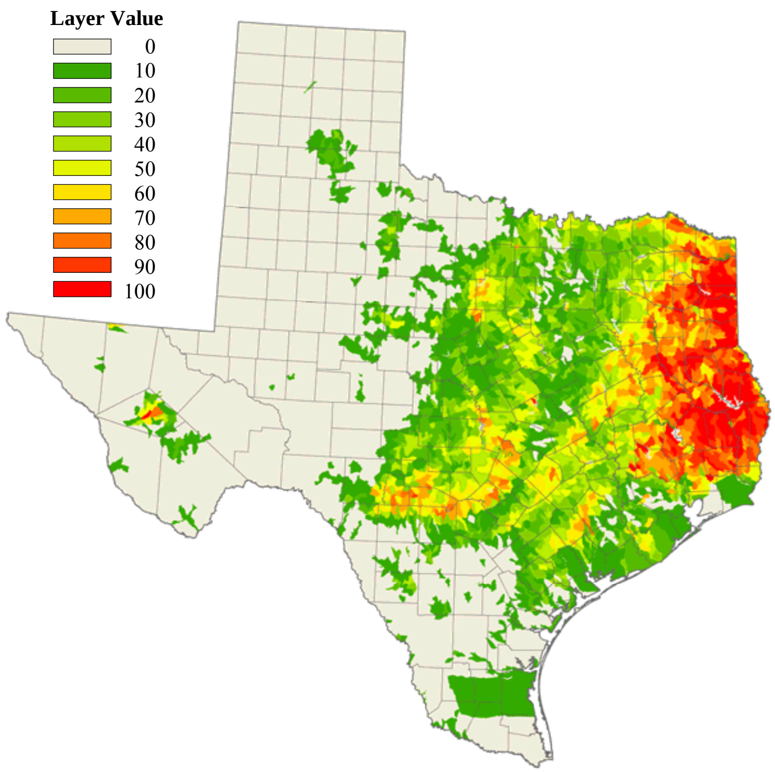
Two existing input layers used in the SFLA were used to calculate Priority Watersheds—Forestland and Riparian Areas. Twelve-digit watershed boundary shapes were obtained from the USDA Natural Resources Conservation Service (NRCS) in each state. The data were rasterized to a 30-meter grid. These 121 classes were classified to a layer value ranging from 0 to 100 based on the two watershed measures. In contrast to the SFLA, greater importance was placed on higher percentages for both measures. Table A-3 shows the layer value scheme used in the Texas Assessment.

Table 3

Layer Value Scheme for Priority Watersheds

Percent of watershed forested	Percent of riparian area forested within watershed										
	0%	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
0%	0	10	20	30	40	50	60	70	80	90	100
10%	10	20	30	40	50	60	70	80	90	100	100
20%	20	30	40	50	60	70	80	90	100	100	100
30%	30	40	50	60	70	80	90	100	100	100	100
40%	40	50	60	70	80	90	100	100	100	100	100
50%	50	60	70	80	90	100	100	100	100	100	100
60%	60	70	80	90	100	100	100	100	100	100	100
70%	70	80	90	100	100	100	100	100	100	100	100
80%	80	90	100	100	100	100	100	100	100	100	100
90%	90	100	100	100	100	100	100	100	100	100	100
100%	100	100	100	100	100	100	100	100	100	100	100

Figure A-5
Priority Watersheds



Public Drinking Water

The Public Drinking Water layer emphasizes areas of watersheds that drain into intake points for public drinking water supply. The dataset is an enhanced version of that used in the SFLA and includes three types of data as described below.

(1) Like the SFLA, it contains the 12-digit Hydrologic Unit Code (HUC) watersheds that contain a surface water intake for public drinking water. Twelve-digit watershed boundary shapes were obtained from the NRCS in each state. Each watershed that contains a surface water intake was given a value of 100. The data were rasterized to a 30-meter grid. Data for surface water intakes were obtained from the Texas Commission on Environmental Quality (TCEQ).

(2) The layer also includes the number of ground water wells used for public drinking water that occur within a quarter-quad (USGS 3.75-minute quadrangle). The summarized data were classified into 6 classes ranging in layer values of 0 to 100 using Natural Breaks classification.

(3) The Balcones Fault Zone outcrop, which is the recharge zone for the Balcones Fault Zone. The area within this aquifer was given a value of 100. Aquifer data were obtained from the Texas Water Development Board.

The three sub-layers were then mosaiced into one Public Drinking Water layer. Any area with values from more than one of the three sources was given the maximum of the overlapping values. The three separate sub-layers are shown in Figure A-6 and the combined final layer is shown in Figure A-7.

Figure A-6
Three Constituent Sub-layers of Public Drinking Water

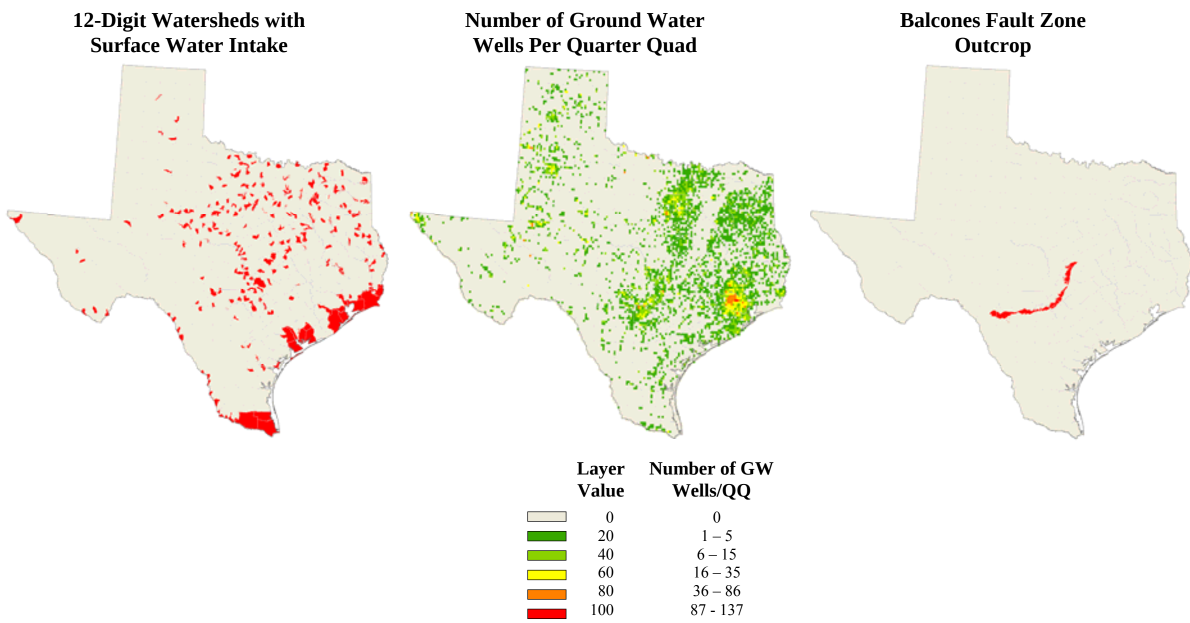
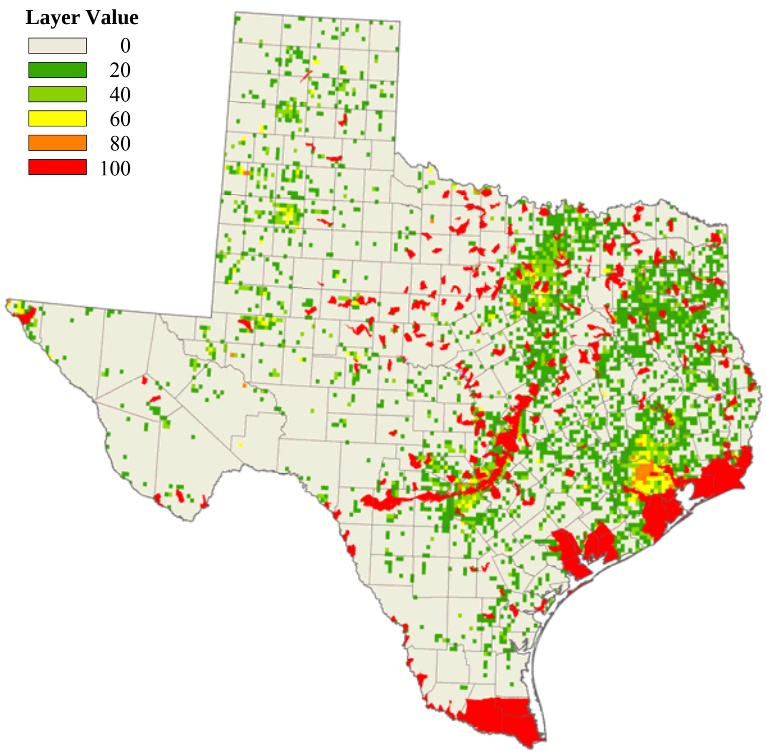


Figure A-7
Public Drinking Water



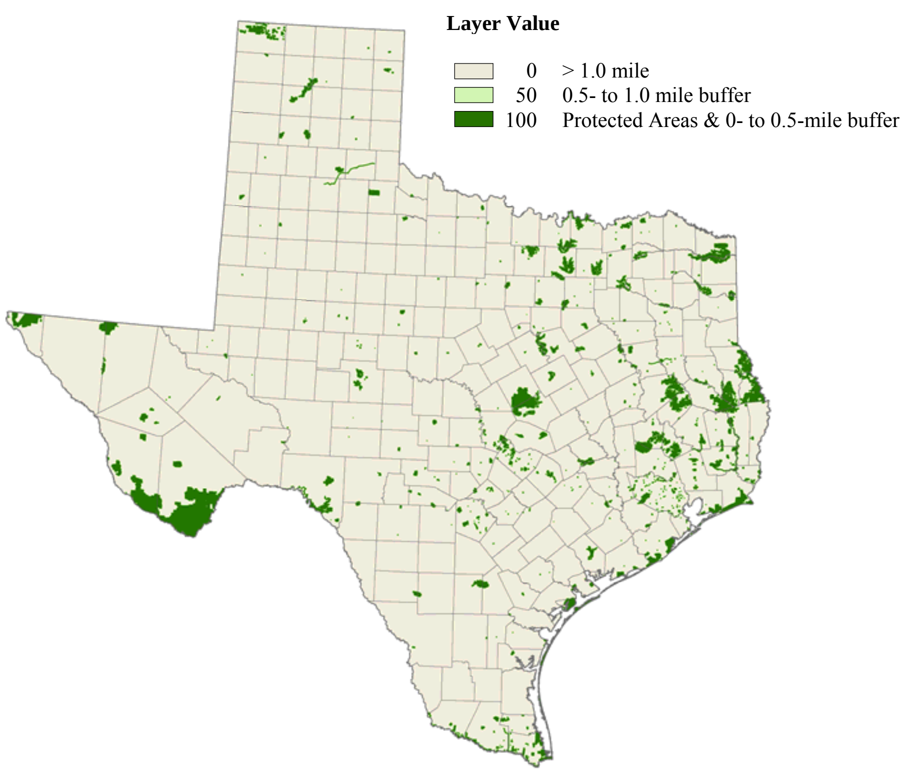
Protected Areas

The Protected Areas layer (Figure A-8), also known as *Proximity to Public Land*, emphasizes areas that are assumed to be permanently protected (and managed) and thus contribute to a viably large, interconnected forest landscape. This layer is based on the assumption that public lands are in a permanently protected status, and is intended to include private lands in a permanently protected status (easements or other).

The data were primarily that provided to Texas Forest Service by the Texas Parks and Wildlife Department who compiled spatial data for public land in 2003. In addition, Texas General Land Office land that Texas Forest Service manages was included (as drawn by Texas Forest Service staff). Additional data, such as Department of Defense lands and private protected areas in perpetual easements, were obtained from the Protected Areas Database (PAD), Version 4, developed by the Conservation Biology Institute of Corvallis, OR and appended to the dataset. In addition, any inholdings (as provided in the AVSORT attribute) were deleted from the PAD data.

Buffers were created for areas between 0 and 0.5 miles of public land as well as for areas between 0.5 and 1.0 miles of public land. The protected areas themselves and the 0- to 0.5-mile buffer were given a layer value of 100 while the 0.5- to 1.0-mile buffer was given a value of 50.

Figure A-8
Protected Areas



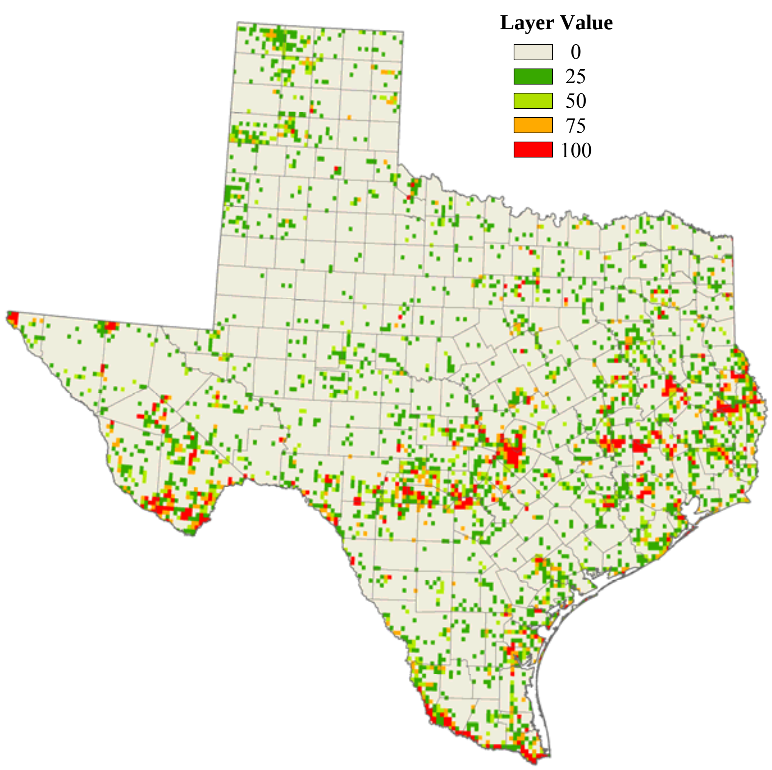
Threatened and Endangered Species

The Threatened and Endangered Species layer (Figure A-9) identifies areas that provide habitat for Threatened and Endangered Species (TES). Natural Heritage Program data (NHP) were obtained from the appropriate state agencies responsible for maintaining the data. In addition to TES, the data include rare plant communities and other communities of conservation value. Because of the sensitive nature of precise point locations, the measure used for this layer is number of occurrences of NHP data within a quarter quad (one quarter of a USGS 7.5-minute quadrangle). Quarter-quad shapes were obtained from the USDA Geospatial Gateway (http://datagateway.nrcs.usda.gov/). Using these shapes and point data representing occurrences of NHP data, the number of occurrences within each quadrangle were determined in ArcGIS using Hawth's Count Points in Polygon tool. This tool is free for download from Hawth's Analysis Tools for GIS (http://www.spatialecology.com/htools/). The point count was then classified into four quantiles plus zero. Each category was assigned a layer value ranging from 0 to 100 in increments of 25. Layer values and quantiles are given in Table A-4.

Table A-4
Layer Value Scheme for Threatened and Endangered Species

Layer Value	Number of Occurrences of Natural Heritage Program Data
0	0
25	1
50	2
75	3 – 4
100	5 –77

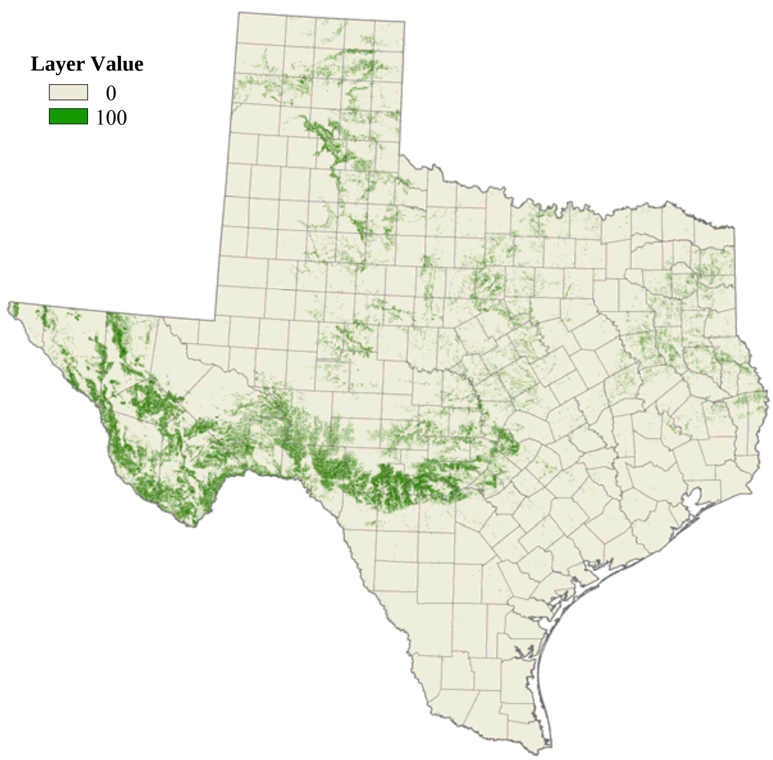
Figure A-9
Threatened and Endangered Species



Slope

Although the National Forest Stewardship Spatial Analysis Project's intent for this layer is to serve as a proxy for forest timber or fiber productivity potential, the national intent was not known when this layer was originally defined within the SFLA, and thus the intent within the SFLA was an integration of forest management operability and erosion potential. The dataset was derived from the U.S. Geological Survey's National Elevation Dataset (NED). The NED is a seamless mosaic of best-available elevation data. Percent slope was calculated within ArcGIS from the NED 30-meter data. The SFLA model reclassed these slope values to a layer value of either 0 or 100. Slopes between 10 and 50 percent (inclusive) received a value of 100 while all other slope values received a layer value of 0 (Figure A-10).

Figure A-10
Slope



Site Productivity

The Site Productivity layer (Figure A-11) emphasizes areas with higher potential productivity in terms of timber production. The measure used for site productivity in the SFLA is site index (tree height in feet at age 50) as determined by the NRCS. The preferred source of data was the NRCS Soil Survey Geographic (SSURGO) database. Where SSURGO data were not yet available, the State Geographic (STATSGO) database was used. Each database has a common link to attribute data files for each map unit component. The SSURGO database provides the most detailed level of information. Components of map units are generally phases of soil series that enable precise interpretation. Soil maps for STATSGO are more generalized than for SSURGO.

This layer used SSURGO data that were available on July 5, 2007. Where SSURGO were not available as of this date, STATSGO data were used. Complete SSURGO coverage is expected sometime in 2008.

The SSURGO data required extensive processing to get it in a form usable for the SFLA. The data were downloaded from the Soil Data Mart website (http://soildatamart.nrcs.usda.gov/). Each soil survey area, which is composed of usually one but sometimes two counties, contains spatial data (polygons) and attribute data. Attribute data are contained in 24 relational tables, four of which are needed to produce this Site Productivity dataset: Legend (legend.txt), Mapunit (mapunit.txt), Component (comp.txt), and Component Forest Productivity (cfprod.txt). Legend contains information about the soil survey area. Mapunit links to the soil mapping polygons and contains information about the soil mapping unit. Component contains information about the components that make up a soil mapping unit. Each mapping unit contains from one to several components. Component Forest Productivity contains site index values for one to several species per component. Therefore, each mapping unit usually contains several site index values.

To develop the Site Productivity layer, a process was developed for calculating one site index value per soil mapping unit. Each component was assigned the highest site index value that occurred in that respective component, regardless of species. A weighted (by proportion of mapping unit that component occurred as) average for site index was calculated for each soil mapping unit. Components that did not have a related site index value were not factored in (i.e., the component proportions were normalized to sum to 1).

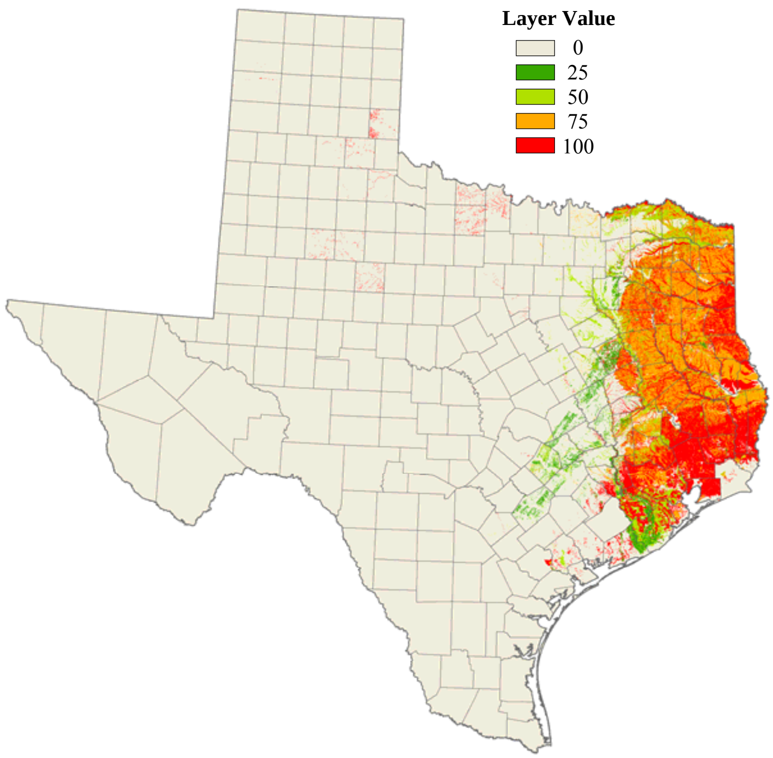
After one site index value was assigned to each of the soil mapping units, the soil survey vector data were rasterized to a 30-meter grid.

The SFLA models reclassify these site index values to produce a layer value ranging from 0 to 100. Table A-5 shows the layer value scheme used.

Table A-5
Layer Value Scheme for Site Productivity

Layer Value	Site Index (height in feet at age 50)
0	< 60
25	60 – <70
50	70 – <80
75	80 – <90
100	>= 90

Figure A-11
Site Productivity



Development Level (SFLA)

The Development Level layer (Figure A-12) used in the Population and Urbanization, Sustainability of Forest Resources in East Texas Forest, and Water Quality and Quantity issues is the same as used for the SFLA. It emphasizes areas that are projected to experience increased housing development from 2000 to 2030. Increased management of private forests can improve the likelihood that these lands will remain forested and continue to provide forest values such as timber, wildlife habitat, and water quality. This layer is especially important in the wildland-urban interface.

The layer was derived from housing density projections for 2030 developed by David Theobald of Colorado State University. The projections were derived through Theobald's Spatially Explicit Regional Growth Model (SERGoM v2) which uses data from the Census Bureau for 2000, Protected Areas Database v3, Geographic Data Technology's Road Density, county population projections, and NLCD 1992. Data were provided in 15 classes depending on housing density as given in the following table.

Table A-6
Theobald's Housing Density Classes

Generalized Group	Theobald Class	Units/Ha × 1000	Units/Acre × 1000	Acres/Unit
Undeveloped Private	1	<= 1	<= 0.5	>= 1,853.3
Rural	2	2 – 8	0.6 – 3.4	1,853.2 – 305.3
	3	9 – 15	3.5 – 6.2	305.2 – 159.6
	4	16 – 31	6.3 – 12.6	159.5 – 78.5
	5	32 – 49	12.7 – 19.9	78.4 – 49.9
	6	50 – 62	20.0 – 25.2	49.8 – 39.6
	7	63 – 82	25.3 – 33.3	39.5 – 30.0
Exurban	8	83 – 124	33.4 – 50.3	29.9 – 19.9
	9	125 – 247	50.4 – 100.1	19.8 – 10.0
	10	248 – 494	100.2 – 200.0	9.9 – 5.0
	11	495 – 1,454	200.1 – 588.5	4.9 – 1.7
Suburban	12	1,455 – 4,118	588.6 – 1,666.6	1.6 – 0.6
Urban	13	4,119 – 9,884	1,666.7 – 4,000.0	0.5 – 0.3
	14	9,885 – 24,711	4,000.1 – 10,000.3	0.2 – 0.1
	15	>= 24,712	>= 10,000.4	< 0.1

The 100-meter raster data provided by Theobald was resampled to 30 meters. The 2000 data were combined (using the Combine function within ArcGIS) with the 2030 data to produce a matrix of classes where one dimension is housing densities in 2000 for each of the 15 classes and the other dimension is housing densities projected for 2030. A total of 120 classes were produced from this combine process.

The SFLA models reclassify these 120 classes to a layer value from 0 to 100 based on three premises:

1. There is resource threat from increases in density occurring in rural areas.
2. There is more threat to the resource when increases are larger in magnitude.
3. Once housing densities reach a certain threshold, there is little chance we can affect change, therefore, increases in these areas have no more threat.

Table A-7 shows the layer value scheme used.

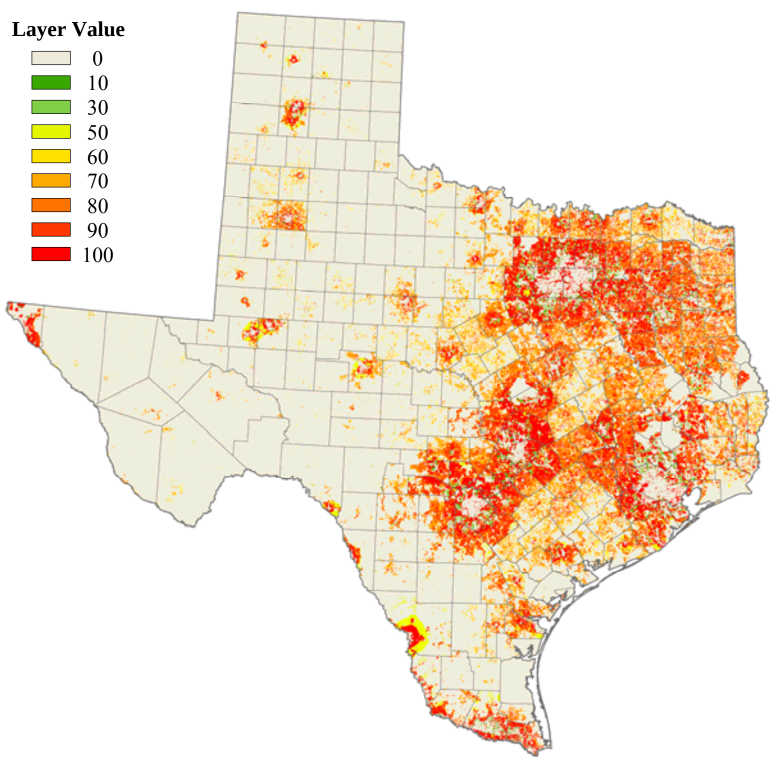
Table A-7
Layer Value Scheme for Development Level for SFLA †

		2030														
		UP	**Rural**						**Exurban**				**SU**	**Urban**		
	2000	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
UP	**1**	0	50	70	90	100	100	100	100	100	100	100	100	100	100	100
Rural	**2**		0	60	80	90	100	100	100	100	100	100	100	100	100	100
	3			0	70	90	100	100	100	100	100	100	100	100	100	100
	4				0	80	90	100	100	100	100	100	100	100	100	100
	5					0	90	100	100	100	100	100	100	100	100	100
	6						0	100	100	100	100	100	100	100	100	100
	7							0	70	70	70	70	70	70	70	70
Exurban	**8**								0	30	30	30	30	30	30	30
	9									0	10	10	10	10	10	10
	10										0	0	0	0	0	0
	11											0	0	0	0	0
SU	**12**												0	0	0	0
Urban	**13**													0	0	0
	14														0	0
	15															0

† UP = Undeveloped Private SU = Suburban

For further information on the housing density datasets see:
Theobald, D. 2005. Landscape patterns of exurban growth in the USA from 1980 to 2020. Ecology and Society 10(1): 32. [online] URL:
http://www.ecologyandsociety.org/vol10/iss1/art32/

Figure A-12
Development Level (SFLA)



Development Level (CTWC)

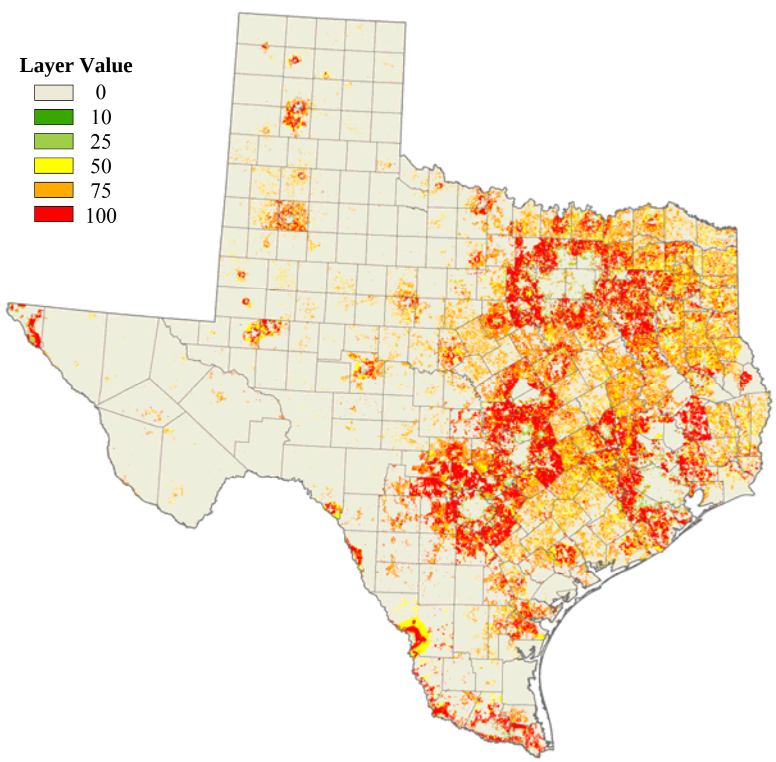
The Development Level layer (Figure A-13) used in the Central Texas Woodlands Conservation (CTWC) issue is a modification of that used for the SFLA. The layer value scheme was modified in such a way that it focused only on areas that are not projected to be urban or suburban by 2030 (Table A-8).

Table A-8
Layer Value Scheme for Development Level for Central Texas Woodlands Conservation †

		2030														
		UP	**Rural**						**Exurban**				**SU**	**Urban**		
	2000	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
UP	**1**	0	50	100	100	100	100	100	100	75	25	10	0	0	0	0
Rural	**2**		0	75	100	100	100	100	100	75	25	10	0	0	0	0
	3			0	75	100	100	100	100	75	25	10	0	0	0	0
	4				0	75	100	100	100	75	25	10	0	0	0	0
	5					0	50	100	100	75	25	10	0	0	0	0
	6						0	50	100	75	25	10	0	0	0	0
	7							0	50	50	25	10	0	0	0	0
Exurban	**8**								0	25	25	10	0	0	0	0
	9									0	0	0	0	0	0	0
	10										0	0	0	0	0	0
	11											0	0	0	0	0
SU	**12**												0	0	0	0
Urban	**13**													0	0	0
	14														0	0
	15															0

† UP = Undeveloped Private   SU = Suburban

Figure A-13
Development Level (Central Texas Woodlands Conservation)



Development Level (UFS)

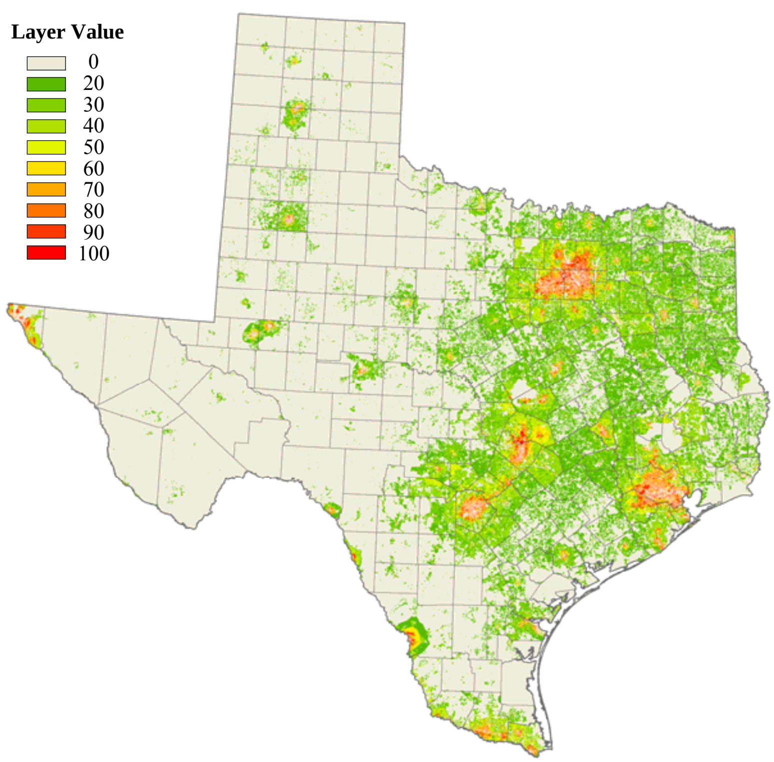
The Development Level layer (Figure A-14) used in the Urban Forest Sustainability (UFS) issue is a modification of that used for the SFLA. The layer value scheme was adjusted to reflect a particular dynamic in urban areas in such a way as to capture changes within the urban housing densities and de-emphasize changes occurring on rural landscapes (Table A-9).

Table A-9
Layer Value Scheme for Development Level for Urban Forest Sustainability†

		2030														
		UP	Rural						Exurban				SU	Urban		
	2000	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
UP	1	0	20	30	40	50	60	70	80	90	100	100	100	100	100	100
Rural	2		0	20	30	40	50	60	70	80	90	100	100	100	100	100
	3			0	20	30	40	50	60	70	80	90	100	100	100	100
	4				0	20	30	40	50	60	70	80	90	100	100	100
	5					0	20	30	40	50	60	70	80	100	100	100
	6						0	20	30	40	50	60	80	100	100	100
	7							0	20	30	40	50	60	90	100	100
Exurban	8								0	20	30	40	60	80	100	100
	9									0	20	30	60	80	100	100
	10										0	20	50	80	100	100
	11											0	40	70	100	100
SU	12												0	70	100	100
Urban	13													0	90	100
	14														0	90
	15															0

† UP = Undeveloped Private SU = Suburban

Figure A-14
Development Level (Urban Forest Sustainability)



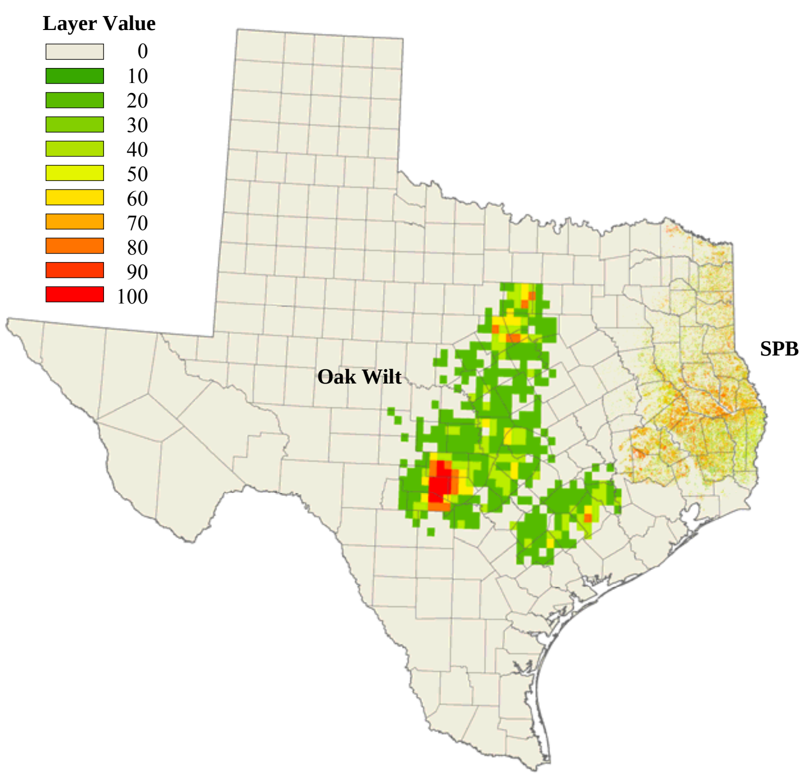
Forest Health

The Forest Health layer (Figure A-15) emphasizes areas where silvicultural treatments can address risks to forest health. This layer is different than that used in the SFLA in that it has been updated with newer, higher resolution southern pine beetle (SPB) data and data on oak wilt has been added. No other insect or disease agents were considered in this layer.

The SPB data is from the Southern Pine Beetle Hazard Maps V1.0 produced by the USDA Forest Service Forest Health Technology Enterprise Team (http://www.fs.fed.us/foresthealth/technology/index.shtml). SPB Hazard is defined as the degree of vulnerability of a stand to SPB, based on stand and physiographic attributes. The model was constructed at 30-meter resolution within a GIS environment using a set of forest parameter layers (basal area, diameter, stand density index, etc.) and a multi-criteria modeling framework. The data were provided as 10 levels of hazard greater than zero.

The oak wilt portion of the layer was developed from data for oak wilt occurrence produced from ground-truthed aerial sketch maps that had previously been digitized and currently are present in a Texas Forest Service geodatabase as polygons. Since oak wilt occurrence is not actually risk, the data was generalized by summing the areas of oak wilt polygons within each USGS 7.5-minute quadrangle. The quadrangle sums were classified into five classes using Natural Breaks classification. The quadrangle polygons were then rasterized to 30-meter resolution.

Figure A-15
Forest Health



Wildfire Risk

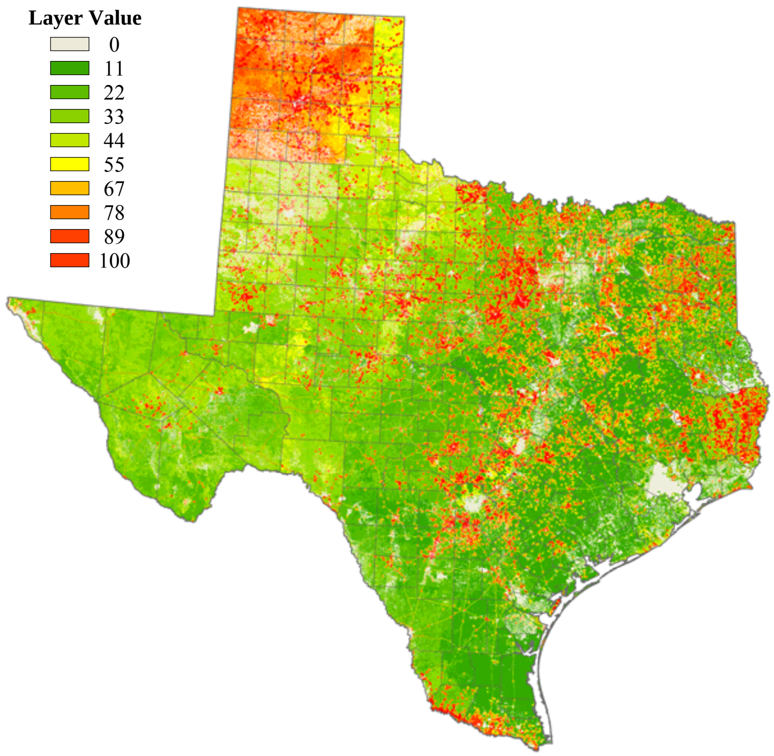
The Wildfire Risk layer (Figure A-16) identifies areas where planning and management are likely to reduce a relatively high risk of wildfire. Wildfire Risk was derived from the Level of Concern for Wildfire Risk output layer developed for the Southern Wildfire Risk Assessment. The Level of Concern (LOC) model integrates historical weather, fire history (ignitions), surface fuels, roads, wildland-urban interface, fire behavior analysis, and fire effects and suppression effectiveness to derive an overall wildfire risk. It combines the probability of an acre burning with the expected effects if a fire occurs. This reflects the possibility of suffering loss. The layer for Texas was updated to include additional fire occurrence data.

The LOC data were provided as floating point data for value. In order to reduce the size of the dataset and improve processing efficiency, the data were reclassified into integers. This layer was further processed to produce layer values ranging from 0 to 100 based on Level of Concern. The layer value scheme is given in Table A-10.

Table A-10
Layer Value Scheme for Wildfire Risk

Layer Value	LOC Break Point as Percentile
0	(non-burnable)
11	22%
22	53%
33	68%
44	74%
55	78%
67	84%
78	90%
89	97%
100	100%

Figure A-16
Wildfire Risk



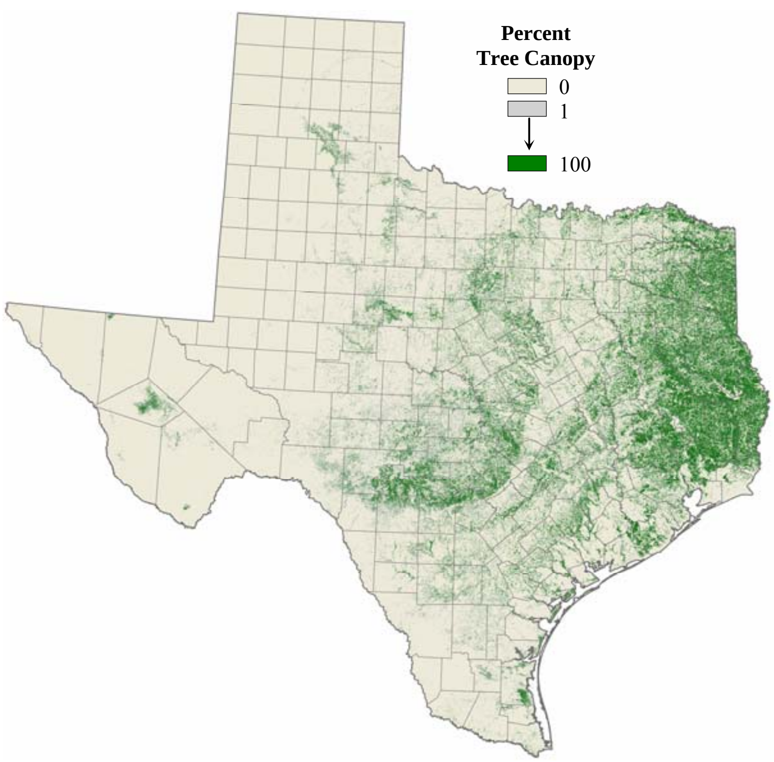
Tree Canopy (and Absence of Tree Canopy)

Tree Canopy (Figure A-17) is a derivative of the NLCD 2001 that quantifies spatial distribution of tree canopy as a continuous variable from 0 to 100 percent. When comparing Tree Canopy to Forestland, several key points are informative:

- Pixel value for Tree Canopy is a continuous variable that can range from 0 to 100 percent
- Pixel value for Forest is a discreet variable with four possible values (41, 42, 43, or 90)
- The minimum size of a NLCD mapping unit is approximately 1 acre (four pixels)
- To be classed as Forest, tree canopy must be at least 20 percent

This data can be downloaded from the Multi-Resolution Land Classification Consortium (MRLC) website at the following URL: http://www.mrlc.gov/.

Figure A-17
Tree Canopy

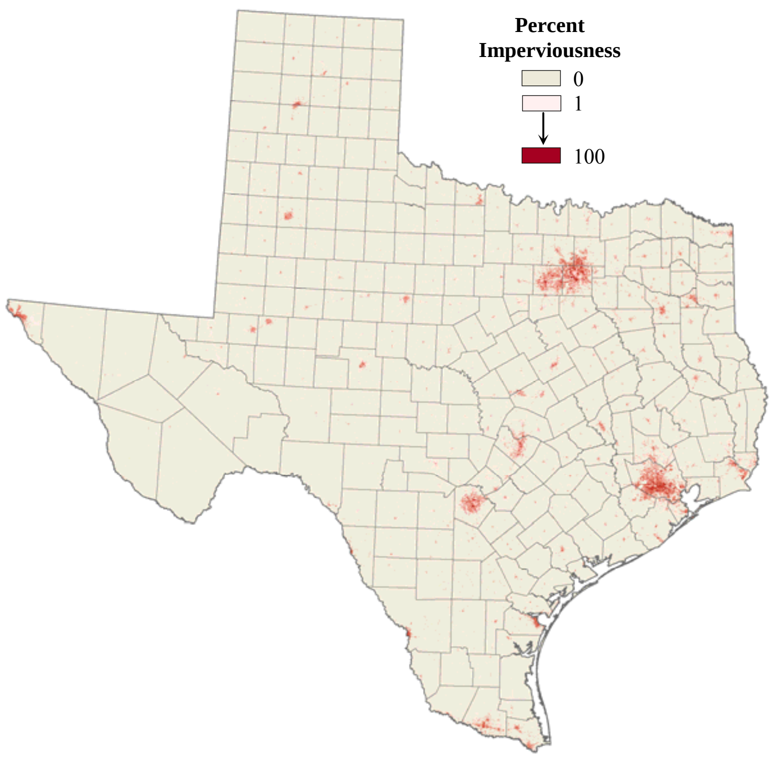


Absence of Tree Canopy is calculated as 100% − Tree Canopy and the corresponding map would appear as an inverse color scheme of that for Tree Canopy.

Imperviousness

Impervious surface (Figure A-18) is also a derivative of the NLCD 2001 and refers to impenetrable surfaces such as rooftops, roads, or parking lots. Imperviousness offers a relatively objective measure of urban density and provides a forum for its classification. For NLCD 2001, imperviousness was chosen as the surrogate for the urban intensity characterization used in the original NLCD 1992. The NLCD 2001 imperviousness quantifies the spatial distribution of impervious surfaces as a continuous variable for urban areas from 0 to 100 percent.

Figure A-18
Imperviousness



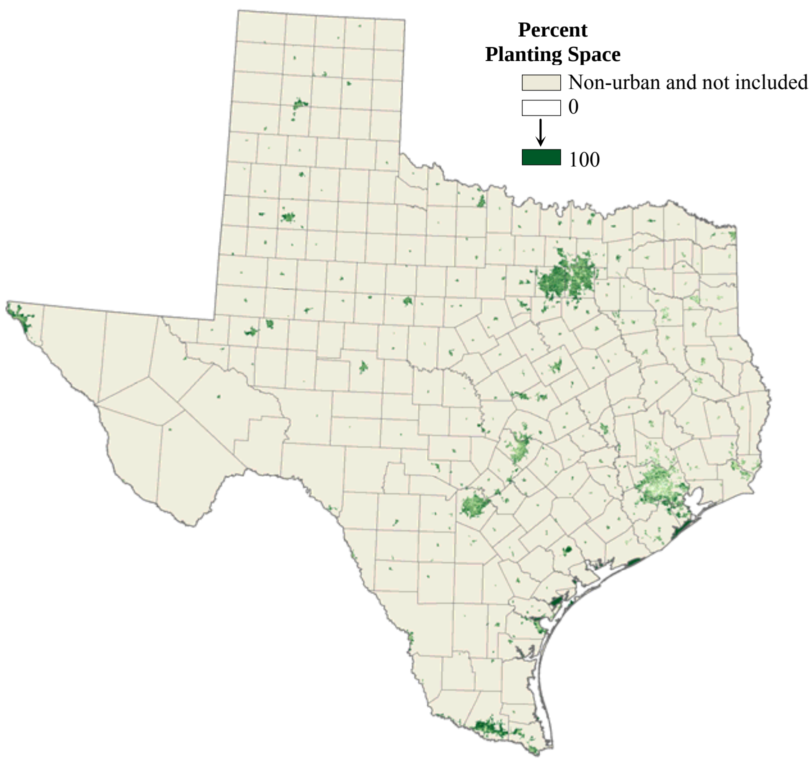
Planting Space

Planting Space is a derived layer that was calculated from the NLCD 2001 Tree Canopy and Imperviousness layers and is calculated as:

$$\text{Planting Space} = 100\% - \text{Imperviousness} - \text{Tree Canopy}$$

Because Imperiousness and Tree Canopy can sum to greater than 100 percent, any values for Planting Space less than 0 were given a value of 0. This layer was used only for the Urban Forest Sustainability Sub-Issue 5 analysis and the Overall Urban Analysis. Thus, only areas within place boundaries or urban boundaries were actually included in any analysis. Figure A-19 shows Planting Space for the Overall Urban Analysis where only U.S. Census Urban Areas and Urban Clusters are included. A comparable map exists for the UFS Sub-Issue 5 analysis in which only the U.S. Census Places are included.

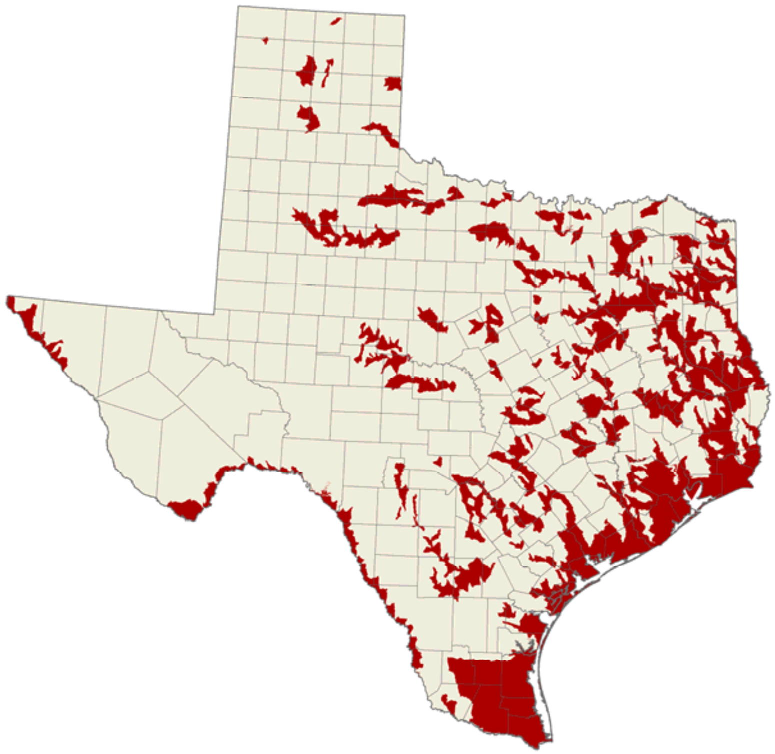
Figure A-19
Planting Space



Impaired Watersheds

Impaired Watersheds (Figure A-20) are defined here as 12-digit HUC watersheds that contain at least one EPA Section 303(d) listed impaired stream segment or water body.

Figure A-20
Impaired Watersheds



Place Growth Zones

For Urban Forest Sustainability Sub-Issue 1—Reduce the impacts of urbanization on forest landscapes—a layer was created to represent growth zones outside city limits. The widths of these zones are based on the Texas rules for the width for each community's extra-territorial jurisdiction (ETJ). The ETJ of a municipality is the unincorporated area that is contiguous to the corporate boundaries of the municipality, the width of which varies by population (Table A-11). U.S. Census Designated Places (CDPs) were also included in the analysis, though under Texas law they do not have ETJs.

Table A-11
Width of Extra-territorial Jurisdiction by Size of Population

Municipality Population	Width of ETJ (miles)
< 5,000	0.5
5,000 –24,999	1.0
25,000 – 49,999	2.0
50,000 – 99,999	3.5
≥ 100,000	5.0

Each pixel of the growth zone layer was identified to a specific Place. This was done by first rasterizing a Place shapefile to 30-meter resolution and then using the Straight Line Allocation function in ArcGIS Spatial Analyst (Spatial Analyst>Distance>Allocation) and setting the maximum distance to the width of the ETJ (in meters). This function creates a new raster layer and assigns each cell, or pixel, the value of the source to which it is closest, in this case, Place. This was done five times, one for each of the five ETJ widths. For each of these five layers, a separate Place layer that had been filtered to include only those places with a population of at least the minimum required for a given ETJ distance was produced and rasterized.

After all five raster layers were produced, they were mosaiced together using the ArcGIS Mosaic to New Raster tool in ArcGIS Toolbox. To ensure that overlapping ETJs were assigned the correct Place, the raster layers were placed in increasing order of ETJ width within the tool and the *Mosaic Method* set to *First*. Although ArcGIS is supposed to automatically determine the correct *Pixel Type*, a software bug was discovered that gave false results for one of the layers unless the *Pixel Type* was set to *32 Bit Signed*. The resulting layer, which is Places with associated ETJ, is shown in Figure A-21.

The layer described above was produced to be able to summarize by ETJ. The actual Growth Zone layer was produced by creating a raster layer where the area within the Place boundaries were given a layer value of 100 and the ETJs outside the Place boundaries were given a value of 0.5. All other areas were given a value of 0. This Place Growth Zone layer is shown in Figure A-22.

Figure A-21
Places with Associated ETJ

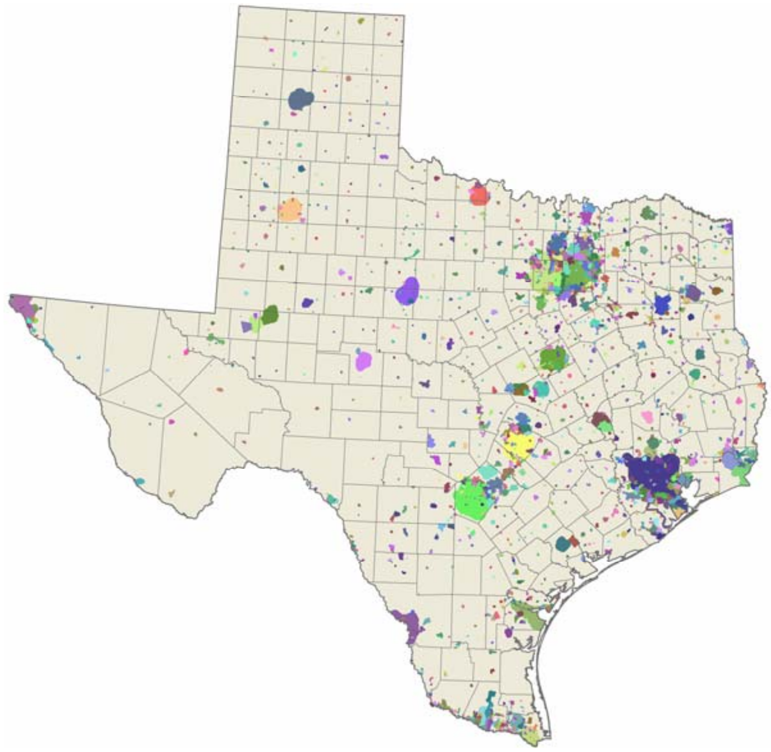
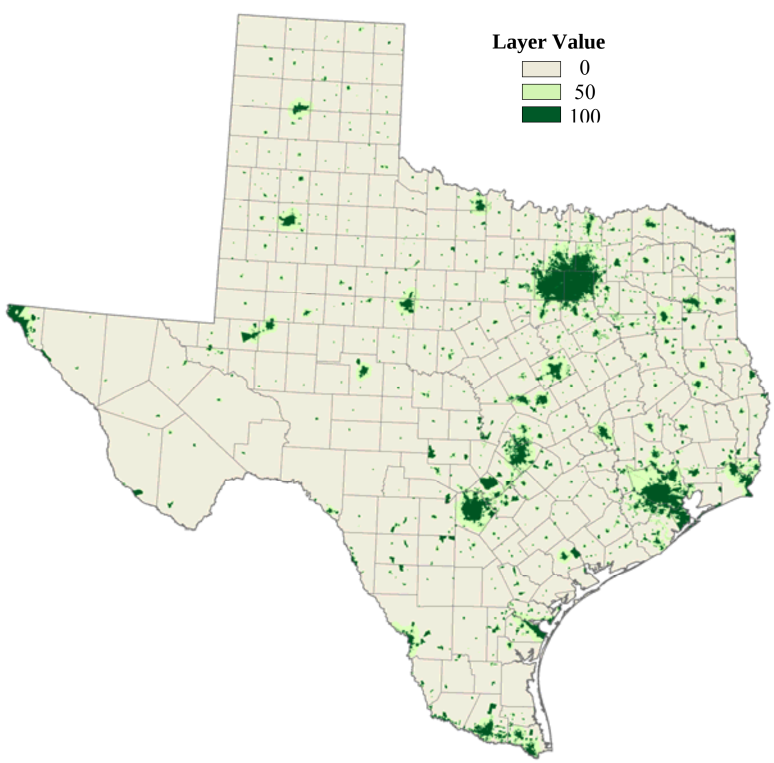


Figure A-22
Place Growth Zones



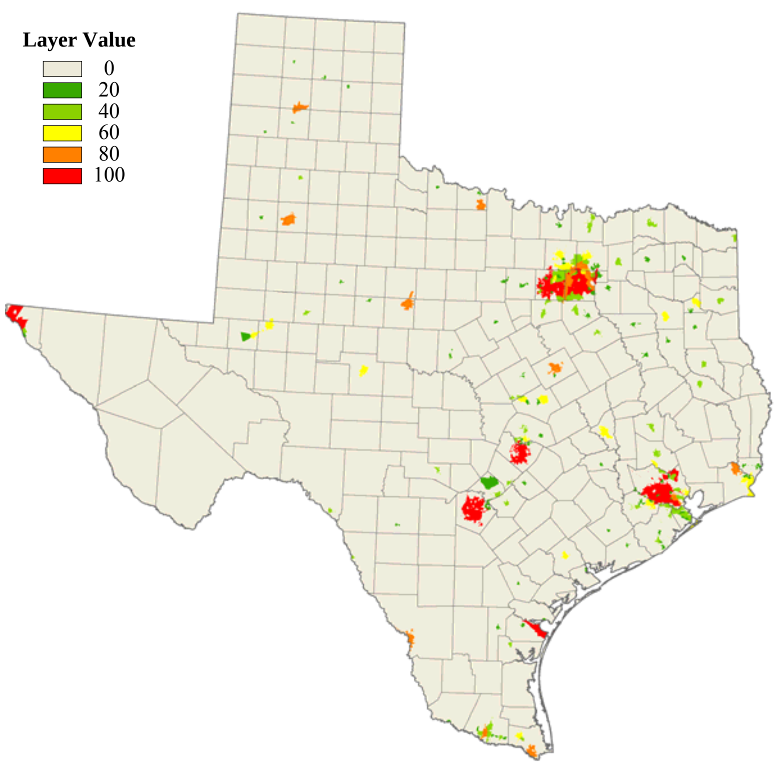
Total Place Population

Total Place Population (Figure A-12) was used in Urban Forest Sustainability Sub-Issue 6—Build U&CF Program Capacity at Local Level. Place spatial data (shapefile) was obtained from ESRI data which contains U.S. Census population data for 2004. The data were classified to six population classes that were given layer values ranging from 0 to 100 as shown in Table A-12. The data were rasterized to 30 meters.

Table A-12
Layer Value Scheme for Total Place Population

2004 Population	Layer Value
≤ 10,000	0
10,001 – 20,000	20
20,001 – 50,000	40
50,001 – 100,000	60
100,001 – 250,000	80
> 250,000	100

Figure A-23
Total Place Population



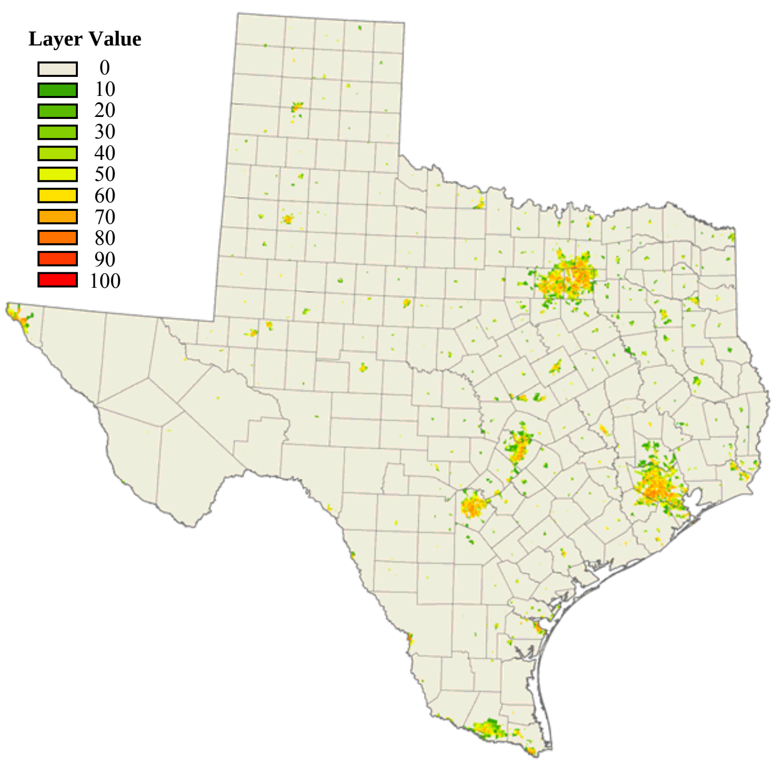
Population Density by Block Group

Population Density by Block Group Figure (A-24) was used for Urban Forest Sustainability Sub-Issues 2, 3, and 5. Block Group spatial data (shapefile) was obtained from ESRI data which contains U.S. Census population data for 2000. The data were classified using ArcGIS's Geometric Interval classification to 11 population classes that were given layer values ranging from 0 to 100 as shown in Table A-13. The data were rasterized to 30 meters.

Table A-13
Layer Value Scheme for Population Density by Block Group

2000 Population	Layer Value
≤ 3,438	0
3,438 – 4,941	10
4,941 – 5,598	20
5,598 – 7,101	30
7,101 – 10,540	40
10,540 – 18,405	50
18,405 – 36,397	60
36,397 – 77,556	70
77,556 – 171,710	80
171,710 – 387,094	90
> 387,094	100

Figure A-24
Population Density by Block Group



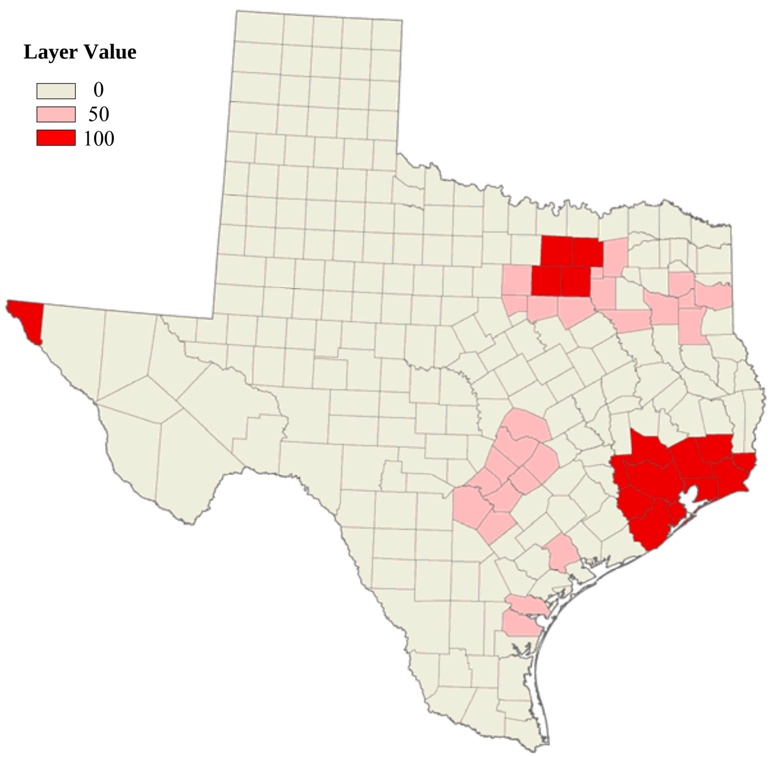
Ozone Non-attainment Areas

The Ozone Non-attainment Areas layer (Figure A-25) was used in Urban Forest Sustainability Sub-Issue 3—Protect and Improve Air Quality. The data were obtained from the Texas Commission on Environmental Quality (TCEQ). Non-attainment is an area that has not achieved compliance with the U.S. National Ambient Air Quality Standards (NAAQS). These counties have been designated by the EPA based on their air quality data. Near non-attainment means an area is very close to falling into non-compliance with the NAAQS and has been given this designation by TCEQ. Non-attainment areas were given a layer value of 100 and near non-attainment areas were given a layer value of 50 (Table A-14).

Table A-14
Layer Value Scheme for Ozone Non-attainment Areas

Zone	Layer Value
Outside zones	0
Near Non-attainment Areas	50
Non-attainment Area	100

Figure A-25
Ozone Non-attainment Areas



Hurricane Risk

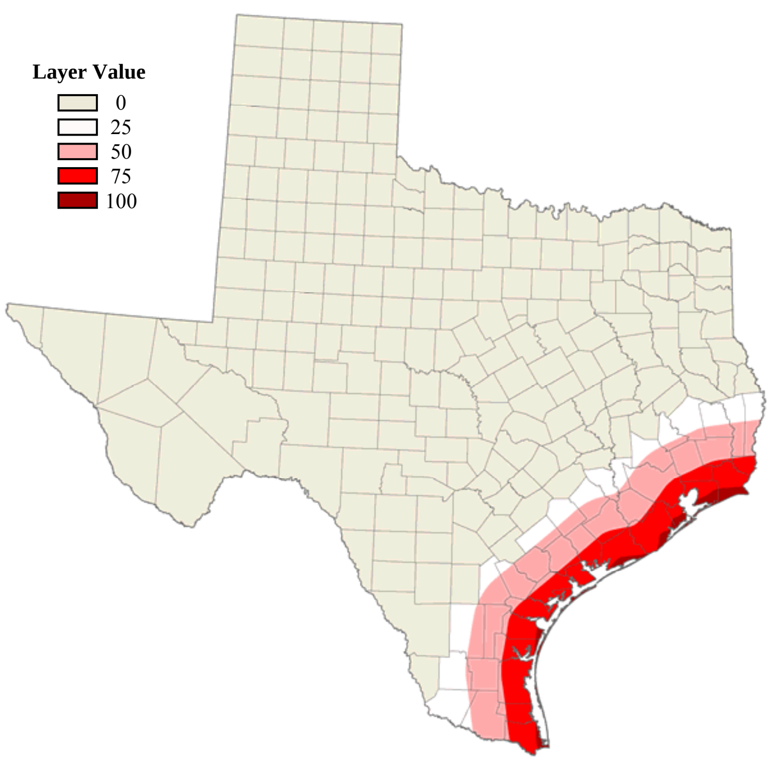
Hurricane Risk was used in Urban Forest Sustainability Sub-Issue 2—Moderate the Impacts of Catastrophic Events. Data for wind risk from hurricanes were obtained from the Coastal Risk Atlas by the National Coastal Data Development Center of the National Oceanic and Atmospheric Administration (NOAA) (http://www.ncddc.noaa.gov/website/CRA_Texas/viewer.htm). The data provide four wind risk categories based on wind speed for a Category 4 storm moving at 12 knots per hour. The data were rasterized to 30 meters using the layer value scheme in Table A-15.

Table A-15
Layer Value Scheme for Hurricane Risk

Wind Risk Class †	Wind Speed	Layer Value
		0
1	75	25
2	92	50
3	109	75
4	127	100

† Category 4 storm at 12 knots per hour

Figure A-26
Hurricane Risk



Ice Storm Risk

Ice Storm Risk (Figure A-27) was used in Urban Forest Sustainability Sub-Issue 2—Moderate the Impacts of Catastrophic Events. Data were produced by digitizing a map of ice-loading districts for ice accumulation on surfaces that was given in the publication Trees and Ice Storms: The Development of Ice-Storm resistant Urban Tree Populations (http://web.aces.uluc.edu/vista/pdf_pubs/ICESTORM.PDF). The data were originally from

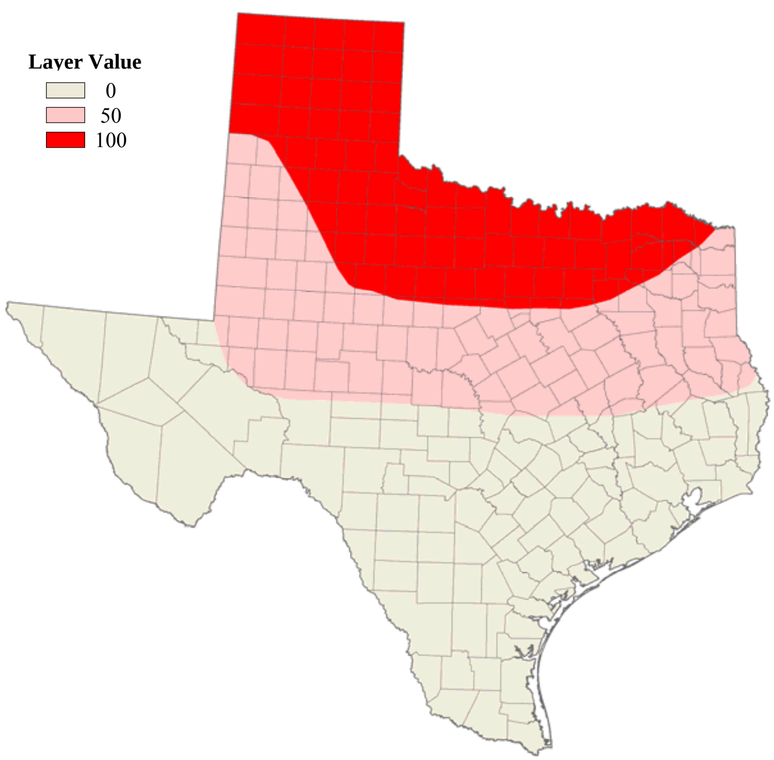
National Bureau of Standards. 1948. National electrical safety code. National Bureau of Standards Handbook H30, pp 161-168. U.S. Government Printing Office, Washington D.C.

Once digitized, the data were rasterized to 30 meters using the layer value scheme in Table A-16.

Table A-16
Layer Value Scheme for Ice Storm Risk

Loading District †	Radial Thickness of Ice (in)	Layer Value
Light	0	0
Medium	0.25	50
Heavy	0.50	100

Figure A-27
Ice Storm Risk



Tornado Risk

Tornado Risk (Figure A-28) was used in Urban Forest Sustainability Sub-Issue 2—Moderate the Impacts of Catastrophic Events. Data for tornado activity was digitized from a map published in

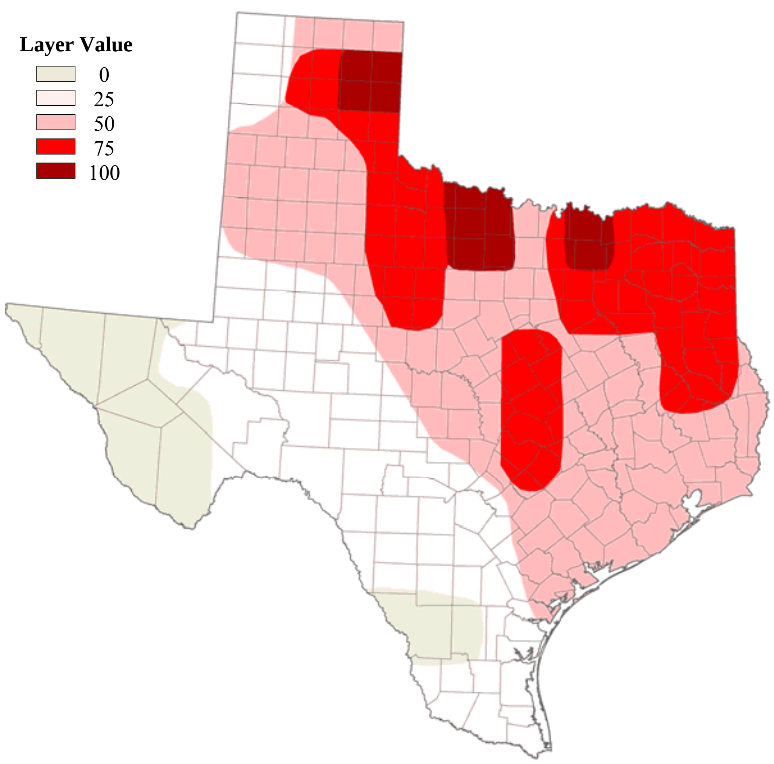
Design and Construction Guidance and Considerations for Large Community Storm Shelters and Safe Rooms. Chapter 2, Protection Objectives. FEMA 361 First Edition July 2000.
http://www.rhinovault.com/fema361.htm

Once digitized, the data were rasterized to 30 meters using the layer value scheme in Table A-17.

Table A-17
Layer Value Scheme for Tornado Risk

Number of Recorded F3, F4, and F5 Tornados per 3,700 Square Miles for 1959 –1998	Layer Value
< 1	0
1 – 5	25
6 – 15	50
16 – 25	75
> 25	100

Figure A-28
Tornado Risk



Community Accomplishment Reporting Systems (CARS)

The Community Accomplishment Reporting System (CARS) is a web-based tool for collecting, storing, and reporting information on urban and community forestry programs at the national, regional, and state level. It is used to report annual accomplishments for the U&CF Program of the USDA Forest Service. Four of the reporting items under CARS are used in assessing a community's urban forestry development:

- Existence of an active urban forest management plan developed from professionally-based resource assessments or inventories

- Existence of professional forestry staff that have degrees in forestry or a related field and/or are arborists certified through the International Society of Arboriculture (ISA)

- Existence and adoption of ordinances or policies that focus on planting, protecting, and maintaining their urban and community trees and forests

- Existence of local advocacy/advisory organizations, such as active tree boards, commissions, or no-profit organizations that are formalized or chartered to advise and/or advocate for the planting, protection, and maintenance or urban and community trees and forests

Spatial data (shape file) were provided by ESRI for U.S. Census Places and joined to table data containing the four CARS measures. The shape file was rasterized four times into four layers to give layer values for each of the four measures—100 for existence and 0 for non-existence. These layers were used in Urban Forest Sustainability Sub-Issue 6—Build U&CF Program Capacity at the Local Level. Figures A-29 through A-32 show these layers. For the UFS Sub-Issue 6 overlay model, these layer values were subtracted from 100 since the non-existence of the criteria was given priority.

Figure A-29
Management Plan/Inventory in Place

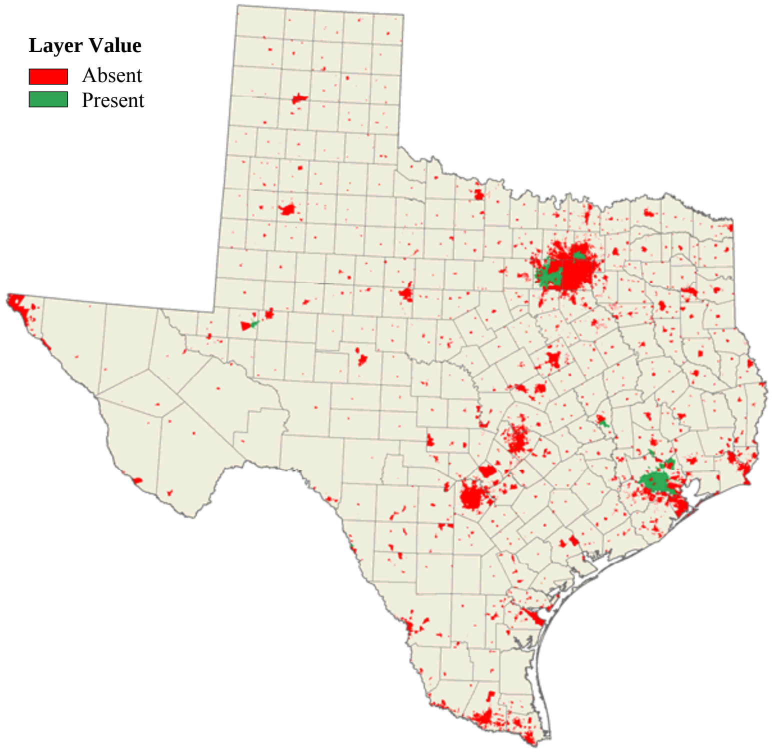


Figure A-30
Professional Staff in Place

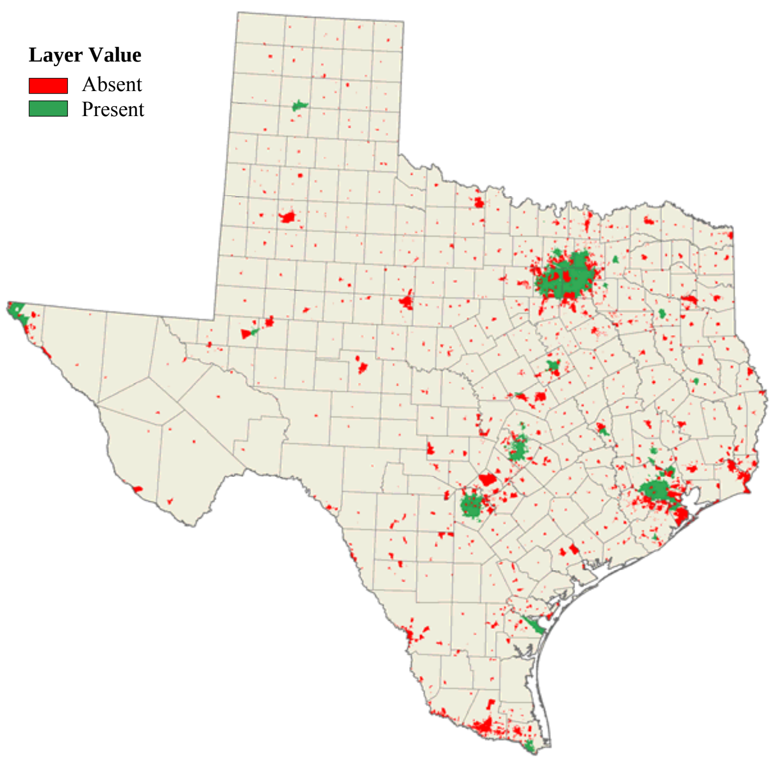


Figure A-31
Tree Ordinance in Place

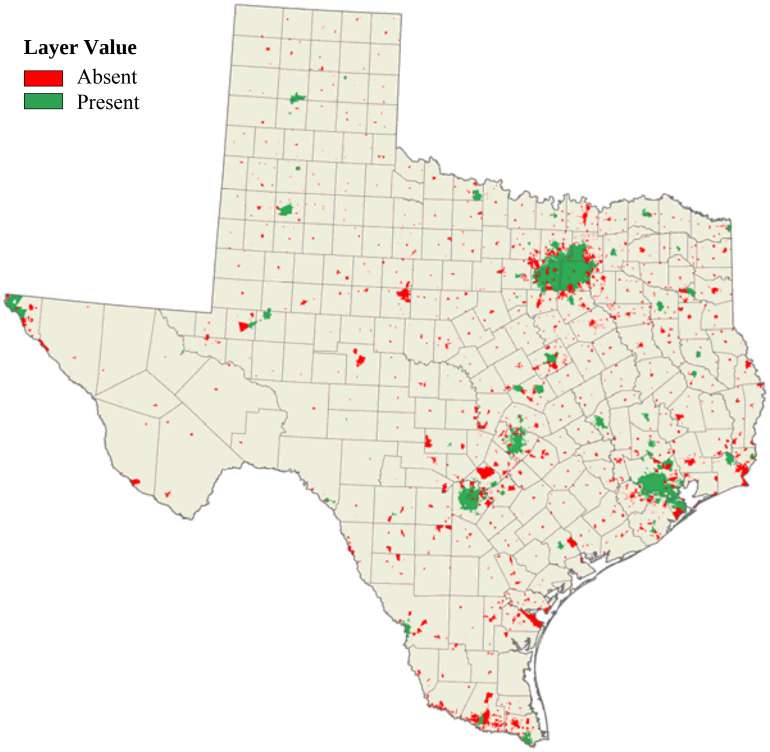
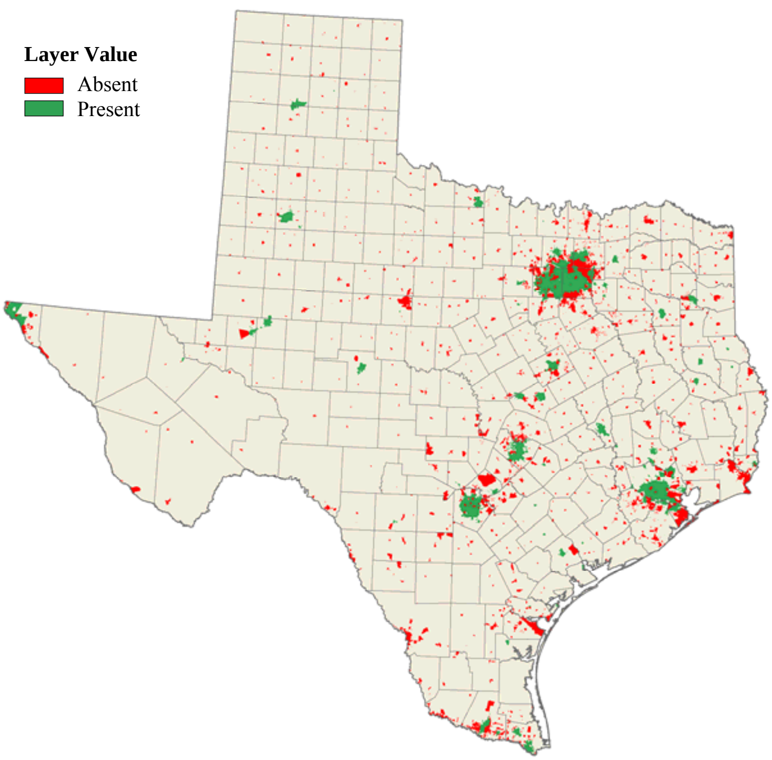


Figure A-32
Advocacy Group in Place



Simple Example of Weighted Overlay Analysis

Figure B-1 shows a simplified example of the concept of weighted overlay analysis using only two layers. For this example, the two layers can each have layer values of 0 and 100. Each layer is then weighted according to its relative importance to the objective of the analysis such that the weights from the two layers sum to 100 percent. Our example uses a layer weight of 70 percent for Layer 1 and 30 percent for Layer 2 (70% + 30% = 100%). When we apply the weights to the two layers, Layer 1 now exhibits weighted layer values of 0 and 70 and Layer 2 exhibits weighted layer values of 0 and 30. The two layers are then overlaid with each other and the weighted layer values for the two layers are added for each coinciding pixel (same spot on the ground). There are four possible final output layer values for our example: 0 + 0 = **0**; 0 + 30 = **30**; 70 + 0 = **70**; and 70 + 30 = **100**. Although four values are easy to comprehend, when more layers or more layer values are used, the number of values can increase significantly. Therefore, it is often advantageous to classify the output layer values to a smaller number of classes using a classification technique such as Natural Breaks. In the example, output layer values of 0 and 30 are classed as Low, a value of 70 as Medium, and a value of 100 as High.

Figure B-1
Simplified Concept of Weighted Overlay Analysis

Two layers:	Layer 1 & Layer 2
Layer values:	0 and 100
Layer weights:	Layer 1 = 70%
	Layer 2 = 30%
	Layer 1 + Layer 2 = 100%