Assessing biodiversity concerns of urban sprawl and projecting smart growth in Hays County, Texas

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Abstract

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“Assessing Biodiversity Concerns of Urban Sprawl and Projecting Smart Growth in Hays County, Texas”

As human population continues to expand into the natural environment, efforts must be made to protect and preserve the biodiversity of plant and animal species. Hays County, located between two major metropolitan areas, San Antonio and Austin, encompasses three distinct ecosystems. Each ecosystem fosters an abundance of native species, some designated by the US Environmental Protection Agency as ‘endangered’ or ‘threatened’.

Our assessment of Hays County’s ecological biodiversity identified two ‘indicator’ avian species for use in a spatial model. Undeveloped areas of Hays County that match the habitat requirements of these species were identified for preservation. Building permits issued over a six-year period from 2000 to 2005 by the county and its municipalities were used to identify development trends and areas of urban sprawl.

Using spatial analyses, including density surfacing, buffering, and raster and vector calculations, biodiversity and sprawl data were modeled. Other environmental components such as soil type, topography, vegetation, and hydrology, were taken into account. Final analyses recommend areas for land development and ‘smart growth’ – where the expansion of human activities will have the least adverse effect on the habitats of selected ‘indicator’ species.

This research is set apart from past analyses by the components used in the model and the simple fact that countywide spatial datasets of building permits in Hays County did not exist before this project.

Keywords: Biodiversity Modeling, Hays County, Texas, Smart Growth

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1. INTRODUCTION

1.1 BACKGROUND

Urban sprawl, also referred to as suburban sprawl, is an uncomplimentary term for the expansive, often volatile and mostly irresponsible, growth of a metropolitan area, traditionally suburbs over a large area (Wikipedia, 2005). Urban sprawl is a synonym for suburbanization, which is the geographical expansion of urban areas at or beyond their borders. More than 90% of urban growth in the United States has been in suburbs in recent decades (Wikipedia, 2005).

Sprawl is characterized by: (1) low concentration of residential development; (2) wide-ranging separation of homes, shops, and workplaces; (3) deficient in distinct, winning activity centers, such as strong downtowns or suburban town centers; and (4) a network of roads evident by very large block size and poor pedestrian access from one place to another. Compact development is the direct opposite of sprawl, keeping corresponding uses close to one another (Ewing et al., 2002).

The Texas State Data Center's figures show that Texas's population will almost double to 33 million by 2030. The majority of this population growth will occur along the I-35 corridor and spread out from it. Hays County, located along the I-35 corridor, is experiencing rapid growth in employment, population and land area affected by development.

Adjacent communities are growing even more dramatically, for example, Hays and Williamson Counties' combined 2000 population of 1.16 million is projected to increase to over 1.4 million by 2010. The population of Hays County has grown from 1990 to 2000 at a (+ 48.7) change.

Though most people assume that growth pays for itself, studies indicate differently. New growth does not necessarily translate into new wealth for communities. The Texas office of American Farmland Trust conducted a study of the fiscal impact of existing land uses on the Hays County's budget. The studies showed that farms, ranches and open lands generate three times more tax dollars for a county than the county spends on them for public services. Industrial and commercial properties provide a net fiscal benefit as well, but residential development requires $1.10 in services for every tax dollar it generates (Texas Environmental Profiles, 2005).

This increase in population will definitely change Hays County, however, we can guide and shape this future growth to both curtail the negative environmental, economic, and social impacts and preserve the best aspects of life in our area. Guiding and shaping future growth to curtail negative economic, environmental and social impacts is referred to as smart growth. Smart growth development policies aim to prevent urban sprawl and pollution. It is somewhat associated with ecology movement efforts to control sprawl and conserve natural habitat, and environmental movement efforts to reduce pollution and reliance on private automobiles (Wikipedia, 2005).

Smart growth means stimulating existing cities and suburbs and making efficient use of land, rather than developing in remote farm fields and forests. It means making cities and suburbs affordable places to live, so that everyone can contribute and benefit from this revitalization (Ewing et al. 2005). Smart growth also means giving wildlife habitats and open space the same level of awareness and concern as roads, utilities and sewers. Additionally, it means giving citizens a meaningful say in how our communities change, using tools such as the Endangered Species Act. The Endangered Species Act provides an important means for important actions that protect wildlife from sprawl. In particular, smart growth is about making communities improve as they grow, so that they are not only more environmentally responsible, but also more lively, beautiful and satisfying for the people who reside in them. The best way to protect natural habitat is to become far more conscious and intentional about creating wonderful human habitat (Ewing et al. 2005). Expanding development will put additional stress on diminishing wildlife resources and their habitats, and has the ability to drive more plants and animals towards extinction. If the U.S. is to preserve its current plant and animal species for future generations, the nation must plan carefully to guide development so that it leaves critical habitat intact (Smart Growth America, 2005).

The study by Texas Resource and Environmental Engineer Systems (T.R.E.E.S.) will investigate Hays County's problem with urban sprawl and assess how it will impact concerned species habitat in Hays County and by using smart growth principals, attempt to guide growth to an area of least unfavorable impact to these habitats.

1.2 PROBLEM STATEMEMT

The purpose of this study is to:

1) identify where urban sprawl is occurring in Hays County,
2) identify the habitat requirements for endangered species in the study area and map out distribution of suitable habitats
3) project an area for smart growth that has the least adverse impact on these habitats.

The extent of our study will focus on urban sprawl located in Hays County, Texas. Hays County is a county in Texas with a population of 114,193, and a total area of 693.5

square miles (U.S. Census Bureau, 2005). The county is located on the border between the Edwards Plateau and the southern Black Prairie region.

1.3 ENDANGERED SPECIES ACT

The Endangered Species Act of 1973 was one of the of U.S. environmental laws passed in the 1970s in an effort to reverse and stop the degradation of the environment. The act is intended to protect critically at risk species from extinction due to "the consequences of economic growth and development untempered by adequate concern and conservation" (Wikipedia, 2005). Congress first passed legislation to protect endangered vertebrates in 1966 and later expanded the law in 1969 to include invertebrates. Subsequently, in 1973 Congress expanded both the power and scope of species protection by creating the Endangered Species Act. The purpose of the Act is to protect species and also "the ecosystems upon which they depend." The Act protects all plants and animals at the species level, while previously laws protected only vertebrates. This Act forbids federal agencies from funding, authorizing or carrying out actions, which may imperil endangered species. Additionally, the Act forbids any government agency, corporation, or citizen from taking (i.e. harming or killing) endangered animals without a permit (Wikipedia, 2005). On an ecosystem level, the Act necessitates that endangered species be established "critical habitats" which include all areas essential for their recovery. Federal agencies are forbidden from authorizing, funding, or carrying out any action which "destroys or adversely modifies" a critical habitat area (Endangered Species Coalition, 2005).

A species can be listed through two methods. The first method is for the Fish and Wildlife Service or National Marine Fisheries Service to take the initiative and directly list the species. The second method is through individual or organizational petition. On the list there are two categories, endangered and threatened. Endangered species are closer to extinction than threatened species (Endangered Species Coalition, 2005).

Furthermore, the Fish and Wildlife Service develops a strategy to assist the listed species to recover, and requires that developers and the government protect "critical habitats," the special places that endangered species need to survive and recover (Endangered Species Coalition, 2005).

The Endangered Species Act has been extremely successful at preventing extinctions. Approximately 98-99% of species protected by the law have been kept from extinction. Scientists believe that the United States might have experienced more extinctions but for the protective provisions of the Endangered Species Act (Endangered Species Coalition, 2005).

The Act contains a citizen enforcement clause, permitting citizens and scientists to sue the government to list a species with decreasing numbers or to act in accordance with the law (Endangered Species Coalition, 2005).

1.4 INTRODUCTION GOLDEN-CHEEKED WARBLER

The Golden-cheeked Warbler is the only exclusively native nesting bird from the 613 bird species reported from Texas. It is rare and endangered, but found locally in the juniper-oak (*Juniperus-Quercus*) woodlands of central Texas, where its unmistakable buzzing song indicates the beginning of spring to many central Texas birders. It becomes scarce by early summer and departs early for the wintering grounds in the mountains of southern Mexico and Central America, where it also uses a mixed evergreen-oak forest habitat. The Golden-cheeked Warbler has been designated an Endangered Species by the U.S. Fish and Wildlife Service (Ladd and Gass, 1999).

1.5 INTRODUCTION BLACK-CAPPED VIREO

The Black-capped Vireo breeds in a relatively narrow area of the south-central United States and north-central Mexico. It is now gravely endangered in Oklahoma and much of the northern, eastern, and central portions of its range in Texas. Among the most influential factors contributing to its decline are nest parasitism by the Brown-headed Cowbird (*Molothrus ater*) and habitat deterioration and loss through development, destruction and natural successional changes resulting from fire suppression. The Black-capped Vireo has been designated an Endangered Species by the U.S. Fish and Wildlife Service (Grzybowski, 1995).

2. LITERATURE REVIEW

2.1 SPRAWL AND ENVIRONMENT

2.1.1 Fulton et al. "Who Sprawls the Most? How Growth Patterns Differ Across the U.S,"

Fulton explains that our planet is now in the midst of a major extinction event because of sprawl. Even though many Americans are aware of the rapid loss of plant and animal species, a great deal of the public debate has focused on resource industries or farming and livestock business in the world's secluded landscapes. Actually, the United States has a rich diversity of plants and animals, and has a diverse gamut of wildlife. Unfortunately, nearly one third of the nation's plant and animal species are at risk, and more than 500 U.S. species are lost and may already be extinct. The extinction crisis is not just a remote problem; it is happening here. The principal risk to most of these species is the destruction or degradation of the habitats on which they depend. Even as many human activities from agriculture to development can change natural habitats, the conversion of natural areas to urban and suburban zones is the fastest growing threat to the nation's wild species. Nearly three quarters of Americans already live in urban or suburban areas, and the U.S. is expected to see continued growth in metropolitan area populations. Urban and suburban areas now cover 64 million acres, having grown by nearly 300 percent since 1955, while the population has risen by no more than 75 percent. Furthermore, the speed of land development has been accelerating in each successive decade since the 1950s. If current development continues at this rate 18 counties are going to exploit all of their remaining non-federal farmland and other natural areas to accommodate projected growth, and another 19 will take up more than one-half of farmland and natural areas. Altogether, approximately 22,374 square miles of natural resource and habitat land in these 35 municipal areas are estimated to be lost to development over the next 25 years. This out of control land use can only be reduced if development is concentrated into existing urban and suburban areas, new development is built to be more compact, and natural areas are protected from reckless development.

2.1.2 Daily, G. C. "Nature's Services, Societal Dependence on Natural Ecosystems"

Daily explains why we need to be concerned with urban sprawl and how important our ecosystem is to us by citing examples. Over 90 percent of all flowering plants and over 75 percent of crop plants that feed humankind rely on pollinators. Pollinators also fertilize plants from which many leading medicines; dyes, beverages and fibers are derived. In the year 2000 alone, the economic value of insect-pollinated crops in the United States was estimated to be from $20 - $40 billion. Therefore, the loss of pollinator species will lead to a succession of devastating losses to our food supply and economy. The loss of individual plant and animal species, both identified and at this time undiscovered, would also represent lost prospects for future advances in medicine. A majority of today's most common medicines were derived from wild plants, animals, or microorganisms. For instance, the treatment of breast cancer has benefited from the discovery of a naturally occurring substance known as paclitaxel. Paclitaxel was first discovered in the Pacific yew, a slow-growing tree found in the Pacific Northwest, and formerly considered a "trash" tree that was burned after clear cutting forests. Beyond safeguarding individual species, protecting natural areas from over-development can generate major economic and environmental benefits, particularly with regard to protecting water quality. Water agencies have found that land conservation can help decrease the impacts of polluted runoff, which endanger both drinking water quality and the endurance of aquatic habitats across the U.S. New York City, for example, acquired watershed lands in the Catskill Mountains for $250 million in the 1990s, and avoided having to spend over $6 billion on new water filtration and treatment plants. Other communities are accomplishing these goals by promoting "low impact development," as is being done in Prince George's County, MD, which educates and encourages builders to use design features and technology that minimize pollution and resource consumption.

2.1.3 Ewing, R.,. et al. Endangered by Sprawl: How Runaway Development Threatens America's Wildlife.

Developmental trends will have considerable detriments for the survival of America's wildlife heritage if development continues on its present course. To better realize the potential extent of this threat, Ewing analyzed the distribution of species classified as imperiled or critically imperiled relative to designated metropolitan areas. Scientific assessments of the conservation status for more than 35,000 U.S. species were completed, and databases were made documenting the precise location of those of greatest conservation concern. The latest assessments are regarded as providing a more comprehensive view of the extinction risk facing the nation's plants and animals than does the listing of species formally protected under the U.S. Endangered Species Act. Ewing currently classifies approximately 6,400 U.S. species as imperiled or critically imperiled, compared with just 1,265 U.S. species that are federally listed as threatened or endangered. Their study analyzed the distribution of 4,173 imperiled or critically imperiled species and subspecies occurring in the mainland United States. Approximately 60 percent of imperiled species were found in one or more of the mainland metropolitan areas, with 31 percent found exclusively within metropolitan areas. Conservation biologists were concerned not only with the total number of species in a region, but also with the number and status of distinct populations of these species. Amazingly, 46 percent of all known population occurrences of imperiled species are within the boundaries of metropolitan areas. These figures suggest that the future of numerous rarest and most endangered species will depend not only on what occurs in remote rural landscapes, but will be directly related to growth patterns within metropolitan areas. The study showed that the 35 fastest growing large metropolitan areas together are home to nearly 29 percent of all known imperiled species, and 13 percent apparently are restricted to these metro areas. Additionally, these 35 areas, which are concentrated in the western and southern regions of the country, also have about 19 percent of all known population incidences of imperiled species. The largest number of imperiled species was found in the San Francisco metropolitan area and contained 257 species. Another western metropolitan area, the Los Angeles-Long Beach-Riverside CSA, was shown to be home to 219 imperiled species, including the Pacific pocket mouse. This region covers an area larger than the state of

South Carolina, and is projected to lose 12 percent of its remaining open space to development by 2005. Regions not usually linked with endangered species conflicts also have significant biological resources that may be at risk. The Charlotte, NC metro area, which is expected to lose 35 percent of its remaining open space to sprawl, is home to 13 imperiled species, such as the Carolina creek shell mussel. In addition, in the Nashville, TN region, where sprawl will expected to consume 17 percent of remaining green infrastructure lands, is habitat to 43 imperiled species, including the Tennessee coneflower. Moreover, the Tampa-St. Petersburg-Clearwater metro area has 26 imperiled species, including the Tampa vervain flower, and is projected to lose 40 percent of its remaining open space to development. The figures are even more pronounced when examined at the county level. Indeed, a total of 287 imperiled species are found in the 37 counties projected to lose half or more of their green infrastructure between 2000 and 2025. In the study, Austin, TX and its surrounding counties consumed 14% of green infrastructure lands, home to 33 imperiled species such as the Golden-cheeked Warbler and Black-capped Vireo. Ahead of the other Texas counties was Harris County, TX, part of the Houston metropolitan area, whose population growth between 2000 and 2025 would use up a astounding 619 square miles of open land at existing densities. In fact, Harris County will run out of open land before the demand is fully met. Six other high-growth counties in Texas are in this same situation. Collectively, the top 20 counties of Texas have projected land consumption of 5,815 square miles.

2.1.4 *U.S. Fish and Wildlife Service "Management Guidelines for the Golden-Cheeked Warbler in Rural Landscapes"*

This leaflet from U.S. Fish and Wildlife Service explains soils and other habitat requirements in the Hays area that would be habitat for the Golden-cheeked Warbler. This information was necessary to further define the soil types for Hays County. Soils listed as good habitat for the Golden-cheeked Warbler are: rocky soils and outcrops, and loamy soils such as: Brackett, Purves, and Real. These soils are good for drainage and for the growth of junipers and oak.

2.2 GIS APPLICATIONS FOR ENDANGERED SPECIES

2.2.1. Shaw, D. "Applications of GIS and remote sensing for the characterization of habitat for threatened and endangered species"

Geographic Information Systems (GIS) and remote sensing technologies were used to identify and describe potential habitat for three species endemic to the Southwestern United States; the Golden-cheeked Warbler (Dendroica chrysoparia), the Black-capped Vireo (Vireo atricapillus) and the Texas kangaroo rat (Dipodomys elator). For each species, the computerized classification of digital satellite imagery was integrated with spatial information (e.g. soils, geology and landuse, vegetation) to construct a database to be used for ecological evaluation as well as habitat protection and management measures. Habitat for both the Golden-cheeked Warbler and Black-capped Vireo consisted of Ashe juniper, Live Oak, Texas Oak, Plateau Live Oak, Texas Red Oak and Shin Oak as major vegetation requirements. Slope requirements were > .5 degrees with water 50 meters away. The size of tracts needed for the endangered species were 30 + in acre size with a canopy cover of 35 –100%. Evaluation of density was done with DOQQ's. Roads to lessen disturbance are located at least 50 meters away from habitats.

3. DATA

3.1 BASE LINE DATA

- County Lines - US Census Bureau
  http://www.census.gov/

- Digital Elevation Model- Texas Natural Resource Information System
  http://www.tnris.org/update3.cfm

3.2 ENVIRONMENTAL DATA

- Hydrology – Capital Area Council of Governments
  http://www.capco.state.tx.us/Information_Clearinghouse/

- Soils – Capital Area Council of Governments
  http://www.capco.state.tx.us/Information_Clearinghouse/

- Species – Texas Parks and Wildlife Department
  Personal Inquiry to find Tabular Data on Species in Hays County

- Land Use / Land Cover- Hays County Land use and cover
  ftp://issweb.ci.austin.tx.us/pub/coa_gis.html

- Vegetation- Hays County Vegetation
  ftp://issweb.ci.austin.tx.us/pub/coa_gis.html

- Building Permits – Hays County Appraisal District (Hays County Records)
  Personal Inquiry to find Tabular Data on Locations

4. METHODS

4.1 CREATION OF PROJECT GEODATABASE

The most efficient way of using ArcCatalog and ArcMap is to create an organized project Geodatabase. This was created in ArcCatalog and named "Sprawl.idb". We assigned NAD 83 as the spatial reference for our database and projected using State Plane Texas Conformal Conic. We established the data that was needed to create a model to show ideal habits and the sprawl growth of Hays County. Once these features were identified we began the creation of the Feature Datasets and Feature Classes. This was prepared to make it possible to import the data to the proper locations and to create an organized model.

4.2 GEOCODING BUILDING PERMITS

To show the development throughout Hays County, T.R.E.E.S. acquired a database showing building permit data from the Capitol Area Metropolitan Planning Organization. These spreadsheets and excel files displayed information about the locations and dates of building permits for Hays County. In order to display this information as a point shapefile through ArcMap, geocoding the building permits was completed. To begin geocoding, a road system for Hays County with detailed street information was necessary to create accurate matches. The Hays County road shapefile (Figure 2) we used was acquired from the Capital Area Council of Governments. A standard format was then chosen for the addresses in the excel database to ensure that the address locator, that was later created, would be able to recognize and place the addresses accurately. US Alphanumeric Ranges (Geodatabase) was used because it was most compatible between the street name in the roads shapefile and the address format for the building permit database. Growth was made into a shapefile because it would be easier to visualize after creating a shapefile showing each individual year. The database was then split into five different sections, each having the building permits that were purchased for that year. Once the five database files were changed to a DBF IV (Database Format Four), we were able to import them into the Sprawl Geodatabase as a table. An address locator was created using the same address format, US Alphanumeric Ranges (Geodatabase), to match the addresses of the permits with the road shapefile that we downloaded. ArcCatalog creates a point shapefile of the building permit locations when the address locator matches the permit addresses with the roads shapefile. Once the shapefile has been created (Figure 1), we imported each one into our Permits Feature Dataset as Feature Classes.

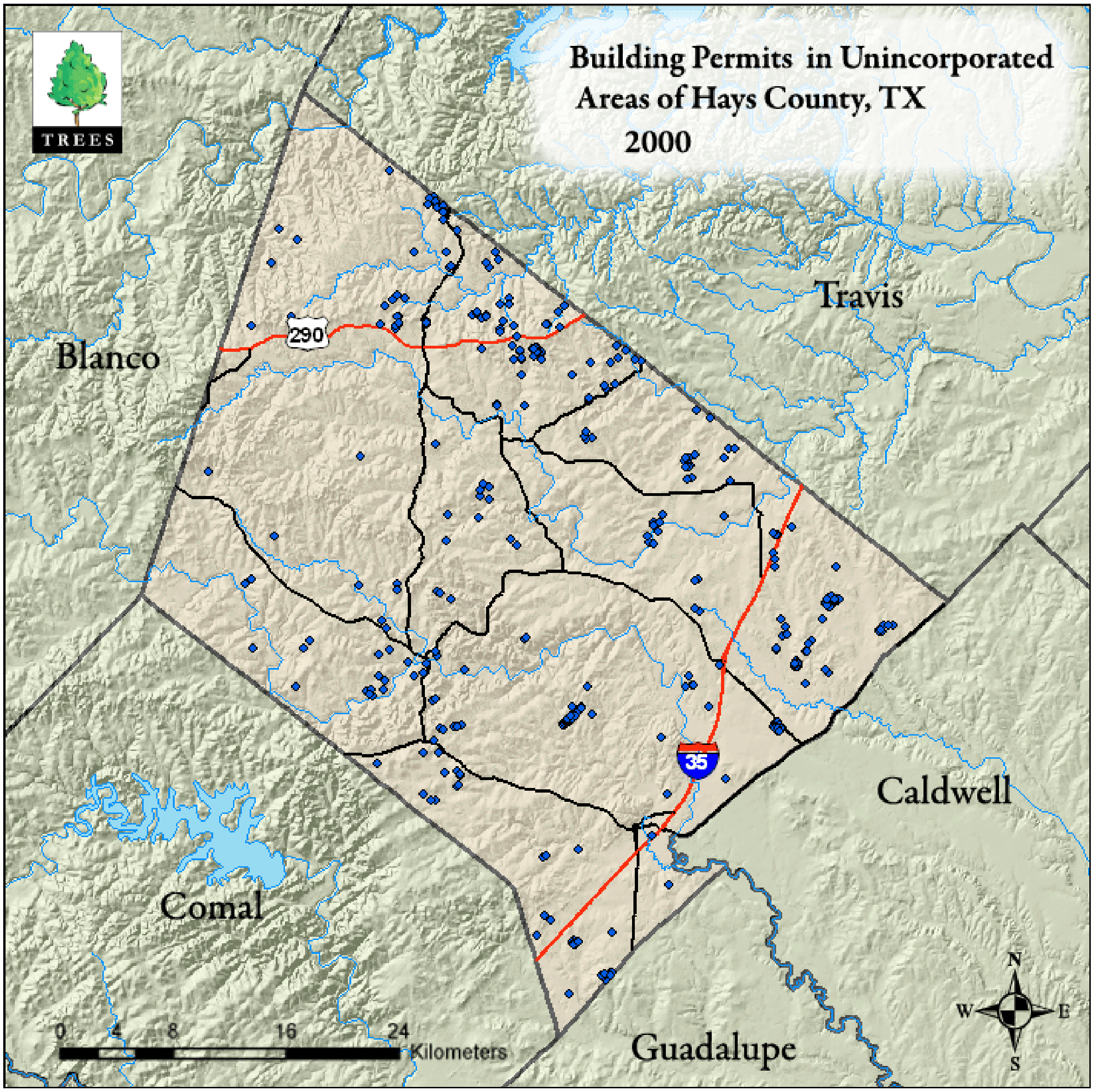

Figure 1. Map of geocoded permit data.

4.3 IDEAL HABITAT LOCATIONS

Habitat locations were configured using information from literature review. Soils needed were rocky outcrop and loamy clay. Vegetation required was juniper and oak woodlands. Slope required was more than 5 degrees. Additionally, buffers were needed around rivers of 50 meters or 164 feet because the optimal habitat is 50 meters from a river or stream. Buffers were also required around the roads of 50 meters or 164 feet because the birds do not live in disturbed areas and must be a minimum of 50 meters away from roads. These requirements are discussed in more detail in the Literature Review and Background sections of the paper.

4.4 HYDROLOGY AND ROADS

In order to find an ideal habitat location for these species we must look at the hydrology (Figure 3) and the road system (Figure 2) of Hays County. The species of concern must be within fifty meters of a lake or stream, and must be fifty meters away from any type of roads. To find this optimal habitat area we created a buffer for both features. We created a new shapefile from both the hydrology and the roads shapefile with an added fifty-meter buffer. The new hydrology shapefile created was then imported into the Sprawl Geodatabase as a feature class named "good_hydro". This feature shows all of the areas in Hays County that could be good habitats that are within fifty meters of a water source. The new roads shapefile with the fifty-meter buffer was also imported into our Sprawl Geodatabase as a feature class named "bad_roads". This feature shows the area that is an unlikely area for our species to live due to the disturbance from the roads. Next, two new feature classes were used to remove the areas where our unsafe "bad_roads" and our safe "good_hydro" overlap. Subsequently, the Union function was used to find where these two areas overlap and to create a new shapefile in the Hydrology Feature Dataset as "bad_hydro". This new area displayed where the water source was too close to the roads to create an optimal habitat.

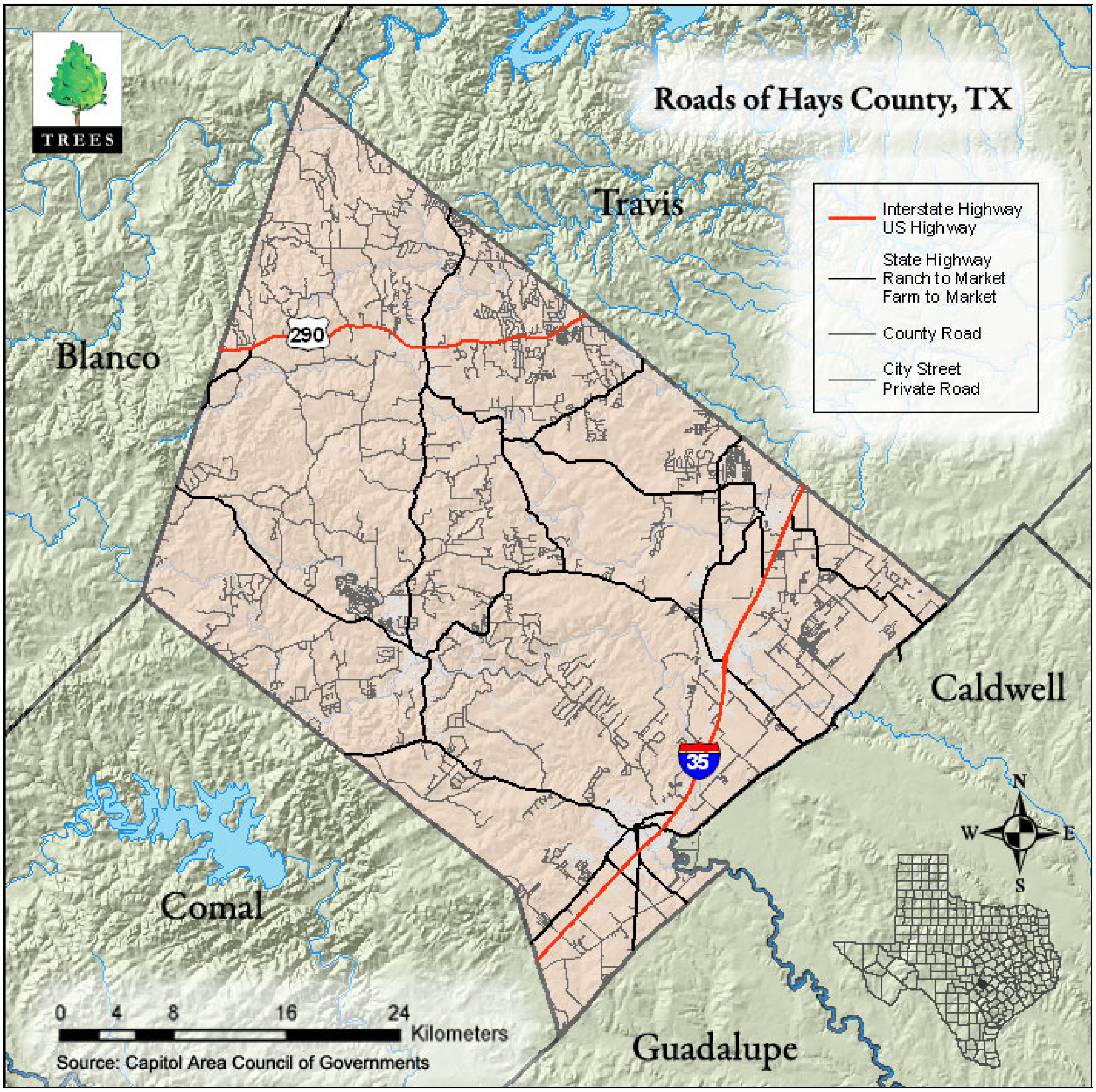

Figure 2. Base map showing roads of Hays County.

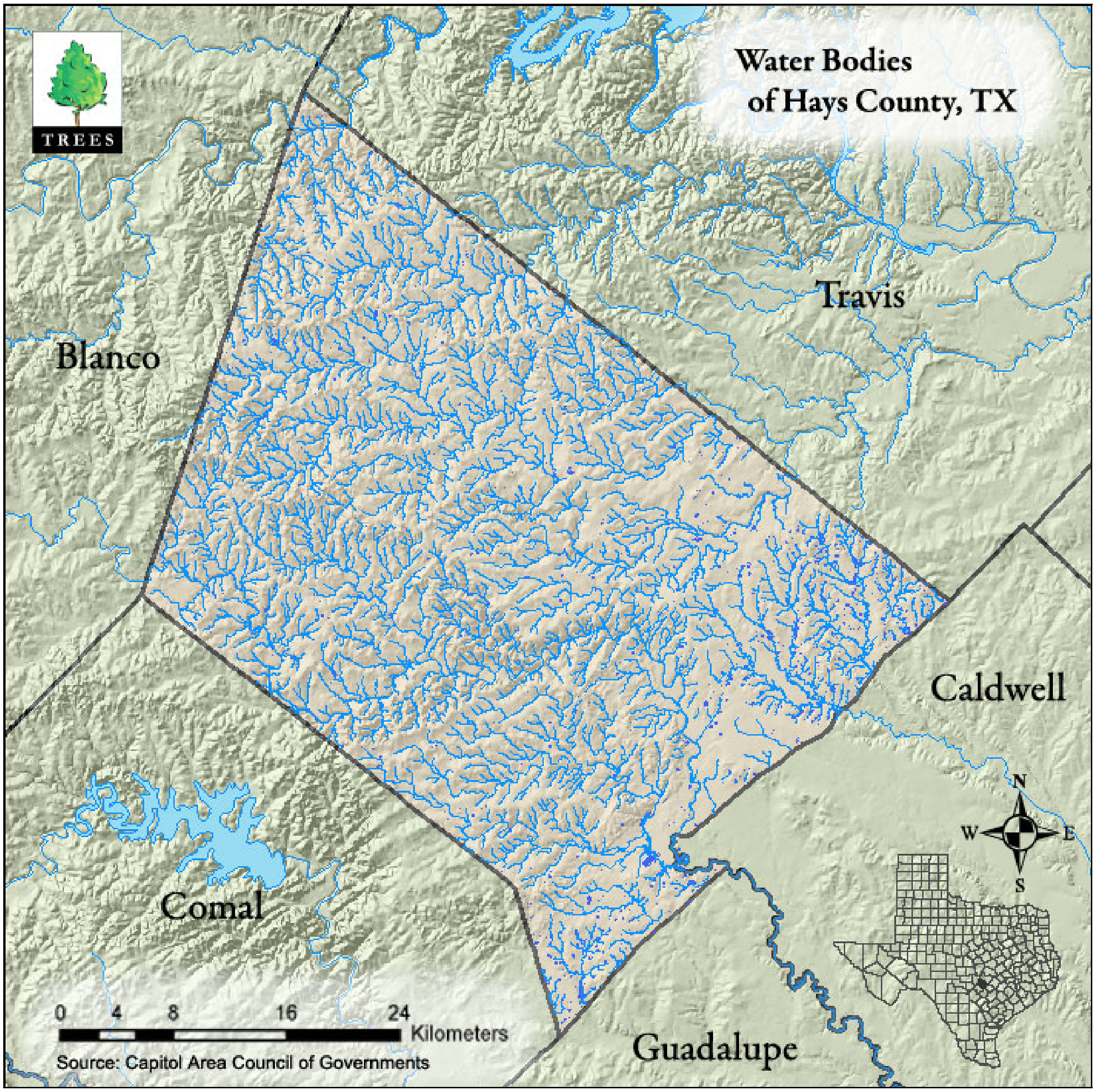

Figure 3. Base map showing water bodies (rivers, streams, ponds) of Hays County.

4.5 VEGETATION AND SOILS

The species of our concern require certain types of vegetation (Figure 4) and soil (Figure 5) to create and maintain a proper nesting site. We used our vegetation shapefile along with our soils shapefile to find areas of overlap that created an optimal area for this species nesting. We created new feature classes in both the Vegetation and the Soil

Feature Datasets that then extracted the prime area from each of these two shapefiles. Next, selection by Attribute function was used to find these ideal areas. The new vegetation shapefile that remained was created and only had the vegetation that our species required. Habitat for both the Golden-cheeked Warbler and Black-capped Vireo consisted of Ashe juniper, Live Oak, Texas Oak, Plateau Live Oak, Texas Red Oak and Shin Oak as major vegetation requirements. We also created a new soil shapefile that consisted of the soils that our species required. Soil requirements consisted of rocky outcrops and loamy soils such as: Brackett, Purves, and Real. Once these new shapefile files were created they were imported into our Sprawl Geodatabase as feature classes. Subsequently, areas were found that were our ideal vegetation and soil shapefiles overlap. The union feature was used again to identify the optimal areas where the soils and vegetation meet the habitat requirements and named the shapefile "Good_Earth".

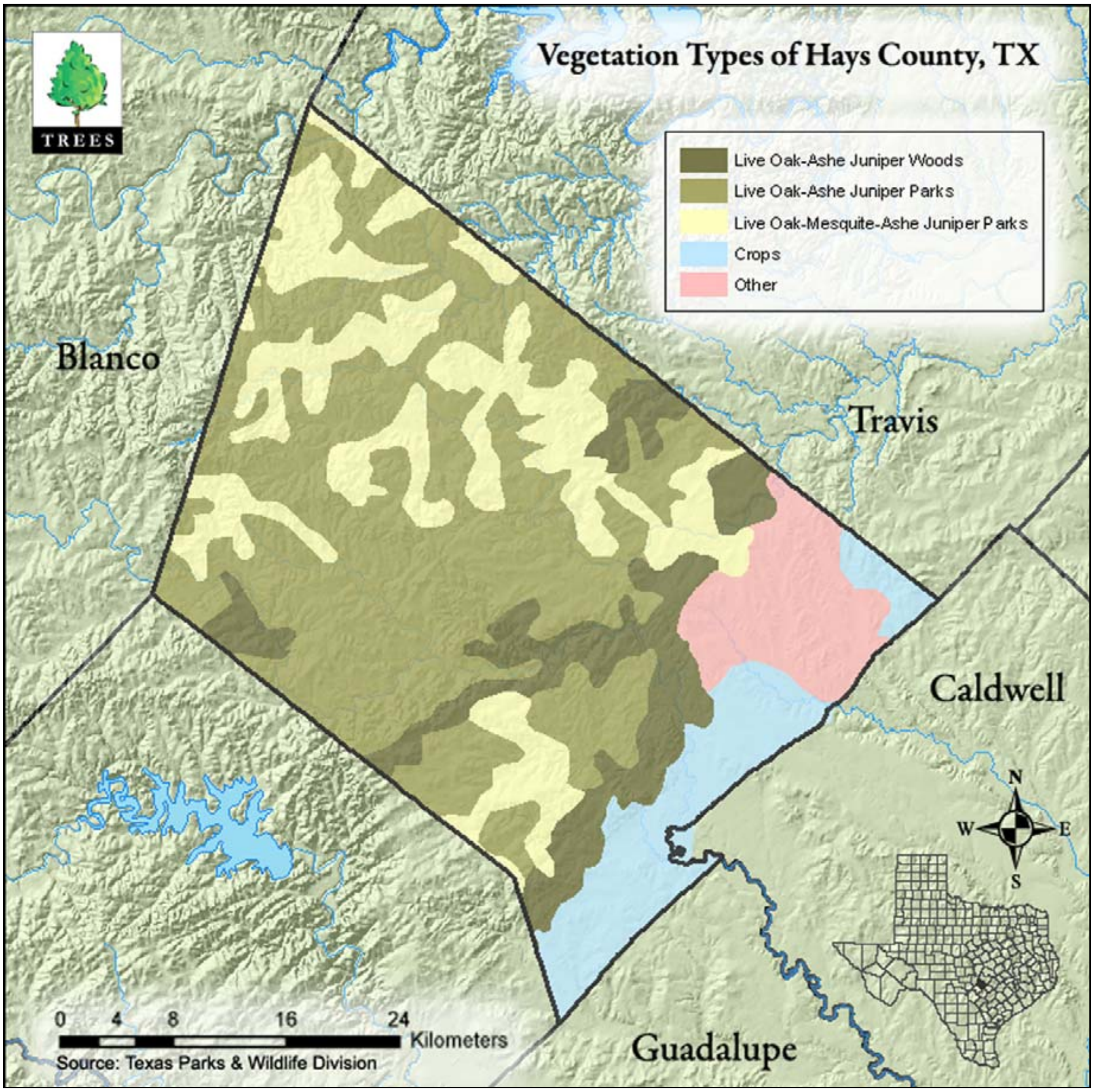

Figure 4. Base map showing vegetation types of Hays County.

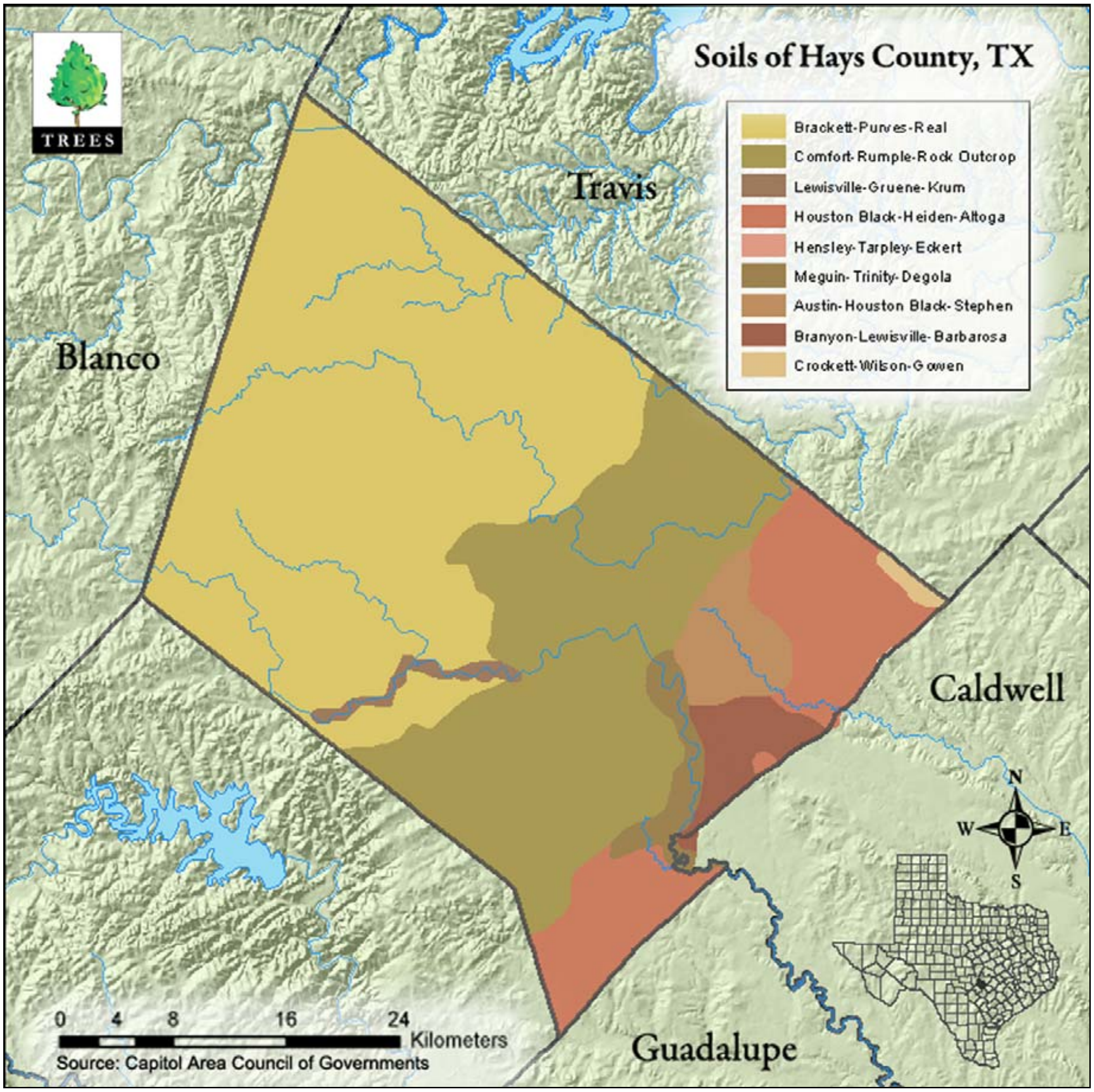

Figure 5. Base map showing soils of Hays County.

4.6 DIGITAL ELEVATION MODEL

We used a digital elevation model to find ideal areas where the slope of the land does exceed five degrees. The Digital Elevation Model (DEM) chosen displays the different elevation through the state of Texas. The extraction feature was used to find the areas of the DEM that are within Hays County. A new raster dataset was created from the extraction of the DEM. The slope function from the Spatial Analyst toolbar created another new raster dataset that displays the slope in Hays County. The new dataset was imported into the Sprawl Geodatabase as a new Raster Catalog using ArcCatalog. Raster Calculator was then used to find the areas with a slope that is greater than five degrees. The DEM (Figure 6) was reclassified into two categories showing the suitable areas with more than five-degree slope, and the unsuitable areas with a slope less than five degrees.

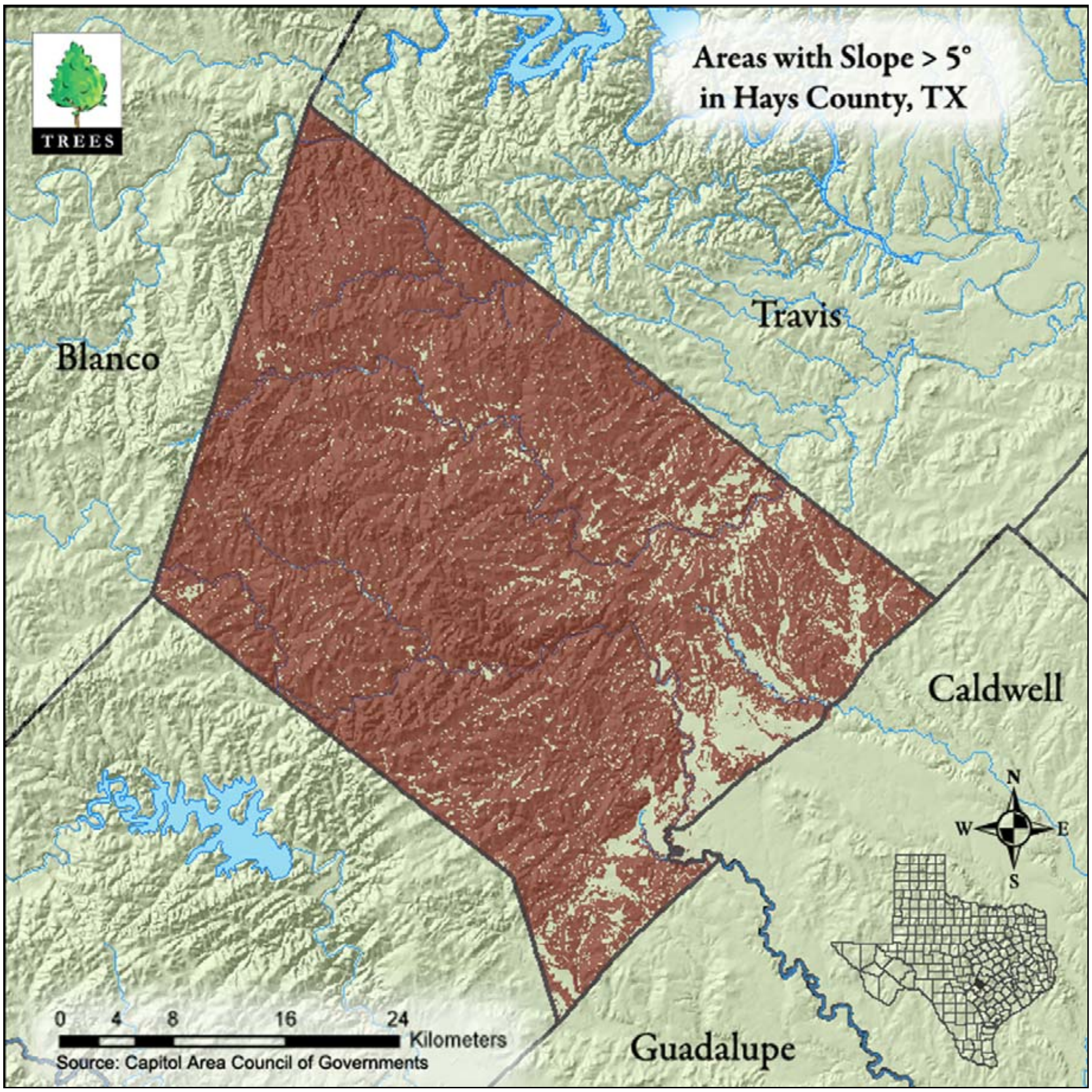

Figure 6. Slope map of habitat greater than 5 degrees.

4.7 RASTERIZING AND RASTER CALCULATION

The creation of our final analysis required all of our data to be in raster format. The final shapefiles “Good_Earth” and “Bad_hydro” must be put into raster format to make it possible to calculate the final optimal habitat. The Feature to Raster function was used to create the new raster datasets. The new raster datasets are then imported into the Sprawl Geodatabase. Once imported into the database, the raster datasets were reclassified to show optimal areas without reference to slope. The raster calculator was then used to calculate where our optimal slope intersects our “Good_Earth” layer without intersecting our “Bad_Hydro”. These areas are not within fifty meters of the road but are within fifty meters of a water source. These areas also meet the vegetation and soil requirements while having a greater slope of five degrees.

5.0 RESULTS

Our first step of the analysis to obtain our results began with creating a 50-meter buffer around the roads (Figure 7). Secondly, a 50-meter buffer was created around the lakes and river systems of Hays County (Figure 8). Suitable vegetation and soils created from analysis are shown in (Figure 9). Habitat analysis created from buffers and vegetation and soils indicating areas that were clipped are shown in (Figure 10). Figure 11 is a map from an analysis of permit density. This map was created to show where the growth was occurring using density analysis. A map was then created from density of habitat analysis indicating areas that are of optimal habitat for the concerned species (Figure 12). Our final map shows the smart growth recommendations for Hays County (Figure 13).

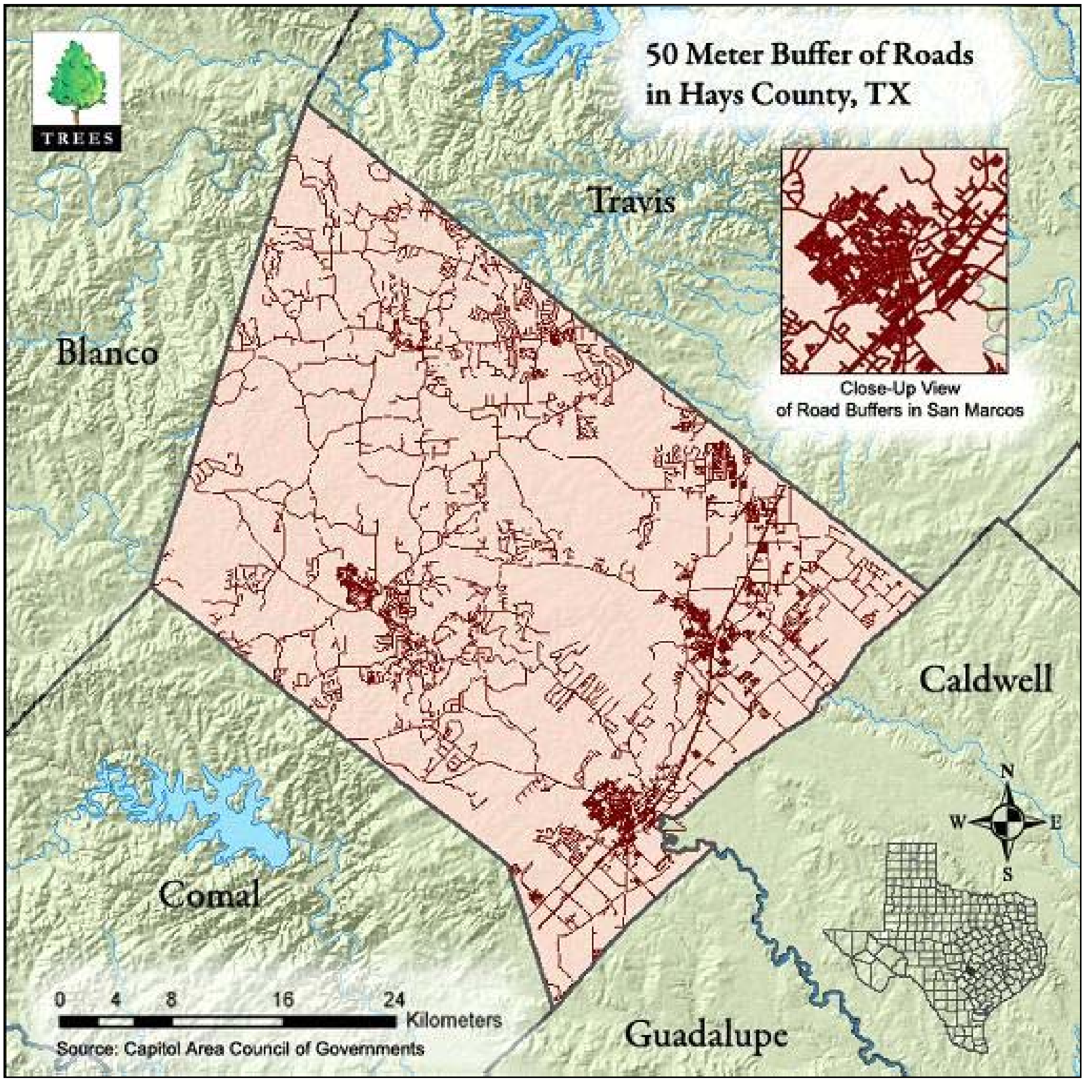

Figure 7. Fifty meter buffer around Hays County Roads.

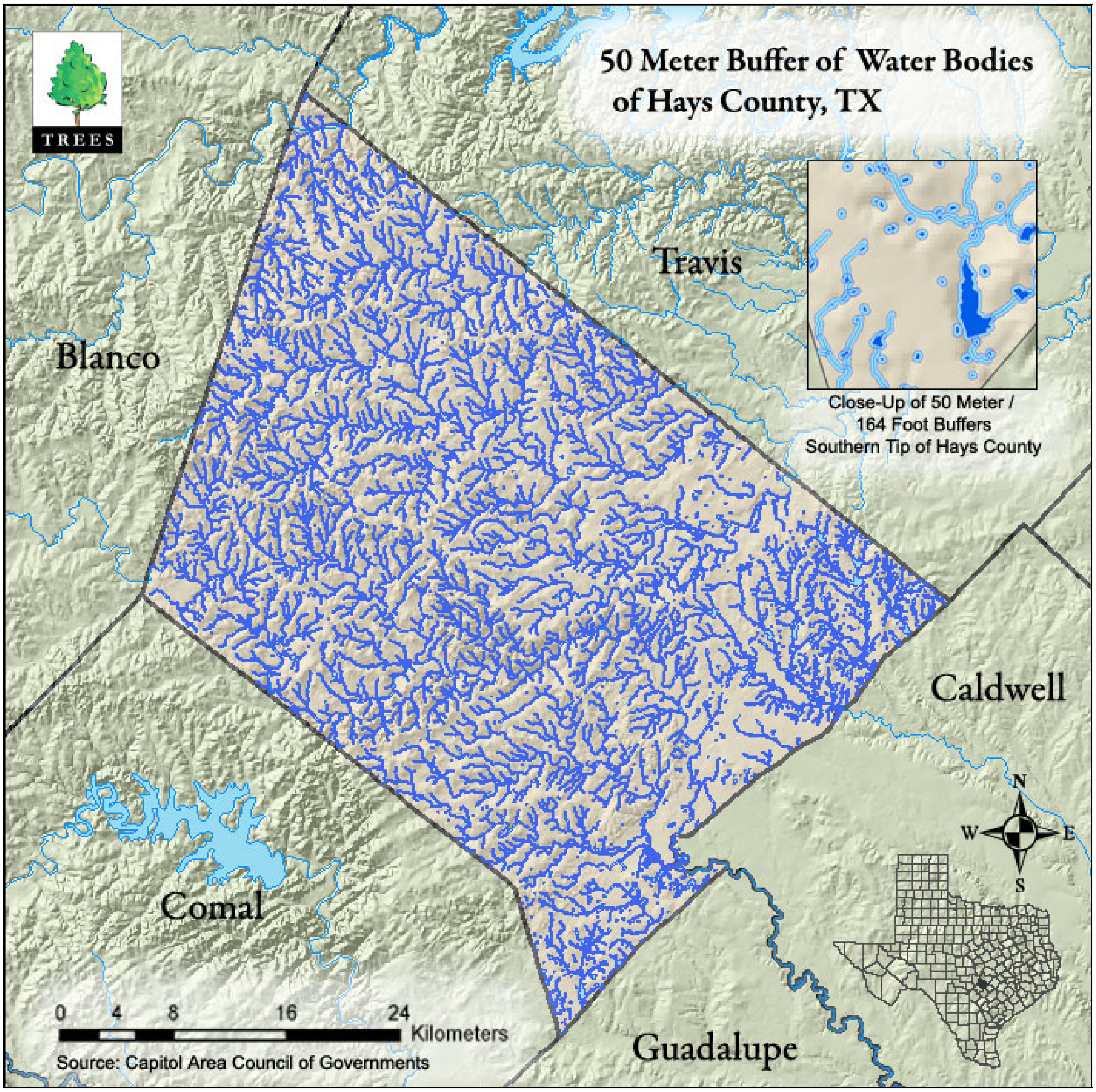

Figure 8. Fifty meter buffer around lakes and river bodies in Hays County.

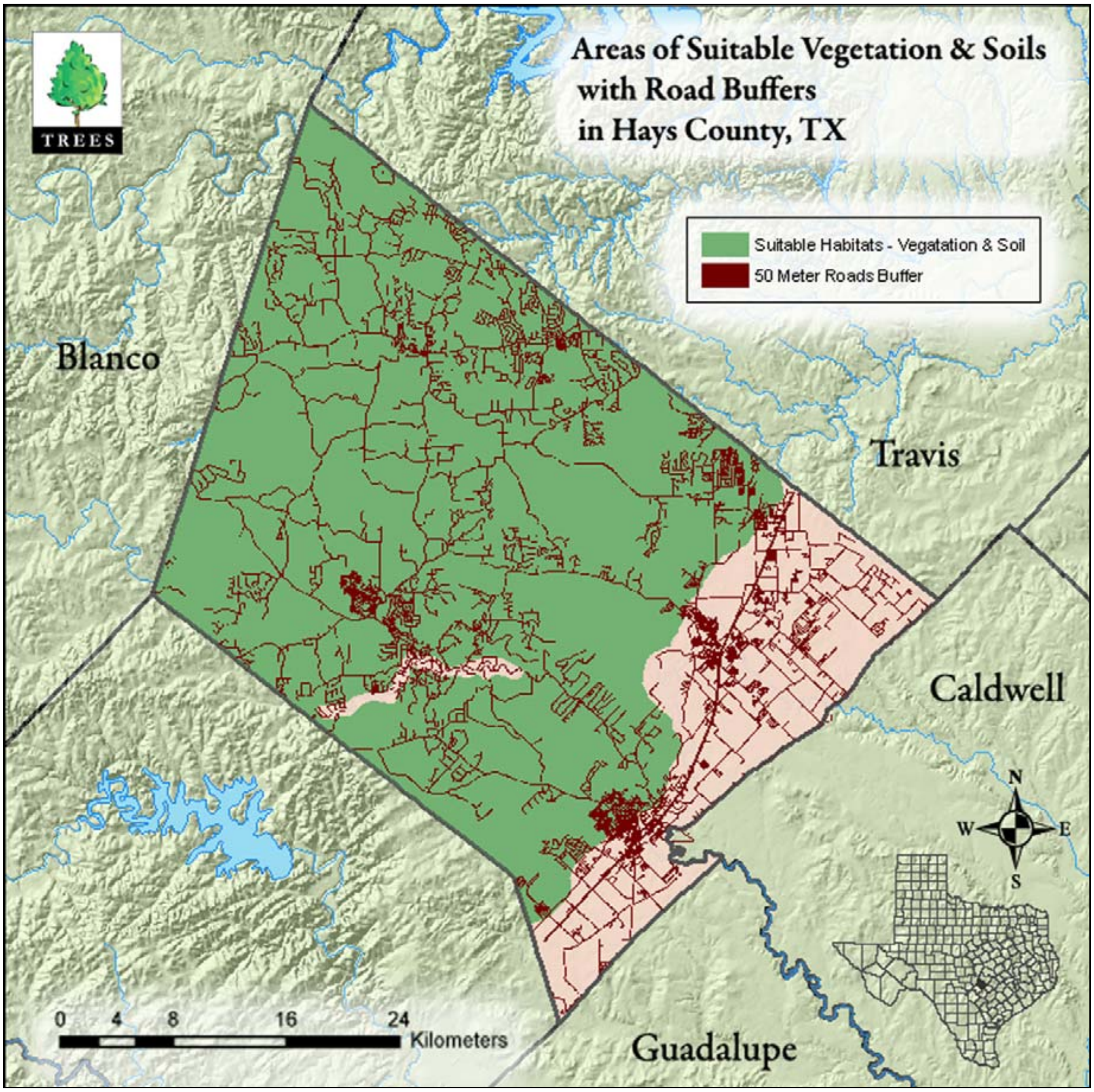

Figure 9. Suitable vegetation and soils map shown with Hays County roads.

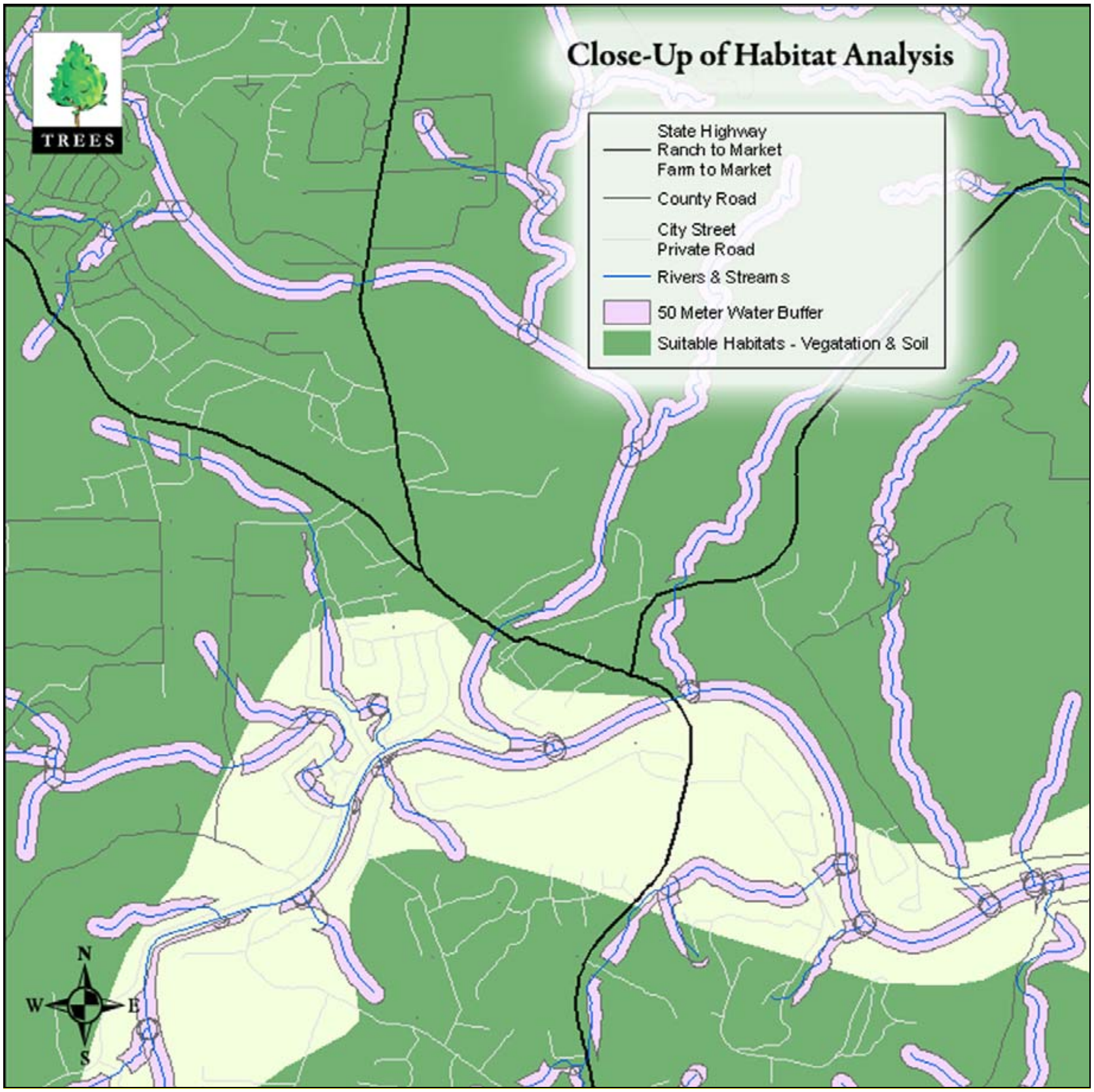

Figure 10. Close-up of habitat analysis showing clipped areas.

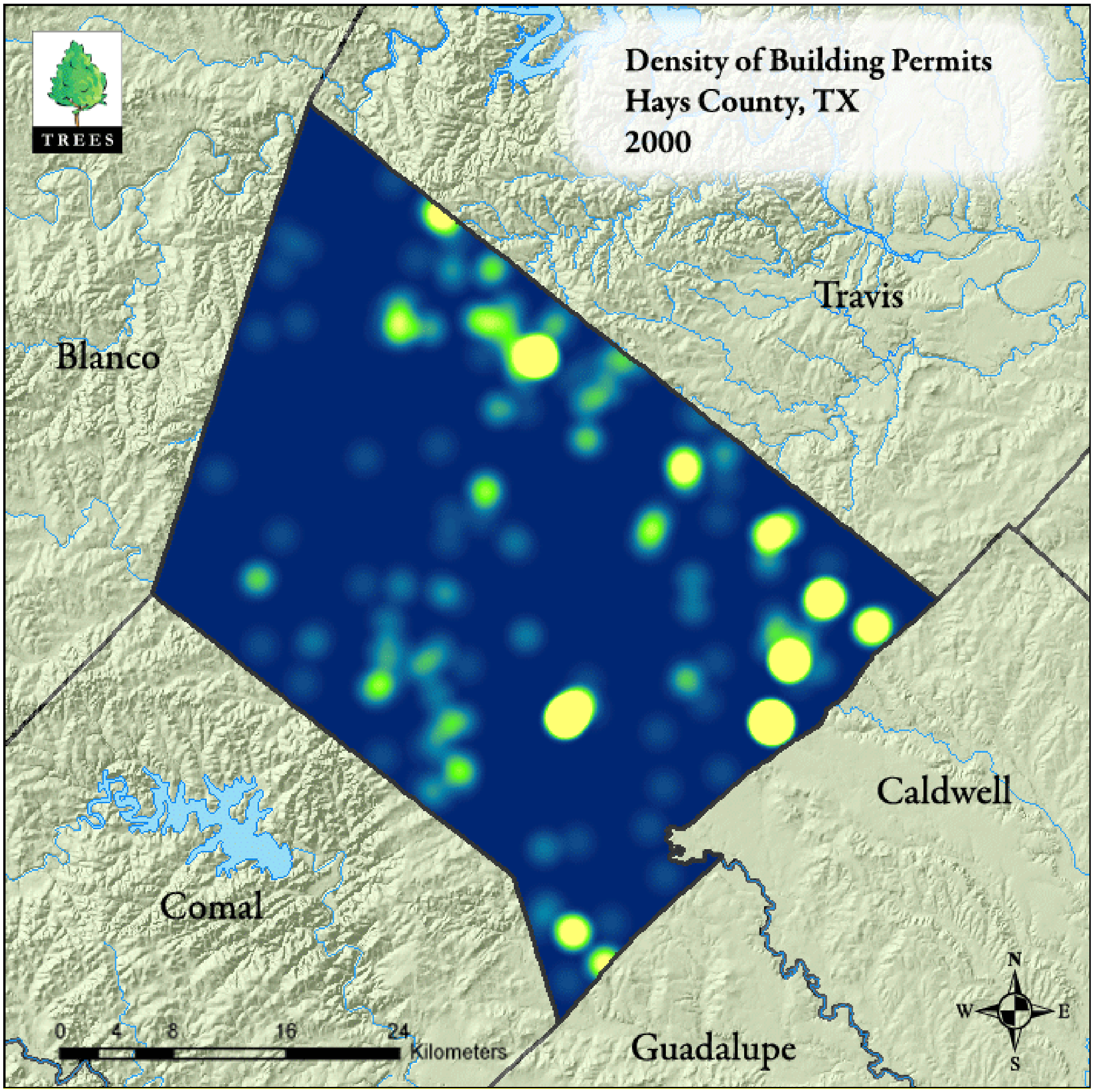

Figure 11. Map of Density of Building permits for 2000 in Hays County.

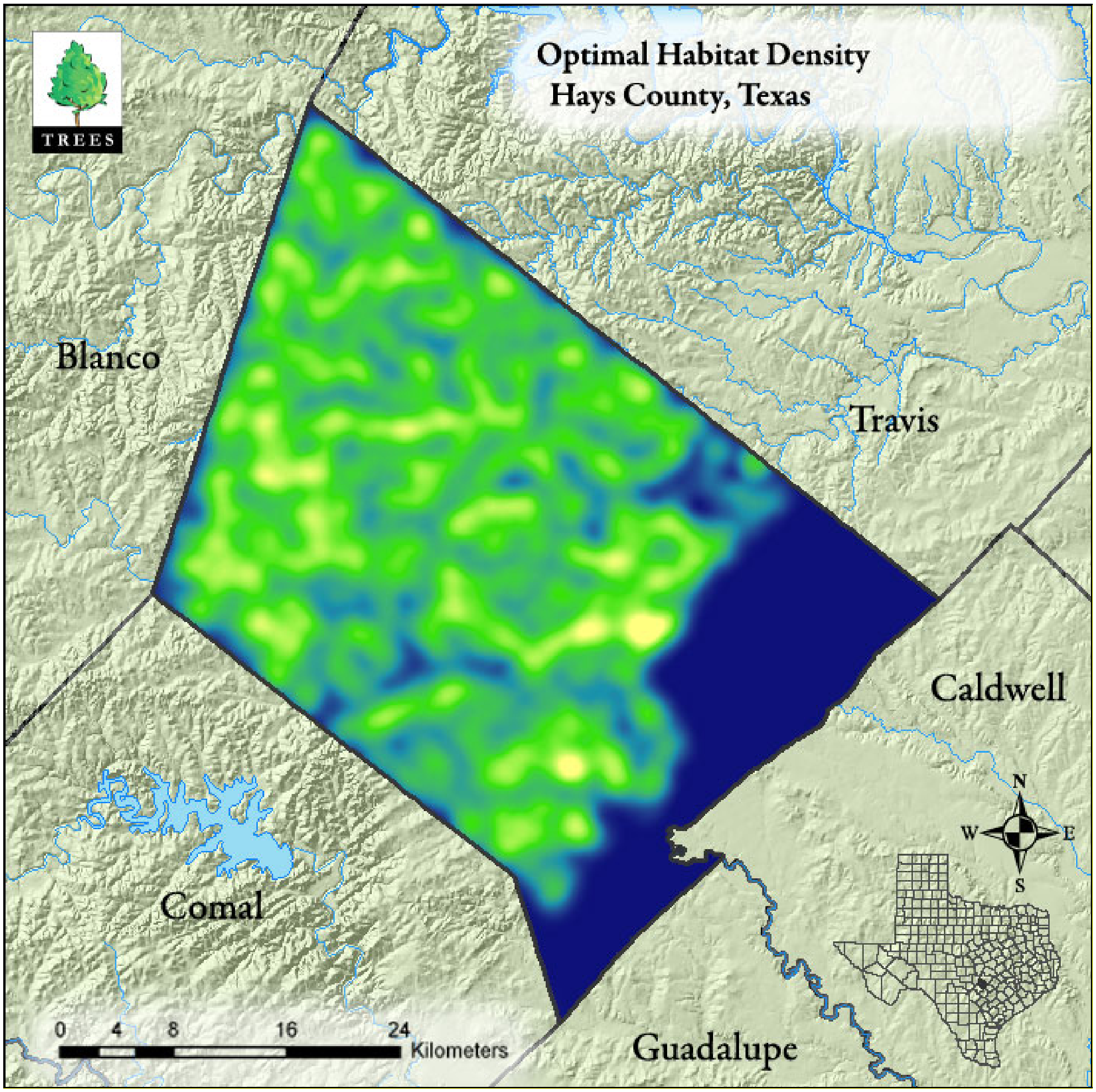

Figure 12. Optimal habitat density Hays County.

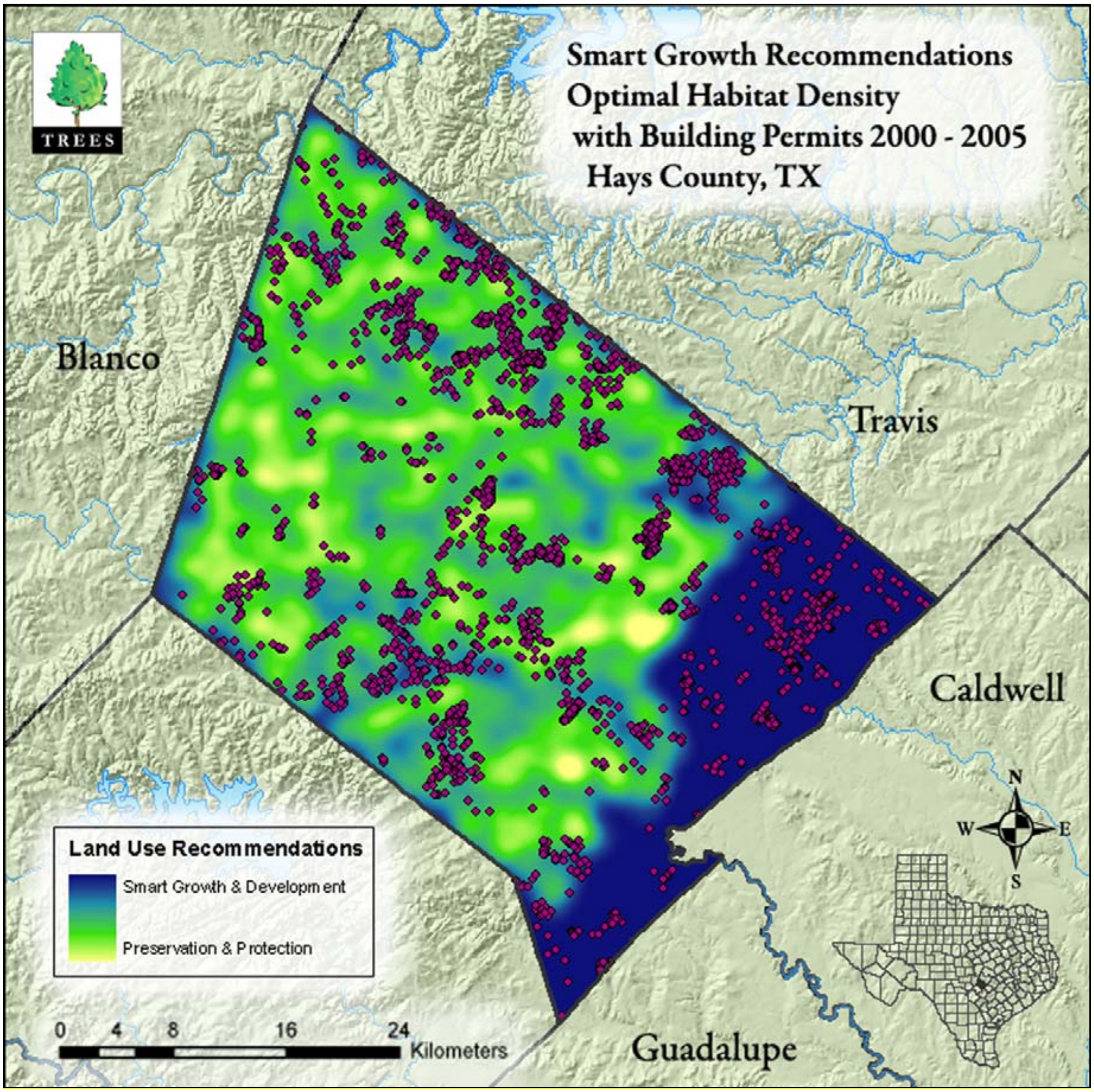

Figure 13. Smart growth recommendations for Hays County.

6. DISCUSSION

Figure 13 provides us with a general guide for the direction of future growth based on the density of ideal habitats for the Golden-cheeked Warbler and Black-Capped Vireo. These federally endangered avian species have a specialized niche in Hays County and their survival depends on the vested interest of all the county's inhabitants. The interest of human survival and comfort often tends to eclipse that of other species.

The implications of this study lend great credit to the protection of our natural environment, but must be carefully weighed with the interests of landowners and policy makers to be effectively used. There is no computer model detailed enough to truly calculate the infinite complexities of our world, however, there are some that can give us a better idea of what is occurring and steps we can take for a more desired outcome. This study is exactly that, a model that gives us a better indication of where we can expand, as a human population, into the natural environment while also protecting and persevering habitats for species whose needs are specialized.

It is also important to note the cultural nature of the study area. Central Texans have a history of efforts to protect the habitats of endangered species. The political environment is receptive to policies that mitigate the effects of human growth for the purpose of preserving the natural environment. Recently, voters in San Marcos, Hays County's most populous city, approved a bond measure to purchase and preserve a tract of land located in the watershed of Aquarena Springs. This artesian spring in the heart of San Marcos provides the only habitat for two endangered species, the San Marcos Blind Salamander and Texas Wild Rice. Granted there were other motivations for voters to approve this bond measure; however, it can not be denied that the protection of these species was not a primary motivation for voters to enact this policy. There have been similar measures passed by voters to the North in Travis County. A study of this nature has a more perceptive audience in Hays County, than it might in other areas of the country.

We used the spatial and temporal distributions of building permits collectively to understand the direction of land development on a regional scale in Hays County. This marks the first time these permits have been cataloged in a geodatabase and used for county-wide spatial analyses. The permits used in this study are from unincorporated areas of the county and, as such, may not be the most accurate or comprehensive selection; however, the majority of habitat for the selected species is more likely to be in these unincorporated areas. Although there may be less ability to control the direction of growth outside the jurisdiction of municipalities and other governing entities, this is where the greatest potential exists to preserve undeveloped land.

Table 1. Geocoding Match Rates of Building Permits

Year	Total Records	Records Geocoded	Unmatched Records	Match Rate
2000	540	482	58	89.26%
2001	1164	966	198	82.99%
2002	859	731	128	85.10%
2003	689	578	111	83.89%
2004	555	464	91	83.60%
2005	201	179	22	89.05%
			Total Average:	84.83%

We successfully geocoded 84.83% of 4,008 records. The discrepancy is a potential source of error in this study. The match rate could most certainly be closer to 100% with the availability of more time and resources; still, however, the percentage of matched records provides us a significant indication of growth trends.

There is most certainly a great potential for further research on the influence of human growth on endangered species' habitats. In the meantime, citizens and policymakers of Hays County may have a better idea of where we can develop land and expand our human footprint while better preserving the biodiversity of our natural environment.

7. CONCLUSION

Recently, urban sprawl among other environmental issues has become a topic of major concern for communities and local government.

Our study was necessary to identify where urban sprawl is currently occurring in Hays County. Secondly, our study identifies the habitat requirements for concerned species in the study area and maps out distribution of suitable habitats. In summary, our project has exhibited an area for smart growth that has the least adverse impact on these habitats. By using our smart growth recommendations, developers can protect endangered species.

Further research should be conducted to further identify areas of concern and additionally ground truthing should be completed in order to verify results from our study.

Additionally, future studies can be conducted on other endangered species in other areas and therefore, our study can be used as a model to identify habitat requirements and sprawl issues.

8. REFERENCES

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APPENDIX I. Metadata

A. Metadata: Hydrology

Identification_Information: natural resources, water sources

Citation:

Citation_Information: Hydrology

Description:

Abstract:

These feature classes represent line and polygon hydrologic features of the CAPCOG region at 1:24,000 scale.

Purpose:

Supplemental_Information:

Data obtained from USGS/EPA National Hydrography Dataset. This metadata was created by CAPCOG and is not the original metadata. See http://nhd.usgs.gov/data.html for a full description of this dataset.

Time_Period_of_Content:

1999

Time_Period_Information:

Currentness_Reference:

Status:

Progress:

Complete

Maintenance_and_Update_Frequency:

Unknown

Spatial_Domain:

Bounding_Coordinates:

N: 31.050439

S: 29.604920

E: -96.528444

W: -98.982460

Data_Set_G-Polygon:

Access_Constraints:

none

Use_Constraints:

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Point_of_Contact:

Capital Area Council of Governments (CAPCOG)

Contact_Information:

Capital Area Council of Governments (CAPCOG)

Data_Set_Credit: USGS/EPA National Hydrography Dataset

Security_Information:

Security_Classification_System:

Security_Classification:

Security_Handling_Description:

Native_Data_Set_Environment:

Microsoft Windows 2000 Version 5.0 (Build 2195) Service Pack 4; ESRI ArcCatalog 9.0.0.535

Cross_Reference:

Citation_Information:

Data_Quality_Information:

Attribute_Accuracy:

Attribute_Accuracy_Report:

Quantitative_Attribute_Accuracy_Assessment:

Logical_Consistency_Report:

Completeness_Report:

Positional_Accuracy:

Horizontal_Positional_Accuracy:

Vertical_Positional_Accuracy:

Lineage:

Source_Information:
Process_Step:
Dataset merged from HUC geodatabases covering the CAPCOG region. Dataset clipped to CAPCOG region. Some fields removed.
Cloud_Cover:

Spatial_Data_Organization_Information:

Indirect_Spatial_Reference:
Direct_Spatial_Reference_Method: Vector
Point_and_Vector_Object_Information: G-polygon count 61215
Raster_Object_Information:
Raster_Object_Type:
Row_Count:
Column_Count:
Vertical_Count:

Spatial_Reference_Information:

Horizontal_Coordinate_System_Definition:
Geographic:
Planar: Abscissa Resolution 0.0002048 Ordinate resolution 0.002048
Local:
Geodetic_Model:
Vertical_Coordinate_System_Definition:
Explicit elevation coordinate included with horizontal coordinates
Altitude_System_Definition:
Depth_System_Definition:

Entity_and_Attribute_Information:

Detailed_Description:
Entity_Type: Feature class
Attribute: FID
Overview_Description:
Entity_and_Attribute_Overview:
Sequential unique whole numbers that are automatically generated.
Entity_and_Attribute_Detail_Citation: soils_statsgo_nrcs

Distribution_Information:

Unlimited Downloadable Data

Metadata_Reference_Information:

Metadata_Date: 20050224
Metadata_Contact: Capital Area Council of Governments (CAPCOG)
Contact_Information:

Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998

B. Metadata: Soils

Identification_Information: natural resources, soils

Citation:
Citation_Information: soils_statsgo_nrcs
Description:
Abstract:
This is a polygon feature class representing generalized soil types of the CAPCOG region. It is the STATSGO soil dataset prepared by US Dept of Agriculture/Natural Resource Conservation Service.
Purpose:
Supplemental_Information:
Mapunit.dbf has been attached to this dataset to provide soil layer name information. This metadata was created by CAPCOG and is not the original metadata.
Time_Period_of_Content:
1994
Time_Period_Information:
Currentness_Reference:
Status:
Progress:
Complete
Maintenance_and_Update_Frequency:
Unknown
Spatial_Domain:
Bounding_Coordinates:
N: 31.050439
S: 29.604920
E: -96.528444
W: -98.982460
Data_Set_G-Polygon:
Access_Constraints:
none
Use_Constraints:
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Point_of_Contact:
Capital Area Council of Governments (CAPCOG)
Contact_Information:
Capital Area Council of Governments (CAPCOG)
Data_Set_Credit: Data obtained from USDA/NRCS and clipped to CAPCOG extent.
Security_Information:
Security_Classification_System:
Security_Classification:
Security_Handling_Description:
Native_Data_Set_Environment:
Microsoft Windows XP Version 5.1 (Build 2600) Service Pack 2; ESRI ArcCatalog 9.1.0.722
Cross_Reference:
Citation_Information:

Data_Quality_Information:

Attribute_Accuracy:
Attribute_Accuracy_Report:
Quantitative_Attribute_Accuracy_Assessment:
Logical_Consistency_Report:
Completeness_Report:
Positional_Accuracy:

Horizontal_Positional_Accuracy:
Vertical_Positional_Accuracy:
Lineage:
Source_Information:
Process_Step:
Dataset copied. Dataset clipped from statewide extent to 10-county CAPCOG extent.
Cloud_Cover:

Spatial_Data_Organization_Information:

Indirect_Spatial_Reference:
Direct_Spatial_Reference_Method: Vector
Point_and_Vector_Object_Information: G-polygon count 92
Raster_Object_Information:
Raster_Object_Type:
Row_Count:
Column_Count:
Vertical_Count:

Spatial_Reference_Information:

Horizontal_Coordinate_System_Definition:
Geographic:
Planar: Abscissa Resolution 0.0002048 Ordinate resolution 0.002048
Local:
Geodetic_Model:
Vertical_Coordinate_System_Definition:
Explicit elevation coordinate included with horizontal coordinates
Altitude_System_Definition:
Depth_System_Definition:

Entity_and_Attribute_Information:

Detailed_Description:
Entity_Type: Feature class
Attribute: FID
Overview_Description:
Entity_and_Attribute_Overview:
Sequential unique whole numbers that are automatically generated.
Entity_and_Attribute_Detail_Citation: soils_statsgo_nrcs
Distribution_Information:
Unlimited Downloadable Data

Metadata_Reference_Information:

Metadata_Date: 20051201

Metadata_Contact: Capital Area Council of Governments (CAPCOG)
Contact_Information:
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998

C. Metadata: Vegetation

Identification_Information: Vegetation of the Austin Metroplex

Citation:
Citation_Information: vegetation_tpwd
Vegetation Types of Texas
Description:
Abstract:
This is a polygon feature class representing vegetative cover types of the CAPCOG region as interpreted from satellite imagery by the Texas Parks and Wildlife Department.
Purpose:
Supplemental_Information:
Data obtained from Texas Parks and Wildlife Department via Texas Natural Resources Information System and clipped to CAPCOG extent. This metadata was created by CAPCOG and is not the original metadata.
Time_Period_of_Content:
1984
Time_Period_Information:
Currentness_Reference:
Status:
Progress:
Complete
Maintenance_and_Update_Frequency:
Unknown
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Bounding_Coordinates:
N: 31.050439
S: 29.604920
E: -96.528444
W: -98.982460
Data_Set_G-Polygon:
Access_Constraints:
none
Use_Constraints:
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Point_of_Contact:

Capital Area Council of Governments (CAPCOG)

Contact_Information:

Capital Area Council of Governments (CAPCOG)

Data_Set_Credit: Data from Texas Parks and Wildlife Department

Security_Information:

Security_Classification_System:

Security_Classification:

Security_Handling_Description:

Native_Data_Set_Environment:

Microsoft Windows XP Version 5.1 (Build 2600) Service Pack 2; ESRI ArcCatalog 9.1.0.722

Cross_Reference:

Citation_Information:

Data_Quality_Information:

Attribute_Accuracy:

Attribute_Accuracy_Report:

Quantitative_Attribute_Accuracy_Assessment:
Logical_Consistency_Report:
Completeness_Report:
Positional_Accuracy:
Horizontal_Positional_Accuracy:
Vertical_Positional_Accuracy:
Lineage:
Source_Information:
Process_Step:
Dataset copied. Dataset clipped from statewide extent to 10-county CAPCOG extent.
Cloud_Cover:

Spatial_Data_Organization_Information:

Indirect_Spatial_Reference:
Direct_Spatial_Reference_Method: Vector
Point_and_Vector_Object_Information: G-polygon count 92
Raster_Object_Information:
Raster_Object_Type:
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Column_Count:
Vertical_Count:

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Horizontal_Coordinate_System_Definition:
Geographic:
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Local:
Geodetic_Model:
Vertical_Coordinate_System_Definition:
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Altitude_System_Definition:
Depth_System_Definition:

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Attribute: FID
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Entity_and_Attribute_Overview:
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Entity_and_Attribute_Detail_Citation: vegetation_tpwd

Distribution_Information:

Unlimited Downloadable Data

Metadata_Reference_Information:

Metadata_Date: 20051201
Metadata_Contact: Capital Area Council of Governments (CAPCOG)
Contact_Information:
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998

D. Metadata: Final Map

Identification_Information: Trees Final Analysis

Citation:
Citation_Information:
Description:
Abstract: This is a combined raster and feature class data set that shows the final analysis of all the previous downloaded data and GIS use. It describes the habitat requirements of the Golden-cheeked Warbler and Blacked-capped Vireo, and the geocoded address data. This data examines the relation to land use and proximity of endangered species to those areas.
Purpose:
Supplemental_Information: This map was created by TREES and is original data.
Time_Period_of_Content: 2005
Time_Period_Information:
Currentness_Reference:
Status:
Progress:
Maintenance_and_Update_Frequency: as needed
Spatial_Domain:
Bounding_Coordinates:
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W: -98.982460
Data_Set_G-Polygon:
Access_Constraints:
none
Use_Constraints: unlimited as long as proper citation is used
Point_of_Contact: Texas Resources Environmental Engineering Systems TREES
Contact_Information: Ryan V Schmidt 512-738-9168
Data_Set_Credit: TPWD, CAPCO, CAMPO,TNRIS
Security_Information:
Security_Classification_System:

Security_Classification:
Security_Handling_Description:
Native_Data_Set_Environment: Microsoft Windows XP Version 5.1 (Build 2600) Service Pack 2; ESRI ArcCatalog 9.1.0.722
Cross_Reference:
Citation_Information:

Data_Quality_Information:

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Attribute_Accuracy_Report:
Quantitative_Attribute_Accuracy_Assessment:
Logical_Consistency_Report:
Completeness_Report:
Positional_Accuracy:
Horizontal_Positional_Accuracy:
Vertical_Positional_Accuracy:
Lineage:
Source_Information:
Process_Step:
Cloud_Cover:

Spatial_Data_Organization_Information:

Indirect_Spatial_Reference:
Direct_Spatial_Reference_Method: Vector
Point_and_Vector_Object_Information: G-polygon count 61215
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Raster_Object_Type:
Row_Count:
Column_Count:
Vertical_Count:

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Local:
Geodetic_Model:
Vertical_Coordinate_System_Definition:
Explicit elevation coordinate included with horizontal coordinates
Altitude_System_Definition:
Depth_System_Definition:

Entity_and_Attribute_Information:

Detailed_Description:
Entity_Type: Feature class and Raster
Attribute: FID, RAS
Overview_Description:
Entity_and_Attribute_Overview:
Sequential unique whole numbers that are automatically generated.
Entity_and_Attribute_Detail_Citation: TREES Final Analysis

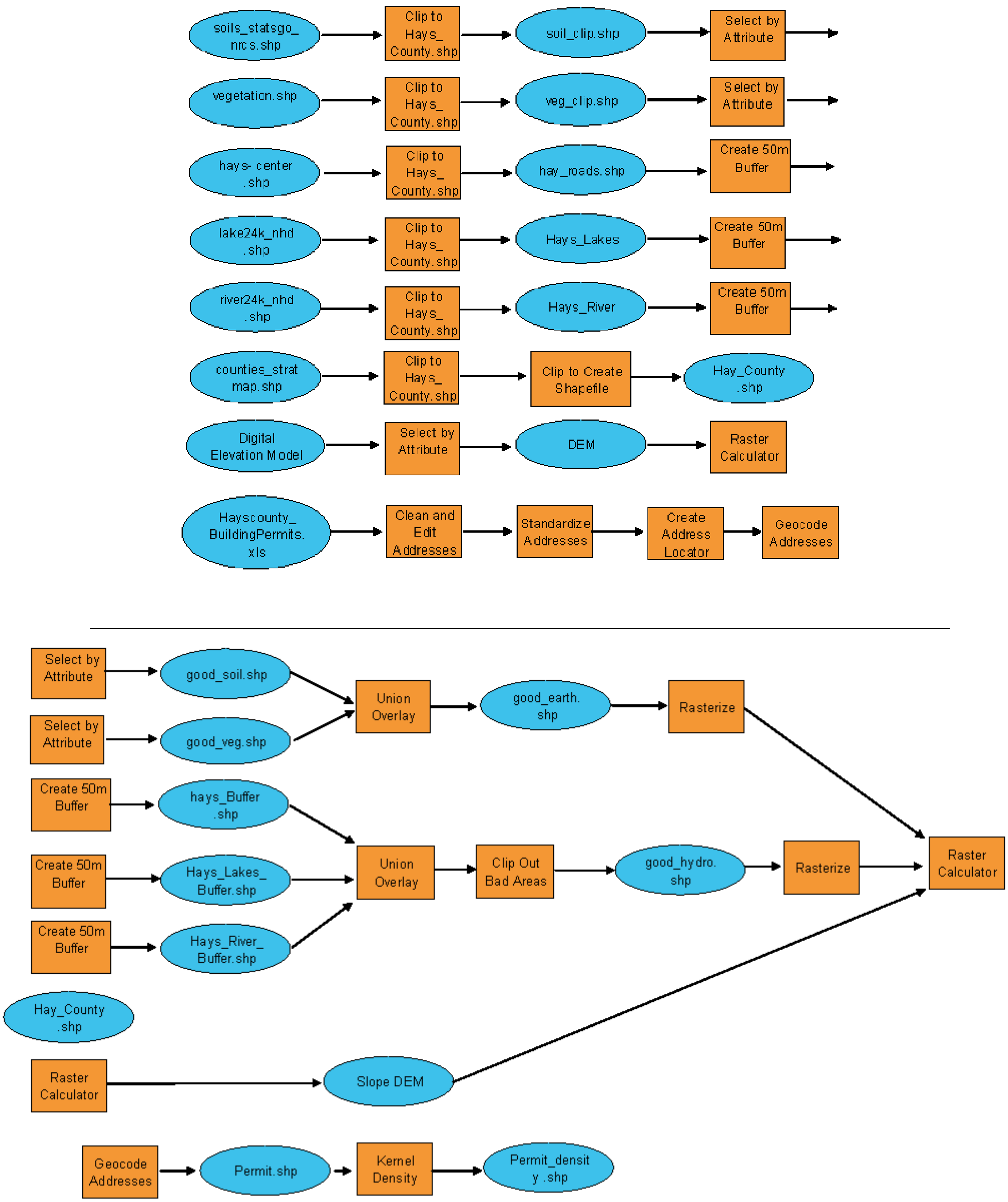
Distribution_Information:

Unlimited Downloadable Data

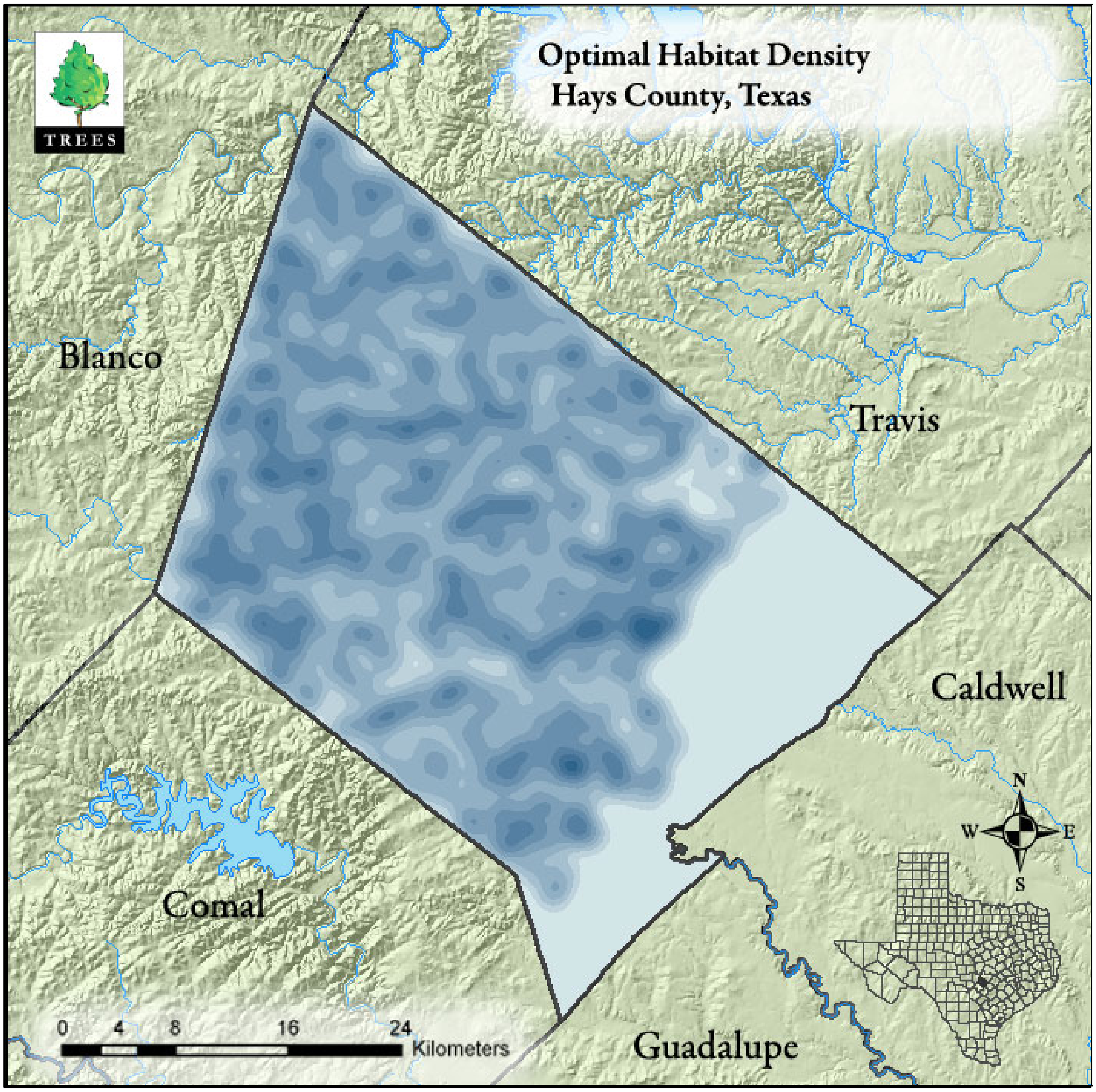
Metadata_Reference_Information:

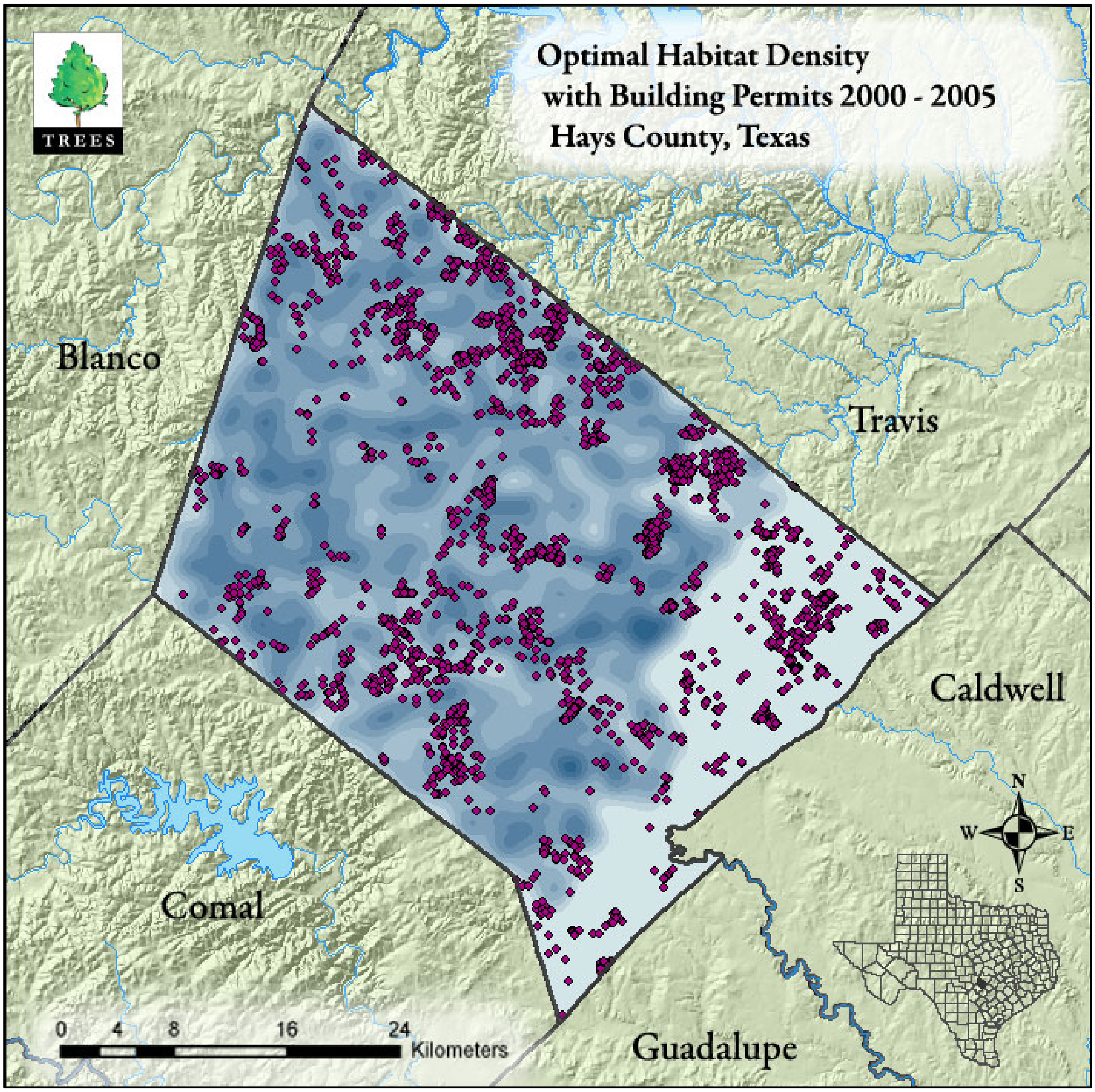
Metadata_Date: 12082005
Metadata_Contact: Ryan V Schmidt
Contact_Information:
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: Metadata_Standard_Version: FGDC-STD-001-2005

APPENDIX II. Flowchart



APPENDIX III. Additional Figures





TREES
Optimal Habitat Density
with Building Permits 2000 - 2005
Hays County, Texas
Blanco
Travis
Caldwell
Comal
Guadalupe
0
4
8
16
24
Kilometers
N
W
E
S

APPENDIX IV. Team Members' Contributions

Project Manager – Stephanie Rosson-Singleton

As Project Manager, Stephanie's most important responsibility was coordination of the project. Her main concern was to create group and individual goals relevant to the project criteria and timeline. She aided group members in staying focused and positive with established goals and helped all of them with completing said goals. Incidentally, she helped all group members from time to time.

Aside from her all consuming managerial goals she worked individually on the composition of group documents, contributed to papers, power point, conducted research, analysis, and helped any group member whenever needed. Additionally, Stephanie's knowledge of biology was necessary to contribute in finding habitat requirements for the species of concern. Stephanie, whose strength is writing, wrote many sections of the report. Report sections written include, Introduction, Background, Purpose, Literature Review, Results, Conclusion, References. Additionally, the final paper was formatted and edited by Stephanie with Ryan as a fellow editor.

Assistant Project Manager – Ryan Schmidt

Ryan, as an assistant manager, main role was that of support. Ryan, as a fellow biologist, was instrumental is helping with creating habitat maps and the habitat analysis. Additionally, Ryan created the Metadata and wrote the Data section of the report. Ryan and Stephanie also created maps that were later edited and improved by Noah.

GIS Analyst – Mark Adair

Mark was instrumental is data collection, geodatabase creation and in getting all the data in the correct projection. Additionally, Mark wrote the Methods section and created the flowchart. Mark also geocoded the building permits data and made the separate permit year files that were instrumental in the analysis.

Webmaster/Analyst – Noah Hopkins

Noah created the webpage and the poster and CD. Noah was instrumental in editing and improving upon the maps created by Cherrie-Lee, Ryan and Stephanie. Noah additionally, created the animation used in the Powerpoint. Furthermore, Noah wrote the Discussion section of the paper, abstract and cover page with table of contents. Noah, additionally, was responsible for printing and binding the final report.

GIS Analyst – Cherrie-Lee Phillip

Cherrie-Lee was instrumental in assisting the group with the project and giving her input on issues with the project. Cherrie-Lee assisted Stephanie and Ryan in researching the species of concern. Additionally, Cherrie-Lee wrote labels for the maps in the Results section and created base maps of soils, vegetation, roads of Hays County that were later edited and improved by Noah.